University of Strathclyde

Department of Strategy and Organisation

ORGANISING WHILE INNOVATING

Towards A Process Theory in Innovation Management

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Declaration of authenticity and author’s rights

This thesis is the result of the author’s original research. It has been composed by the author and has not been previously submitted for examination which has led to the award of a degree.

Signed: **Date: 30th September 2015**

In memory of Mutachan,

***Late Shri Kondoth Gopalan Nair**, my grandfather,*

and for Ammamma,

***Smt Vijayalakshmi Karath,** my grandmother,*

to whom with affection, this thesis is dedicated.

A.K.N
Glasgow, UK
June 2015

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Attributing the ‘outputs’ of scholarship to an individual, underplays the distinctly collective nature of its pursuit. This thesis is no different. Undertaking this study is perhaps the most difficult task I’ve attempted. On several occasions, I’ve felt quite unequal to the task. Looking back, this exciting intellectual journey was enabled by the unrelenting support, encouragement and faith placed in me by several individuals.

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Abstract

The focus of mainstream innovation research has largely been on innovation as an output rather than innovating as a process. Thus, the dynamics of the messy process of innovating, characterised by its complexity, non-linearity, false starts, dead ends, ineffability and becoming, remain under theorised. Current process theories on innovating, notably the efforts of Kathleen Eisenhardt, Robert Burgelman, Andrew Van De Ven and Raghu Garud, which attempt to unravel the dynamics constituting the innovating process, have all emphasised that innovating involves change. However, the surfacing of the debate between the 'substantialist' and 'process' metaphysical perspectives in organisational studies has produced new insights on organisational change and adaptation. ‘Process’, in the former perspective refers to an epistemological position where change is construed as epiphenomenal and occurring between two stable states or structures or entities. ‘Process’ in the latter refers to an ‘ontological’ position where order and organisation are regarded as temporarily-stabilised accomplishments or relatively stabilised patterns of relations in a churning sea of change.

These insights have triggered several theoretical and methodological debates which bear profound implications for our understanding of how innovations come into being. Specifically, these insights challenge four apparent paradoxes: a) persistence versus change; b) synchrony versus diachrony; c) necessity versus chance and d) structural determinism versus agentic free will; which have persistently puzzled the ‘substantialist’ innovation process theorists. Despite its ability to dissolve these paradoxes, the application of the ‘processual’ perspective to explore innovating remains, both theoretically and empirically underexplored. The objective of this thesis is to address this lacuna by exploring organising while innovating from a ‘processual’ perspective. ‘Processual’, here refers to both an ontological and epistemological position. Adopting this perspective requires theorists to pry open the proverbial black box which conceals the unfolding dynamics and their subsequent stabilisation while innovating. Put differently, the research must answer how organising and innovating entwine as they become.

Doing so required designing a theory of method that is inherently sympathetic to process and movement as fundamental features of reality. Such a methodology was designed and deployed in this seven month long, real time, ethnographic field study of two new product development projects at a Scottish high value manufacturing firm. Analysis of the data illuminates the unfolding of three distinct yet intertwined dynamics which I’ve called the dynamics of preferential equivocality, the dynamics of temporal scaffolding and the dynamics of relational coherence. The findings also reveal that these three dynamics are regulated by a mechanism, called ‘tensegrity’ (portmanteau for tensional-integrity). I expand and elaborate on the tensegrity mechanism, which was seen to influence the entwinement and unfolding of organising while innovating.

This study, offers four distinct research contributions. One, it develops a ‘processual’ theoretical approach to study the process of innovating. Two, it offers a theory of method that conceptually integrates and translates this framework to the practical activity of fieldwork in process research. Three, this research is among the few empirical field studies on innovating from a ‘processual’ perspective. And four, by identifying the dynamic processes and explicating the mechanism through which organising while innovating becomes, it offers theoretical and practical guidance to navigate the innovation journey. Overall, this study clears the ground for a more extended ‘processual’ inquiry within innovation research and organisational theory.

Contents

Table of Acronyms

ANT	**Actor Network Theory**
BOM	**Bill of Materials**
BSI	**British Standards Institute**
CAD	**Computer Aided Design**
CAS	**Complex Adaptive Systems**
CE	**Conformité Européenne**
CMS	**Carbon Molecular Sieve**
CSA	**Canadian Standards Association**
DDP	**Design Development Process**
ECN	**Engineering Change Notification**
EU	**European Union**
GCMS	**Gas Chromatography Mass Spectroscopy**
ICV	**Internal Corporate Venturing**
IT	**Information Technology**
LCMS	**Liquid Chromatography Mass Spectroscopy**
MIRP	**Minnesota Innovation Research Program**
NPD	**New Product Development**
NPI	**New Product Introduction**
OEM	**Original Equipment Manufacturer**
OI	**Organisational Innovativeness**
PSA	**Pressure Swing Adsorption**
RIS	**Regional Innovation Systems**
R&D	**Research and Development**
SMT	**Strategic Management Team**

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1 Introduction

‘New’ is an old word. Let’s have a new one.

Anonymous Poet in the *London Review of Books*

1.0 Introduction

Despite roots in Latin antiquity, innovation, or rather its pursuit has lost none of its allure. Originating from the Latin words *in* meaning within and *novus* meaning new; innovation refers to the ability to *re-new from within* (The Oxford Dictionary of English Etymology). Innovations are vital for the growth, survival and prosperity of organizations (Hamel, 2000; Drucker, 1985). A recent survey by The Boston Consulting Group (2014) ranked innovation as being among the top three strategic priorities of senior executives representing global corporations. However, these executives also believe that innovation isn’t getting any easier and feel less confident about their innovation capabilities.

While the benefits of innovations, for both organizations and societies at large, are rarely disputed, undertaking concrete effort to transform an innovative idea into reality is perhaps the most vexing problem facing managers. The ‘process of creative destruction’ (Schumpeter, 1942, pp. 81-86) fills firms with both anxiety and excitement in equal measure. Amazon, whose online sales model and e-books began upending the book publishing and retail business, is a good illustration of the ethos of creative destruction. To quote from the Boston Consulting Group report:

> “The company has used the lessons learned to expand into myriad other areas of retailing, significantly transforming the consumer purchase pathway and rearranging consumer expectations of what the shopping experience should be. It has embraced thousands of customers as product reviewers and engaged thousands of traditional retailers with the development of Amazon Marketplace. Amazon rolls out new products and services with almost frightening speed: the Kindle e-reader, Kindle Fire Tablet, the Amazon Fire Phone, Amazon Prime, AmazonFresh, and Subscribe & Save have all been introduced in the past ten years. Amazon Web Services has led the paradigm shift to cloud computing and is a major force in enabling big-data analytics” (pp. 12-13).

Other salient examples include companies like Apple, IBM, Tesla Motors, 3M, Samsung and Google. However, according to another estimate, only 19 of the *Fortune* top 100 US based industrial companies in 1965 remain within the top 100 in the first decade of the twenty first century (Burgelman & Grove, 2007, p. 965). Corporate history is replete with examples of old orders being disrupted and new orders emerging. The above examples paint a very heterogeneous picture on the organisational significance, complexities and challenges of sustaining innovation. While successful product innovations benefit organisations, both in terms of increased cash flows as well as in higher firm valuations by equity markets; developing such innovations can be risky, costly and a 'double-edged sword' (Evanschitzky, et al., 2012; Kaplan & Vakili, 2014).

Consequently, innovating or the task of attending to the 99% perspiration required to realise the 1% inspiration as Edison memorably put it, is complex and difficult to sustain (Garud, et al., 2013; Dougherty & Hardy, 1996; Govindarajan & Trimble, 2010). Ask any manager entrusted with the task of executing an innovation within their respective organisations and you can sense their exasperation. They describe the glacial pace at which the innovative idea musters organizational support, the mobilization of staff, crystallisation of project teams, scamper for resources and just when the project slides into operation, it is caught by an avalanche of complexity involving (but not restricted to) ambiguities in technologies, markets and organisational priorities. Innovating, put differently includes, not just the generation of new ideas but also the necessary work required to translate these ideas into business opportunities. Or in the words of Ray Stata, founder and Chairman of the $2 billion semiconductor manufacturer Analog Devices:

> "The limits to innovation in large organisations have nothing to do with creativity and nothing to do with technology. They have everything to do with management capability."
>
> (Quoted in Govindarajan & Trimble, 2010, p. ix).

Developing the managerial capability for sustaining innovation requires an understanding of how to organise while innovating. Yet, to date most theories of innovation do not address this question. So how exactly do we organise while innovating? Anticipating this question, several innovation scholars have identified both a need for a more integrated theory on the role of organising while innovating (Tidd, 2001, p. 173; Ahuja, et al., 2008; Crossan & Apaydin, 2010; Keupp, et al., 2012) as well as a richer conceptual understanding of the process of innovating (Garud, et al., 2013).

This thesis originated out of a deep desire to understand *innovating-in-practice*. Current academic literature on innovation has, for the most part, been pre-occupied with conducting post mortems on innovations after they have been realised. Such theories, which provide *insights into how innovations ought to happen*, have *failed to sufficiently resonate* with the challenges confronting practitioners (Crossan & Apaydin, 2010; Keupp, et al., 2012). Developing a theory which resonates with innovation practitioners requires a reorientation of our analytical attention from the rear view mirror to the windscreen whilst on the innovation journey.

The remainder of this chapter outlines what might be considered a thesis route map. Like route maps used by navigators, it aims to prepare the reader for a journey which investigates the dynamics of organising while innovating. In what follows, I begin by identifying some of the key reasons for the rift between innovation theory and practice. These reasons, I argue, have led to a "fragmentation and lack of interconnectedness" (Crossan & Apaydin, 2010, p. 1165) within innovation research. The next section highlights the research question along with the central contribution of this thesis for the theory and practice of organising while innovating. This chapter concludes by presenting a thesis outline.

1.1 Rift between Theory and Practice

Managing the innovation journey, where the journey is defined as "a sequence of events in which new ideas are developed and implemented by people who engage in relationships with others and make the adjustments needed to achieve desired outcomes within an institutional or organisational context" (Van de Ven, et al., 1999, p. 181), is a challenging exercise fraught with ambiguity. Despite several decades of research on innovation and how it might be sustained, the resulting insights have failed to yield a comprehensive framework to guide innovation research or management practice (Tidd, 2001, p. 173; Ahuja, et al., 2008; Crossan & Apaydin, 2010; Keupp, et al., 2012). There are several reasons why this limited insight persists.

First, a widespread impediment to systematic innovation research has been the rather imprecise and liberal application of the term *innovation*, “often employed as a substitute for creativity, knowledge, or change” (Crossan & Apaydin, 2010, p. 1155). As Ray Stata’s remark suggests, innovation is not the same as knowledge or ideation. The literature on creativity is perhaps better equipped to explain the mysteries shrouding ideation (Amabile, 1995; Harvey & Kou, 2013; Harvey, 2014). Another widespread and problematic confusion in the innovation literature stems from the conflation of knowledge with innovation. Knowledge, as West and Bogers (2014) point out, is “a resource that is utilized in the process of creating innovations” (p. 826). It could also be an outcome of innovating (Nonaka & Takeuchi, 1995; Nonaka & von Krogh, 2009). The literature on organisational learning better explores the nature and role of knowledge within organisations (Argote, 2011; Tsoukas & Vladimirou, 2001). Innovating does involve change but not all change processes lead to innovation. The result of this broad interpretation of ‘innovation’ has been a fragmentation of theoretical insights which prevents us from deepening our understanding of specific facets of innovating.

Second, much of the voluminous research on innovation to date has focussed on innovation as an output (Ahuja, et al., 2008; Crossan & Apaydin, 2010; Garud, et al., 2013). Utilising proxy indicators like R&D expenditure, number of patents or surveys of new product announcements (Tidd, 2001, pp. 169-170; Adams, et al., 2006), the ‘innovation as output’ scholars have addressed questions about what produced an innovation. However, the inconclusiveness of such empirical test results based on widespread assumptions regarding which variable is dependent and which is independent has drawn a lot of criticism (Ahuja, et al., 2008; Camison-Zornoza, et al., 2004). As Van de Ven and Huber (1990) bluntly observe,

> “To say that R&D investment causes organizational innovativeness is to make important assumptions about the order and sequence in which R&D investment and innovation events unfold in an organization. Thus, one way to significantly improve the robustness of answers (which has been the most frequent kind of questions examined by organization scientists) is to explicitly examine the process theory that is assumed to explain why an independent (input) variable causes a dependent (output) variable. To do so requires opening the proverbial "black box" between inputs and outcomes, and to take process seriously by examining temporal sequence of events” (p. 214).

Put differently, ‘innovation as output’ assumes rather than demonstrates a process theory. Besides, questions to which it provides answers like, “What factors increase the likelihood of new idea emergence?” or “What factors determine the characteristics of the new idea, e.g., whether the new idea is incrementally or radically different from the old one, whether it is successful or not, and so forth?" (Gupta, et al., 2007, p. 886), are of little use to general managers and largely overlook the encompassing problems they confront while managing innovations (Van de Ven, 1986, p. 590). Since innovation is defined as an outcome, it is not surprising that the underlying mechanisms through which innovation managers generate, contextualise, infuse, translate, adapt and shape innovations have not been developed as fully (Garud, et al., 2014; Crossan & Apaydin, 2010).

Third, the innovation journey which is "a nonlinear cycle of divergent and convergent activities that may repeat over time and at different organisational levels" (Van de Ven, et al., 1999, p. 16) is often represented as a simple, linear, cumulative sequence of stages or phases (Wolfe, 1994; Rogers, 1983). Such static representations of innovation mask what is inherently a complex process with multiple feedback and feed forward loops. Thus the linear stage model proved a deceptive distraction to further scholarly inquiry into the process of innovating (Wolfe, 1994, p. 411). Additionally, addressing innovation dynamics by restricting the "levels of analysis" (Gupta, et al., 2007, p. 885) to either a single stage or "stages within various types of innovation such as product, process, or business model innovations" (Crossan & Apaydin, 2010, p. 1154) has proved inadequate. The analytical specificity it demands seems problematic because several complexities (e.g evolutionary, relational, temporal and cultural) which managers encounter while innovating may transcend organisational levels (Garud, et al., 2013) or spill across multiple levels of analysis (Gupta, et al., 2007). Consequently, the interacting complexities have received very little empirical attention and to date remain poorly understood.

Finally, research on the process of innovating, which focusses on how innovating within organisations is fostered, emerges, grows, develops or aborts over time (Van de Ven & Huber, 1990; Langley, et al., 2013) and might be sustained in constructive directions, remains both underexplored and underdeveloped (Crossan & Apaydin, 2010, p. 1167; Keupp, et al., 2012). Innovating, as the growing body of evidence suggests, involves change and is "multifaceted, encompassing the generation of novel ideas for products and services, as well as related fixes to business processes, technological capabilities, and production and distribution methods" (Bartel & Garud, 2009, p. 107). While several studies have sought to understand the process of innovating, the identification of a "clear prototypical process for the management of innovation" (Gupta, et al., 2007, p. 886), has to date proven elusive. Therefore, from a managerial viewpoint, to organise while innovating, requires us to identify the ongoing organising processes along with their underlying mechanisms.

In sum, despite the significant strides made by scholars to identify determinants of innovation (Ahuja, et al., 2008, p. 74), innovation research remains fragmented, theoretically underdeveloped (Crossan & Apaydin, 2010, p. 1174) and has failed to deliver clear and consistent findings that can provide a practical framework to guide innovation managers (Keupp, et al., 2012; Tidd, 2001). The broad and imprecise use of ‘innovation’, the conceptualisation of innovation as an output that conceals more than it reveals, the resulting oversimplification of the complexity and uncertainty by restricting organisational levels of analysis and the under developed view of ‘process’ theories in innovation literature, have all made the management of innovation a “daunting task” (Drazin & Schoonhoven, 1996, p. 1081). It has left practitioners and theorists alike, with “an overwhelmingly complex literature and very little practical guidance” (Keupp, et al., 2012, p. 368) on how to organise while innovating.

1.2 Research Question and Contributions

Rifts between the theory and practice of innovation raise a simple yet vexing question: How do we organise while innovating? This thesis encapsulates my quest to find an answer to this question. Here, it is important to clarify what I mean by the terms organising and innovating. I use the word 'organising' instead of 'managing' to denote a coming into being of coordination and order. Though 'organising' and 'managing' have both, in the past, been used interchangeably, I have chosen to stick with 'organising' over 'managing' for two reasons.

First, etymologically 'organise' comes from the French word *organiser* which means 'to give organic structure or function to'; or 'to arrange or form into' a body. The etymological roots of the word 'manage', on the other hand, originates from the Italian word *maneggiare* which means 'to handle, control' or 'to exert one's authority or rule over' (The Oxford Dictionary of English Etymology). Since the extent to which innovating can be 'controlled' will remain contentious, 'organising', I believe, is much more appropriate than 'managing'.

Second, because of its emphasis on 'control', the term managing (with good reason) could be viewed as the exclusive prerogative of managers within organisations. Organising, in contrast, includes the efforts of both managers and non-managerial staff within organisations.

Managing is therefore subsumed under organising. For these reasons, organising is preferred over managing. Organising, therefore refers to preparations or acts for ordering by (re)configuring existing resources, skills or organisational arrangements. Innovating on the other hand refers to the acts of executing or realising novelty. It can therefore be defined as the "invention, development, and implementation of new ideas" (Garud, et al., 2013, p. 776) by people within an organisational context.

I began by undertaking an extensive review of the literature in order to explore various theoretical mechanisms that scholars have invoked to explain organising while innovating. The review revealed that existing theoretical mechanisms fail to sufficiently account for the dynamics which engulf organising while innovating. This was because innovating entails change, and failure to incorporate the change process within innovation theories inevitably limits their explanatory potential. Additionally, the exercise also showed how 'process studies' (Langley, et al., 2013; Garud, et al., 2013; Steyaert, 2007) on innovation have received very little empirical attention.

Therefore, developing a process theory seemed logical until I was confronted with four recurring theoretical puzzles. The first involved the relationship between persistence and change while studying the process of innovating. If innovating involves change, then how do organisations remain stable? Alternately, if organisations are indeed stable then how do they facilitate the change required to innovate? My second puzzle involved the role of time in the study of organisational dynamics. Are temporal dynamics better explicated synchronically or diachronically? This puzzle also has significant methodological implications for my research question. The third puzzle called into question, the very nature of the process of innovating. Are we to consider innovating as a process of discovery (Shane & Venkataraman, 2000) or is it better understood as a process of creation (Alvarez, et al., 2013)? The role of chance is emphasised in the former while the latter stresses necessity. And finally are innovation processes 'path-dependent' or are they 'path creating' (Garud, et al., 2010)? The former invokes structural determinism while the latter invokes performativity underpinned by agentic will. These puzzles obscured the black box that conceals the dynamics of organising while innovating.

In order to productively engage with these puzzles and find a work around, I undertook a meta-theoretical analysis. The analysis revealed two insights that were to prove useful to my research question. First, it highlighted two competing ontologies, namely the substantialist and processual, each of which originate from vastly different worldviews (Tsoukas & Chia, 2011). *In the former, processes represent change in things whilst in the latter things are reifications of processes*. Second, it allowed me to trace the origin of the theoretical puzzles to the substantialist ontology. This crucial breakthrough highlighted the limitations of substantialist thinking and allowed me to embrace the alternate processual ontology. However, this processual ontology presented a new dilemma. While on the one hand it held out the alluring promise of being able to pry open the black box that conceals the dynamics of organising while innovating, on the other hand it remains conceptually and empirically under-developed within social science in general and management research in particular.

Fortunately, my search led me to the social anthropological writings of Tim Ingold (1986; 2000; 2007; 2011; 2013b). His oeuvre proved to be the theoretical equivalent of a gold mine (no pun intended) for this frantic researcher, eager to develop a 'processual' theory on organising while innovating. Much of what followed involved weaving Ingoldian insights into process research in general and innovation research in particular. Specifically, this meant, first, clarifying the difference between a process ontology and a process epistemology. The difference is significant because process epistemology alone does not sufficiently inform our understanding of organisational dynamics, and, in fact, leads to the four theoretical puzzles discussed earlier. And second, introducing the Ingoldian becoming perspective as a viable alternative allowed me to work around the puzzles that confront 'substantialist' process scholars. This exercise not only highlighted the paucity of innovation research that combines a process ontology and epistemology but also opens up new and exciting frontiers for management research, save one problem. How do I carry out such an investigation?

The challenge now was to develop a 'processual' methodology that conceptually integrates and translates the Ingoldian lens into the practical activity of fieldwork in innovation research. This was achieved by consulting various sources, synthesising, and drawing on resources from other branches of social theory, particularly social anthropology. I developed my "theory of method" (Pettigrew, 1990, p. 267) which I then deployed to investigate the dynamics of organising while innovating at a Scottish high value manufacturing organisation. My methodology offers new opportunities to develop empirically informed theories which combine the process ontology with the process epistemology. This methodology could prove useful to future scholars who seek to shed more light on organisational dynamics by undertaking empirical 'processual' research within management.

All of these led me to the central contribution of my thesis. I pry open the black box which until now concealed the dynamics of organising while innovating. My analysis has identified and untangled three dynamic process complexes along with their regulatory mechanism. The three process complexes are: (i) dynamics of preferential equivocality which refers to a gradual emergence and revealing, over time, of various preferences that shape innovating, (ii) the dynamics of temporal scaffolding which refers to the ongoing enactment and maintenance of temporal boundaries by regulating development priorities and activity sequences while innovating, and (iii) the dynamics of relational coherence which refers to the changing patterns of dependencies between various organising processes as innovating unfolds.

Further, these three dynamics were regulated by tensegrity, a mechanism where dynamic stability is maintained by counteracting forces of tension and compression which equilibrate throughout the structure. Applied analogically, the three dynamic process complexes along with the tensegrity mechanism constitutes, what I call, 'The tensegrity model of organising while innovating'. The model sheds light on how the dynamics of organising and innovating unfold as they become. In other words, it provides an answer to my original research question, how do we organise while innovating?

To conclude, this study offers four distinct research contributions. One, by tracing the current debates within innovation theory to their substantialist underpinnings, it offers clarity and insight into the limitations of 'substantialist' process research. Two, it introduces an alternate 'processual' worldview by presenting an Ingoldian becoming perspective which allows us to side step the 'substantialist' dilemmas. Three, it offers a theory of method that is inherently sympathetic to a 'processual' worldview by conceptually integrating the Ingoldian lens with the practical activity of fieldwork in innovation process research. Four, I am yet to come across research which develops and deploys a theoretically informed, empirically tractable 'processual' examination of the innovating process. By identifying the dynamic processes and explicating the mechanism through which organising while innovating becomes, my study offers theoretical and practical guidance to navigate the innovation journey. Overall, this study clears the ground for a more extended 'processual' inquiry within innovation research and organisational theory.

1.3 Thesis Outline

This thesis is structured as follows. In Chapter Two, I undertake an extensive review of the literature to identify and understand the various unresolved theoretical issues raised by scholars who have studied the challenges of organising while innovating. The review identified two broad streams of innovation research: the output stream and the process stream. Reviewing both streams in turn reveals that research from the output stream has enjoyed considerable success generating *know that knowledge* but has failed to create the crucial *know how* knowledge on innovating (Langley, et al., 2013). While the process stream on innovation partially addresses this knowledge gap, it is yet to provide a comprehensive answer to my research question. Four specific theoretical puzzles emerge from the literature review which have a crucial bearing for my research question. These puzzles signal a need to undertake an explicit meta-theoretical analysis which examines the very conceptualisation of organisations within management research.

In Chapter Three, I undertake this meta-theoretical analysis. My analysis reveals that organisations have been conceptualised from two competing metaphysical perspectives: the substantialist and the processual perspectives (Tsoukas & Chia, 2002; Chia, 1997). After clarifying the differences between the two perspectives, I demonstrate how the theoretical puzzles from the literature review are a direct consequence of a substantialist ontology. Then by consulting Ingold's (1986; 2000; 2007; 2011; 2013b) writings, I introduce his alternate 'becoming' perspective which allows us to work around these theoretical puzzles. This in turn equips us to pry open the proverbial black box which until now had concealed the dynamics of organising while innovating. Research now must answer how organising and innovating entwine as they become.

In Chapter Four, I outline my theory of method which translates the 'processual' lens introduced in Chapter Three into an empirically tractable methodological framework. This 'processual' methodological framework was deployed to investigate the dynamics of organising while innovating. The real-time field study of two new product development projects (Alpha and Theta) at a Scottish high value manufacturing firm called Peak Scientific Limited lasted for seven months. Tracking two new product development projects in real time within the same organisation allows for a genuinely open-ended and comparative yet critical understanding of organising while innovating.

Chapter Five, presents narratives from the twin field studies. These narratives describe the unfolding of organising and innovating within the two projects I tracked. By offering rich descriptions of the challenges of organising while innovating, the narratives provide anecdotal evidence required for systematic theory building (Mintzberg, 1979b).

In Chapter Six, I present findings from the systematic data analysis that I undertook. My findings reveal previously unreported aspects and suggest three process complexes of fundamental significance for the proper understanding of organising while innovating. I've called these process complexes the dynamics of preferential equivocality, dynamics of temporal scaffolding and dynamics of relational coherence. Additionally, I've also developed these concepts further by identifying their constitutive sub-processes which entwine as they unfold. The findings also demonstrate that these three process complexes shape one another. The organising challenges which emerge while innovating depended on how these three process complexes tangled or knotted as they unfolded over time.

Chapter Seven, addresses a puzzle that emerged from Chapter Six. If innovation entails persistent change then how is stability being maintained while innovating? Applying the analytical framework developed in Chapter Six to 'breakdown' episodes revealed *tensegrity* as the stabilising mechanism that regulates organising while innovating. Tensegrity demonstrates how the dynamics of preferential equivocality, temporal scaffolding and relational coherence are configured to sustain organising while innovating. I also highlight the implications of the three process complexes and the tensegrity model for the theory and practice of organising while innovating.

Chapter Eight, brings my investigation to a close by summarising the key contributions of this thesis. It highlights how the tensegrity model of organising while innovating provides an answer to my original research question, how to organise while innovating? It also highlights some promising areas for future research. Overall, this study paves way for extending 'processual' inquiry within management research.

To summarise, we have limited conceptual and empirical insights into the dynamics of the process of innovating (Crossan & Apaydin, 2010; Garud, et al., 2013). Although foregoing works have identified reasons for why an innovation occurred, they do not provide adequate insight into the processes by which organisations stabilise the dynamics that drive innovating and how these dynamics in turn triggers organising. How do organising and innovating unfold as they become? This study aims to answer this research question by examining the possibilities opened up by the juxtaposition of organising and innovating processes. By doing so, it provides a deeper theoretical understanding of how innovations are forged within the crucible of organising processes. In the chapters that follow, I build on these observations by highlighting the need to consider organising and innovating in tandem to lay the conceptual groundwork for exploring organising while innovating.

2 Re-Cording the Literature

Fish gotta swim / Bird gotta fly
Man gotta sit and say / Why why why

Thomas McEvilley (2002) in *The Shape of Ancient Thought (p. xxxii)*

2.0 Introduction

How do we organise while innovating? My goal for this review is to examine current literature on organising and innovating that address my research question. For this, my review highlights “key theoretical mechanisms” (Ahuja, et al., 2008, p. 3), or explanatory logics that bind relationships identified by management research on organising and innovating. I begin by taking stock of current approaches to innovation within organisations. This burgeoning literature can broadly be divided along two theoretical perspectives: ‘innovation as output’ and ‘innovation as process’ respectively (Crossan & Apaydin, 2010; Garud, et al., 2013). Each perspective makes significant contributions towards our understanding of innovation. I begin this review by clarifying the difference between these two theoretical perspectives.

I then divide the literature review into two parts. The first part focuses on the ‘innovation as output’ perspective. The majority of extant literature on innovation adopts this theoretical approach. Here, research focusses on identifying the necessary and sufficient conditions that serve as predictors of firm innovativeness (Ahuja, et al., 2008; Wolfe, 1994; Crossan & Apaydin, 2010; Keupp, et al., 2012). Reviewing the ‘innovation as output’ literature offers not just a historical overview of the broader intellectual currents shaping research on innovation but also allows me to identify the theoretical and practical challenges within innovation literature. This establishes the theoretical backdrop which led to the emergence and growth of the ‘innovation as process’ perspective within management research. Part two, explores the ‘innovation as process’ literature within management.

The exercise highlights how theory so far has not adequately accounted for the dynamic nature of organising while innovating. The theorising challenges for doing so along with their practical implications, which emerge from the literature review, are then articulated as four key theoretical puzzles. These puzzles remain vigorously contested within current innovation scholarship. Clarifying these puzzles is key to advancing our understanding of organising while innovating. This chapter closes by posing a crucial question which is not often asked, but might offer a solution for our puzzles. Figure 1 below, summarises the structure of this chapter.

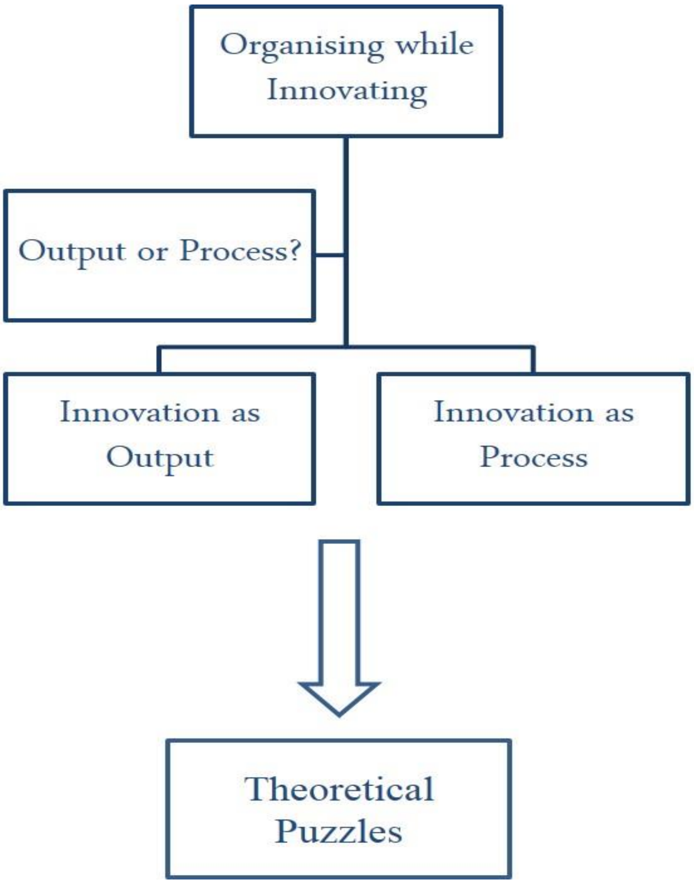


Figure 1: Structure of the Literature Review

2.1 Equivocating on Innovation: Output or Process?

The term 'innovation' has been defined by several scholars along multiple lines (Keupp, et al., 2012; Crossan & Apaydin, 2010; Ahuja, et al., 2008; Christensen, 1997; Tidd, 2001; Van de Ven, 1986; Govindarajan & Trimble, 2010; Garud, et al., 2013; Gupta, et al., 2007; Nonaka & Takeuchi, 1995) which are "notoriously ambiguous" (Adams, et al., 2006, p. 22). The definitions range from the complex: "Innovation is: production or adoption, assimilation, and exploitation of a value-added novelty in economic and social spheres; renewal and enlargement of products, services, and markets; development of new methods of production; and establishment of new management systems. It is both a process and an outcome" (Crossan & Apaydin, 2010, p. 1155), to the simple, innovation is "the production or emergence of a new idea" (Gupta, et al., 2007, p. 886). While some distinguish it along the dimensions of technology and change as either sustaining and disruptive (Christensen, 1997) or incremental and radical (Tushman & O'Reilly, 1996), others distinguish it along dimensions of learning and knowledge as either exploring or exploiting (March, 1991) and tacit or explicit (Nonaka & von Krogh, 2009; Nonaka & Takeuchi, 1995). The theoretical plurality and nuances notwithstanding, unanimous in all these definitions of innovation is 'novelty'.

A more fundamental distinction is between competing theoretical conceptualisations of 'innovation as output' and 'innovation as process'. Distinctions on whether the innovation is radical or incremental, sustaining or disruptive can only be judged when the innovation in question has been conceptualised as output. The innovation 'output', also serves as a reference while deciding, if the innovation resulted from an exploratory or exploitation process, or if it is an embodiment of tacit or explicit knowledge. The key yet often unasked questions here are, if an innovation is radical, radical with respect to what? If an innovation is disruptive, then disruptive for whom? Such conclusions are judgements in retrospect made possible by defining innovations as outputs. Innovation defined as a process has the advantage of overcoming some of these conceptual difficulties.

The process view on innovation, pioneered to a great extent by the Minnesota Innovation Research Program (MIRP) scholars (Van de Ven, et al., 1999; Garud, et al., 2013), defines innovating (rather than innovation which preoccupies majority of research) as the "invention, development, and implementation of new ideas" (Garud, et al., 2013, p. 776) by people within an organisational context. The process perspective seeks to address questions pertaining to change, growth, emergence, development or termination of an innovation within an organisation. By doing so, it creates the crucial "know-how" knowledge (Langley, et al., 2013, p. 4). This contrasts with the 'innovation as output' perspective, which focuses on understanding the antecedence and consequences of certain organisational forms or practices on innovation (Van de Ven & Huber, 1990), in effect producing "know-that" (Langley, et al., 2013, p. 4) type of knowledge. Both perspectives therefore, have different conceptual and analytical orientations. An important caveat here is that "process as a *form* of innovation outcome should not be confused with innovation viewed as a process" (Crossan & Apaydin, 2010, p. 1168). For example, Henry Ford's assembly line for producing cars might be regarded as a process innovation for the cars themselves were not new. Innovation viewed as a process would then explicitly examine the temporal sequence of activities which led to the creation of the assembly line.

Thus adopting a particular definition will have deep ontological, epistemological and methodological implications for innovation research. This suggests that bringing together the 'output' and 'process' perspectives on innovation into a single, elaborate definition, as Crossan and Apaydin (2010) do, masks these profoundly different meanings of innovation. The resulting confusion is a proliferation of innovation research where theorists speak simultaneously of the appearance of new forms *in innovation* and *of innovation as* the 'process' that creates or brings things into being. Innovation in other words is simultaneously reduced to both, a mechanism and an output. The result has been an "assembly of empirical generalizations" (Ahuja, et al., 2008, p. 4) which neither resonate with the innovator's ongoing challenges nor are general enough for practitioners to adopt.

In this thesis I have not considered research on innovation diffusion (Rogers, 1983) which tends to see innovation as "the adoption of an idea or behaviour that is new to the organization" (Hage, 1999, p. 599). Leaving out this literature was a pragmatic decision, taken to make the scope of this review more manageable. Also, this literature does not directly relate to the core question which this thesis seeks to address, which is 'how to organise while innovating?' Since diffusion, by definition, is after the innovation has been realised, the literature on innovation diffusion is therefore beyond scope of this review.

2.2 Innovation as Output

Innovation as 'output', has enjoyed a long and preeminent place within innovation literature (Crossan & Apaydin, 2010; Ahuja, et al., 2008; Keupp, et al., 2012). In this section, I shall explore some of the arguments from the innovation as output perspective which provide clues to answer 'How to organise while innovating?' This section is organised into three sub-sections. In the first sub-section, I tackle the literature on organisational structures and innovation. In particular I explore the debates on the relationship between environment and organisation structure, various organisational design configurations, the efficiency versus effectiveness dilemma while designing structures and finally the various structural mechanisms along with their limitations vis-à-vis innovation. The second sub-section provides a conceptual summary of the findings from innovation research carried out at the individual, group, industry and network levels of analysis. The third and final sub-section summarises and highlights the key insights and limitations from the 'open innovation' research paradigm. The structure of this section is summarised in Figure 2 below.

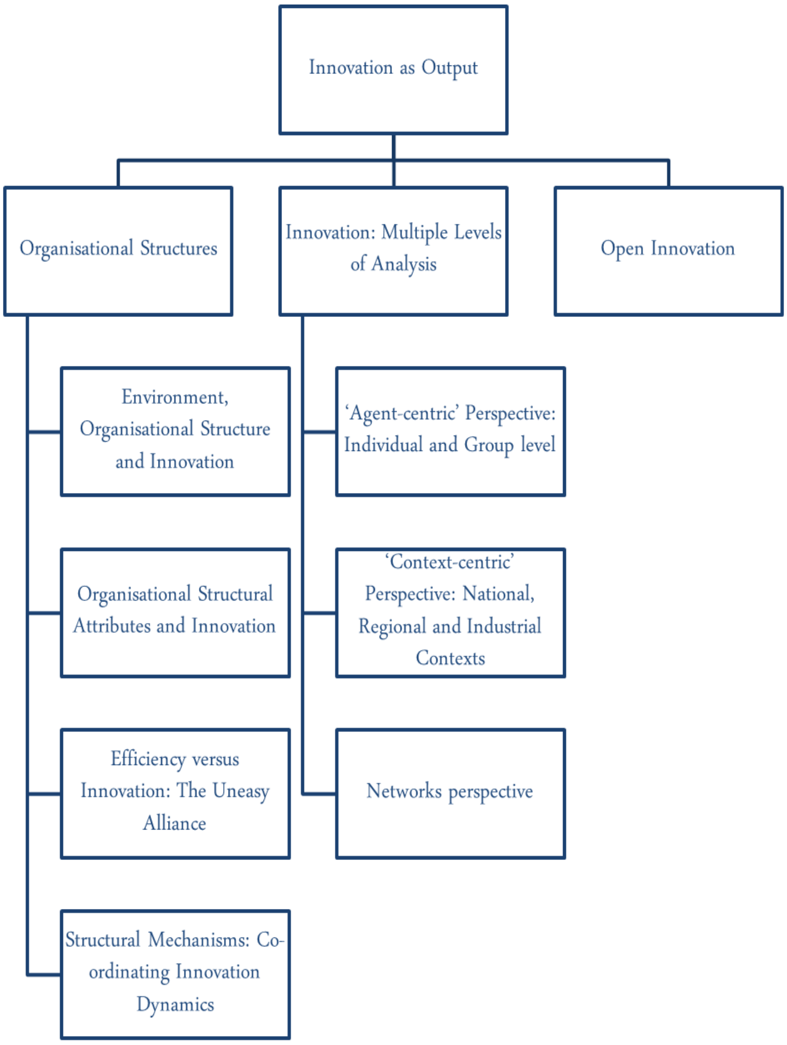


Figure 2: Structure of the literature review 'Innovation as Output' perspective

2.2.1 Organisational Structures

Organisational structuring, defined as "configurations or arrangements which enable the integration of expertise and information across organisational silos created by functions, business units and distributed company locations" (Edmondson & Nembhard, 2009, p. 125), is vital for innovation. Organisation theorists have for some time now explored various design choices about an organisation's architecture, considered "some of the most powerful strategic levers" (Gulati, et al., 2009, p. 575) available to managers, for innovation. Since existing theories suggest that the innovation capacity of teams is a function of both individual skills and the working relationship between them (Edmondson & Nembhard, 2009; Govindarajan & Trimble, 2010, p. 31), theorists have paid particular attention to the internal workings of firms in order to understand how they innovate. The remainder of this section provides a conceptual summary of the insights and limitations from this stream of research.

2.2.1.1 Environment, Organisational Structure and Innovation

The groundwork for this genre of research was laid by Burns and Stalker (1961) when they identified the 'mechanistic' and 'organic' structural archetypes which they attributed to the nature of the environments in which organisations operate. Depending on the relative stability of the commercial and technical environments, organisations adopt either a mechanistic or organic structure (Burns & Stalker, 1961). This insight was extended by the 'contingency approach' (Lawrence & Lorsch, 1967) where organisational design is seen as a "constrained optimization problem" (Van De Ven, et al., 2013, p. 400). Organisation structure results from the need to differentiate patterns of labour and integrate effort. 'Conflict resolution' is viewed as an integration mechanism (Lawrence & Lorsch, 1967).

Despite the problematic assumption of unidirectional, "well behaved" causality (Van de Ven & Poole, 2005, p. 1388) where causes for structure are seen to flow from the environment to the organisation and not vice versa, these studies are widely credited with triggering a research movement dubbed organisational innovativeness (OI) research (Wolfe, 1994). In a quest to develop predictable theories, the objective of OI research is to discover "the determinants of an organization's propensity to innovate" (Wolfe, 1994, p. 408). Scholars of innovation have frequently, yet inconclusively investigated the links between size, technology and task uncertainty, which they believe influence organisational structures (Tidd, 2001; Damanpour &

Aravind, 2006; Ahuja, et al., 2008). Also, OI research offers very little insight into the mechanisms of organising while innovating, providing no justification for why structural variables are primary determinants of organisational innovation (Wolfe, 1994, p. 409).

2.2.1.2 Organisational Structural Attributes and Innovation

So how can structural variables be integrated into explanations for how to organise while innovating? Such an exercise would require theorists to implant the variables into representational schemas of organisations. Representational schemas are archetypes of internal organisational configurations which explain the variability of the investigated variables by the impact of its effects on organisational structure. Adhocracy, proposed by Mintzberg (1980), was one such representational schema designed to solve the structural configuration required for innovation. Mintzberg distinguishes between, what he calls an 'Operating Adhocracy' and an 'Administrative Adhocracy'. In the former schema, “the administrative and operating work tends to blend into a single effort” while in the latter these “components are sharply differentiated” (p. 338) and preserved within separate structures.

Mintzberg’s schemas triggered research on structural attributes like centralization, complexity, specialization and formalization and their impact on innovation (Damanpour & Aravind, 2006; Ahuja, et al., 2008). Organisations were conceptualised as systems of interdependent choices (Siggelkow, 2001; Siggelkow, 2011). Organising while innovating was viewed as the problem of aligning internal fit: “configuration of mutually reinforcing choice of activities” with external fit: “appropriateness of those choices for the given environment in which the firm operates” (Siggelkow, 2001, p. 839). While this reconceptualization better integrates managerial action with environmental influences, the processes and mechanisms for the alignment of ‘internal’ and ‘external’ fit remain under-theorised and underexplored.

Also, research on links between structural attributes and innovation remain inconclusive and can only capture static attributes within representational schemas (Tidd, 2001, p. 173; Ahuja, et al., 2008; Crossan & Apaydin, 2010; Keupp, et al., 2012; Marion, et al., 2012). It fails to explain and account for the sheer dynamic nature of organising while innovating. The focus on forms rather than forces within such configurational approaches, as Mintzberg (1991) himself acknowledges, limits the processual quality of such explanations. It is inadequate for explaining *how the dynamic organising and innovating process unfolds* within organisational settings. This approach might at best serve as a useful starting point to deepen our inquiries but purged of the dynamics such theories reach their explanatory dead ends.

2.2.1.3 Efficiency versus Innovation: The Uneasy Alliance

Mintzberg's (1979a) research on structural attributes, however, raised an important analytical question on the 'uneasy alliance' (Clark, et al., 1985) between efficiency and innovation (Galbraith, 1982; Dougherty & Hardy, 1996; Govindarajan & Trimble, 2010). Empirical research has demonstrated that structures and strategies in mature organisations, by attempting to maintain efficiency, reinforce existing practices hostile to innovation (Burgelman & Sayles, 1986; Dougherty & Hardy, 1996). March (1991) in a seminal article characterised the efficiency versus innovation 'structuring dilemma' in organisational learning terms as one between exploration and exploitation. According to March (2008, p. 109), a strategy reliant on exploitation without exploration leads to obsolescence, whereas the alternate which relies on exploration without exploitation could be a route to elimination.

The result is a trade-off between organisational stability and organisational adaptability (Lavie, et al., 2010, p. 116). Arguing that organisations are conventionally designed to support functional excellence rather than cross-functional team effectiveness (Edmondson & Nembhard, 2009), theorists recommended separating the ongoing operations from innovation activities by creating appropriate organisational structures and functions for each unit (Galbraith, 1982, p. 6; Govindarajan & Trimble, 2010). Variations of this logic can be found in solutions like, the use of 'heavyweight teams' (Clark & Wheelwright, 1992), spin offs (Christensen, 1997, p. 121), skunkworks, corporate venture capital investments (Ahuja, et al., 2008, p. 53) and new venture divisions (Burgelman, 1985).

Yet, the empirical evidence for the efficacy of these structural mechanisms is weak. As Dougherty and Hardy (1996) highlight, in the absence of organisation wide mechanisms for integrating new products into on-going production processes, the mere existence of collaborative structures does not lead to innovations. Consequently, even separated innovation projects were vulnerable to the unintended consequences of this neglect. This might not have come as a surprise to process scholars like Van de Ven (1986) who characterises this problem as "the structural problem of managing the part-whole relationship" (p. 591).

Hence, we can see that a simple separation of the organisation units into a ‘performance engine’ and ‘innovation engine’ (Govindarajan & Trimble, 2010) does not solve the innovating problems within organisations. Often, as scholars have observed, organisational boundaries which were first drawn to facilitate the operation of existing processes, impede the creation of new processes required for innovating (Christensen & Overdorf, 2000). Therefore creating new venture divisions within organisations is far more complex than what meets the eye and requires further research on the generative dynamics of the process of innovating.

2.2.1.4 Structural Mechanisms: Co-ordinating Innovation Dynamics

Responding to calls for a more ‘dynamic’ understanding of innovating, Jelinek and Schoonhoven (1990) propose “dynamic tension”, a configuration that combines chaos and structure by mixing freedom with tight controls as a mechanism, only to find it dismissed as being “oxymoronic” and “threatening implementers with a seemingly insurmountable set of practical contradictions” (Kunda, 1997, p. 326). “Corporate culture” (Kanter, 1983) which was mooted as a mechanism is yet to come up with “a compelling theoretical explanation” (Buschgens, et al., 2013, p. 764) for how it relates to innovation.

Noting that innovating within established organisations requires structural mechanisms to both, competently build on their past as well as simultaneously define their future, O’Reilly and Tushman (2004; 2011) propose ambidexterity as a mechanism to balance efficiency with innovation. The notion of ‘ambidexterity’ is itself quite ambiguous and has been flexibly interpreted to refer to the simultaneous pursuit of “adaptability and alignment, controllability and responsiveness, innovation and efficiency and incremental and revolutionary change” (Turner & Lee-Kelley, 2013, p. 180). These differences notwithstanding, the notion of ambidexterity is synonymous with the notion of balance, either structural or behavioural (Lavie, et al., 2010, p. 132).

Research by Davis, Eisenhardt and Bingham (2009) point that organisations with too little structure are often confused and lack efficiency, while organisations with too much structure are overly constrained and therefore lack the flexibility needed to innovate. They suggest that moderate structural balances between these two states are likely to result in higher performance, offering no explanation for how this desired state might be achieved. Additionally, there is limited theorising and empirical evidence within the literature explaining how exploitation and exploration are achieved in practical, team-based operations (Lavie, et al., 2010; Turner & Lee-Kelley, 2013).

Yet, critics of the concept, like Schreyogg and Sydow (2010), are less convinced. They ask if it is "realistic to assume that certain sub-units in contemporary organizations do not have to respond to changing environments and therefore do not need to be alert, whereas others are fully adaptable and can therefore ignore any institutional constraints?" (p. 1257). Generating managerial insights would therefore require a reconciliation of the various interpretations of 'ambidexterity'. Such a reconciliation is mooted when Turner, Swart and Maylor (2013) argue for 'ambidexterity' to reflect an organisational 'capability' rather than a managerial 'activity'. Or as they put it: "Instead of being something that managers 'do', it is a way of looking at what they do" (p. 319). It is an output, in other words, of a process which remains under investigated and requires illumination.

2.2.1.5 Summary

Organisation structuring can constraint or unleash the flexibility to innovate within an organisation. However, all the theories and mechanisms reviewed offer little or no explanation for the process through which this constraint or liberation is realised. The focus on organisational structures within innovation research lacks the theoretical suppleness which can account for dynamism. Such dynamics can arise from assorted interconnected choices: choices with respect to work routines, decisions, organisational structures, capabilities, and resources in inherently uncertain conditions. Identifying the origins and nature of these dynamics, therefore became an important research agenda. Having established the subtlety and interplay between structural attributes, the environment and innovations, scholars turned to identify sources of these dynamics and understand innovation across various levels of analysis.

2.2.2 Innovation: Multiple Levels of Analysis

Inconsistent findings from research (Wolfe, 1994; Camison-Zornoza, et al., 2004) led to calls for investigating innovation at and across multiple levels within organisations (Gupta, et al., 2007). This stream can broadly be divided into 'agent-centric', 'context-centric' (Garud, et al., 2014, p. 1178) and 'networks-centric' research. An 'agent-centric' approach focusses on factors that allow individuals and their teams to successfully innovate. 'Context-centric' research investigates links between factors like national competitiveness, regional innovation clusters and networks of linkages between manufacturers, suppliers and sub-contractors, and innovation outcomes (Autio, et al., 2014; Gupta, et al., 2007). Innovation research has also attempted to bridge these perspectives across multiple levels of analysis using the network perspective on innovations. The sub sections which follow will elaborate on each of these perspectives.

2.2.2.1 'Agent-centric' Perspective

Since innovation within firms is carried out by individuals or teams, research has attempted to identify a wide range of individual or team characteristics as predictors of innovation. Identifying these characteristics, it is argued, allows firms to make decisions on how and to whom must resources be allocated to influence innovation outcomes (Conti, et al., 2014; Chatterji & Fabrizio, 2012). Prior research has highlighted individual differences, types and levels of motivation, job characteristics, and contextual influences as significant predictors of individual level innovation (Hammond, et al., 2011). Research on teams has tended to focus on either the role played by the composition and structural characteristics of teams or the relationship between task and goal interdependence in promoting innovative behaviour within organisations (Hulsheger, et al., 2009; Alexander & Van Knippenberg, 2014).

'Agent-centric' research at the individual level, has attempted to link individual differences with the creativity required to innovate by examining underlying personality traits (Unsworth, 2001), the role of intrinsic and extrinsic motivation (Amabile, 1996; Chatterji & Fabrizio, 2012; Ahuja, et al., 2008) and the role of 'self-efficacy'. Self-efficacy refers to an individual's beliefs about his or her competence with regard to his or her task or creativity abilities (Bandura, 1997). Under the rubric of job characteristics, several studies have explored links between attributes such as job complexity, autonomy, time pressure, and role requirements on innovation (Hammond, et al., 2011, p. 92; Conti, et al., 2014). Overall, such research plays an important role in identifying *what* individual level attributes are significant to innovation but fail to specify *how* these attributes combine (if at all they do) while innovating.

'Agent-centric' research at the team level, has attempted to link various team characteristics to innovation by examining the role of team diversity, nature of interdependence within teams and the need for 'psychological safety' (Hulsheger, et al., 2009). Under team diversity, prior research has investigated the impact of job-relevant diversity and background diversity within team composition as significant predictors of innovative behaviour (Amabile, 1996). Research has also identified and distinguished between task interdependence or the extent to which tasks of team members overlap, and goal interdependence which refers to the extent of overlap between the goals and rewards of various team members, as significant predictors of team level effectiveness while innovating (Hulsheger, et al., 2009, p. 1130; Alexander & Van Knippenberg, 2014). Finally, since innovating involves the completion of difficult tasks in uncertain, complex environment, research has identified the need for 'psychological safety' (Edmondson, 1999) within intragroup decision making as a key predictor of innovation success. However, team centric studies can identify only "stable and powerful agents of innovation at the team level" (Hulsheger, et al., 2009, p. 1129) and provide scant insight into the dynamics of the process of innovating.

Agent-centric research suffers from several limitations. First, despite findings showing that compound traits are better predictors of innovation than single traits, such studies continue to investigate traits in a "one at a time" fashion (Hammond, et al., 2011, p. 102)**,** ignoring composite complexities which might arise due to the interaction of such traits (Camison-Zornoza, et al., 2004). Second, these studies generally rely on self-reported measures which make it difficult to understand the biases associated with the different data sources. Thus, the relation between attributes and innovation, regardless of how they are measured, is a particularly difficult problem to solve (Adams, et al., 2006). Third, although organisational innovation is a complex non-linear process (Van de Ven, et al., 1999; Dooley & Van De Ven, 1999), agent-centric studies continue to parse their variables assuming a linear logic (Hulsheger, et al., 2009; Hammond, et al., 2011). As a result, such studies cannot address questions about the validity and significance of predictors at various stages within the innovation process. Finally, such theories ignore or under theorise the role of contexts (Autio, et al., 2014; Garud, et al., 2014) by attributing the inconsistencies in their findings to contexts within which such innovating takes place.

Overall, agent-centric theories throw little light on the situational complexities associated with innovating (Camison-Zornoza, et al., 2004; Hulsheger, et al., 2009; Hammond, et al., 2011). This lack of actionable insight highlighted the need to factor the contingent role of contexts and its "potential curvilinear effects within innovation processes and outcomes" (Hulsheger, et al., 2009, p. 1141).

2.2.2.2 'Context-centric' Perspective

In contrast to the 'agent-centric' perspectives which are concerned with 'micro' level attributes as predictors of innovation, 'context-centric' perspectives tend to offer macro level insights into the role played by industrial, national and regional contexts in inducing or sustaining innovation (Garud, et al., 2014). Since inventors within organisations do not operate in a vacuum, such research focuses not so much on the organising processes while innovating but rather on the interplay between the structural dynamics of industries and how these link to the emergence and diffusion of innovations (Gupta, et al., 2007).

Studies at the national level tends to focus on the differing abilities of various nations to sustain innovation by identifying input factors such as role of government, strong venture capital networks, skilled R&D manpower and drivers of R&D productivity (Porter, 1990). The success of Israel's high tech industry (Drori, et al., 2013) and the 'techno-paradigm' responsible for Japan's technological edge in the early 1980s (Kodama, 1995) are fine examples of innovation studies at the national level. Scholars have also explored the role of Regional Innovation Systems (RIS) on firm innovativeness and technology path development by examining the systemic interaction between organisations, regional institutions, universities and R&D centres which impact the exploration and diffusion of knowledge required for innovating (Cooke, et al., 2011).

At the industrial level, the theoretical explanations underlying a 'context-centric' approach normally concentrate on the different innovation possibilities afforded by different contexts. These possibilities, it is argued, shape the technological and entrepreneurial trajectories of various innovations thereby calling into question, the "regulating influence of context on innovative activity" (Autio, et al., 2014, p. 1098). Further, the under theorised relationships between environmental contingencies, organisation configurations and performance warrant a better characterisation of 'contexts' which affect the opportunity for and constraints on innovation (Tidd, 2001). Ring and Van de Ven's (1994) framework explaining the development of inter-organisational relationships during innovation and Garud and Rappa's (1994) socio-cognitive framework explaining how technological evolution unfolds at the industry level serve as illustrative examples.

Overall, context-centric approaches challenge the ‘linear’ conceptualisation of innovation adopted by ‘agent-centric’ scholars by highlighting “the non-linear character and the contextually embedded nature of innovation processes” (Autio, et al., 2014, p. 1099). But such macro-level theories tend to over emphasise structure at the expense of agency, and consequently, provide insufficient insight into the dynamics of the process of innovating. The macro focus limits the conception of innovation, to patentable technological innovation (Ahuja, et al., 2008). Therefore, it cannot provide sufficient insights into the drivers of change while innovating or on the mechanisms that can explain the evolution and growth of innovations over time (Autio, et al., 2014; Gupta, et al., 2007).

2.2.2.3 Networks Perspective

While ‘agent-centric’ and ‘context-centric’ theories have highlighted the importance of individual effort and contexts, both approaches fail to capture the non-linear dynamics and complexities of innovating which tend to spill across multiple levels of analysis (Garud, et al., 2014; Gupta, et al., 2007). Since organizational networks span multiple levels of analysis, embracing a ‘networks perspective’ was viewed as key to understanding organising while innovating (Kilduff & Brass, 2010; Zaheer, et al., 2010; Ahuja, et al., 2012). According to this perspective, organisational networks are defined as a set of nodes representing connections and relationships (or lack of relationships) between individuals or higher level collectives like organisations or organisational units (Ahuja, et al., 2012, p. 434; Phelps, et al., 2012, p. 1117). The networks perspective could therefore investigate organisational arrangements like partnerships, cooperative arrangements, joint ventures, strategic alliances, collaborative arrangements, coalitions and consortia, through which organisations access the resources and capabilities required to innovate (Provan, et al., 2007, pp. 480-481; Zaheer, et al., 2010; Ahuja, et al., 2012).

There are two broad streams of research within the ‘networks perspective’, the relatively well developed ‘social capital’ research stream and the under developed ‘network development’ research stream (Carpenter, et al., 2012, p. 1329; Ahuja, et al., 2012). Social capital network research has primarily examined the influence of structural and relational properties of networks on knowledge creation and transfer while innovating, across multiple levels (Phelps, et al., 2012; Carpenter, et al., 2012). Networks are seen as conduits which generate and convey social capital that enable accessing resources, fostering and managing trust, exercising power and controlling, transmitting or receiving market signals while innovating (Zaheer, et al., 2010, p. 65; Ahuja, et al., 2012, p. 435). Research therefore focuses on using network constructs to serve as predictors of innovation by focussing on identifying "the outcomes and consequences of networks for actors and explaining the underlying mechanisms of these network outcomes" (Carpenter, et al., 2012, p. 1329). Specifically, it has investigated the effects of inter-firm collaboration on innovation performance, the effects of alliance network structures on firm innovation and the impact of network involvement on organisational learning and innovation, to suggest that networked firms profit from information benefits that accrue in the form of access, timing and referrals, while innovating (Ahuja, et al., 2008; Provan, et al., 2007; Kilduff & Brass, 2010; Phelps, et al., 2012).

However, the social capital perspective on networks research suffers from three limitations. First, it assumes networks and their features as given prior to innovation. Therefore, such research tends to focus on 'networked organisations' and not on 'network organising' (Meyer, et al., 2005, p. 468). Due to its static orientation, it offers few (if any) managerial insights into the network forming processes underway while innovating (Zaheer, et al., 2010; Ahuja, et al., 2012). Second, such research has a penchant for conflating information with knowledge that obscures the mechanisms and "knowledge composition activities of network members" (Phelps, et al., 2012, p. 1143) through which information is actually translated into the knowledge required for innovating. Third, the majority of social capital network studies rely on cross-sectional data. Such data is inappropriate for assessing several assumptions which underwrite network studies, the most fundamental of which is that structure drives firm behaviour or performance (Zaheer, et al., 2010).

These limitations leave yawning gaps about network dynamics, origins and evolution of various network types and their orchestration and governance mechanisms (Ahuja, et al., 2012; Phelps, et al., 2012; Provan, et al., 2007). This need to better understand and explain the organising dynamics of networks has led to the mushrooming of the 'networks development' perspective in organisational network research. Network development research is concerned with questions relating to how agents create and shape network structures that benefit themselves by "recognizing the patterns and determinants of network formation and change" (Carpenter, et al., 2012, p. 1330; Ahuja, et al., 2012). Though nascent, the 'networks development' perspective thus far has highlighted several network characteristics like the potential path-dependent nature of network evolution (Schreyögg & Sydow, 2011), coevolutionary processes which lead to the establishment of industry technology standards among competing technology networks (van den Ende, et al., 2012) and the dilemmas which face network orchestrators as they simultaneously attempt to establish and maintain the legitimacy of the network's activities with a wide audience, while also attracting potential members who will create ties (dubbed the "blind dates" versus "arranged marriages" dilemma) (Paquin & Howard-Grenville, 2013).

However, this perspective, though promising remains conceptually, theoretically, methodologically and empirically underdeveloped (Ahuja, et al., 2012; Carpenter, et al., 2012). These shortcomings have led to calls for furthering longitudinal studies within networks research by according priority to the temporal dynamics of network evolution (Ahuja, et al., 2012).

2.2.2.4 Summary

In this section I have analysed literature which explores innovation across multiple levels of analysis. In particular, I've scrutinised research from the 'agent-centric', 'context-centric' and 'networks' perspectives. Despite several organising insights, these studies tend to be unreliable predictors of innovation. This suggests that there is a need for conceptual and theoretical advances to be made before we can understand organising while innovating. Two conceptual limitations of this approach are salient. The first relates to the question of scale, while the second concerns assumptions linking contexts with action (Hoholm & Araujo, 2011).

First, to assume that contexts sediment in advance into multiple levels prior to innovating assumes, as Hernes (2008) rightly points, "…the question of scale in advance" (p. 74). This imposes restrictions on observing and understanding *how* connections, ties and associations between heterogeneous actors are made (Hoholm & Araujo, 2011). Put differently, if one were to follow the evolving practice of innovating, rather than study evolved networks which produced innovation, then distinctions such as micro and macro, 'agent-centric' and 'context-centric' levels are no longer relevant as analytical concepts. "Context", as Hoholm and Araujo (2011) write "if anything, becomes an empirical question on how the actors draw boundaries and 'frame' their activities" (p. 934). Second, focusing on levels, implies turning away from activities which trigger the dynamics that ripple across the various levels of analysis. Therefore, starting from observable practices rather than from assumed contexts, serves to better illuminate organisational dynamics.

2.2.3 Open Innovation

Research on innovation at and across multiple levels of analysis has highlighted how agents, contexts and the network of existing industry relationships allow firms to not just utilise these networks as an external source of innovations, but also employ them to promote their own internally and externally sourced innovations (Vanhaverbeke, 2006; Dahlander & Gann, 2010; Chesbrough, 2006). The Open Innovation paradigm, first proposed by Chesbrough (2003), therefore became "the umbrella that encompasses, connects, and integrates a range of already existing activities in innovation literature" (Huizingh, 2011, p. 3). Open innovation in a recently updated definition refers to "a distributed innovation process based on purposively managed knowledge flows across organizational boundaries, using pecuniary and non-pecuniary mechanisms in line with the organization's business model" (West, et al., 2014, p. 806).

The three theoretical perspectives which inform current research on Open Innovation include the role of 'lead users' in innovation generation (von Hippel, 1988; von Hippel, 2007), the 'profiting from innovation framework' (Teece, 1986) and the role of business models in innovation (West, et al., 2014). By combining these perspectives, the Open Innovation paradigm urges managers to span organisational boundaries in both the creation and commercialization of innovations. This shift in the dominant logic of R&D, away from 'internal discovery' toward 'external engagement' (West, et al., 2014, p. 805), has been demonstrated by studying, among others, Procter & Gamble's "Connect and Develop" program (Huston & Sakkab, 2006) and open innovation initiatives at Italcementi, an Italian cement manufacturer (Chiaroni, et al., 2011).

Such studies have highlighted how networks, organisational structures, evaluation processes and knowledge management systems complement traditional R&D practices and serve as key managerial levers for implementing open innovation. Studies have also identified that open innovation strategies require firms to confront a trade-off between the costs and benefits of obtaining innovation from external sources by aligning search breadth and search depth (Laursen & Salter, 2006). In light of these findings, the single largest body of research on open innovation has investigated the relationship between ‘absorptive capacity’ (Cohen & Levinthal, 1990) and open innovation (West & Bogers, 2014).

Absorptive capacity, was coined by Cohen and Levinthal (1990) to explain the ‘spill-over’ benefits of high investments in R&D which not just increases the likelihood of internal innovation but also increases the organisation’s ability and internal capability to track and evaluate R&D developments outside its boundaries. Open Innovation research has therefore probed the effects of a firm’s internal R&D capabilities on its ability to utilise external knowledge. Insights from this line of inquiry are summarised by the following two hypotheses:

> I. Firms with high absorptive capacity will be more likely to use innovations from external sources, or
> II. Firms will be more successful in such use.
>
> (West & Bogers, 2014, p. 821)

Though imprecise, measures like R&D intensity, total R&D expenditure or proportion of employees with graduate education or a scientific-technical graduate education have been used to quantify ‘absorptive capacity’ (West & Bogers, 2014). The main contribution of these insights are that they challenge and discredit misplaced assumptions about open innovation, particularly claims made by scholars like Christensen (2006) who suggest that in an open innovation world, firms would be better off shifting their focus from developing deep technological competencies, to instead shore up their integrative competencies required to integrate externally sourced innovation. Open innovation, in other words, complements internal R&D but can never, as its proponents would like, replace or substitute it.

However, the open innovation perspective too has several limitations, most of which are not uncommon to the ‘innovation as output’ research tradition. First, critics of the paradigm have questioned the very premise of ‘openness’ attributed to the paradigm. They argue that innovation has always been an open process since time immemorial and that the extent of ‘openness’ or ‘closeness’ are of degree rather than kind (Huizingh, 2011; Dahlander & Gann, 2010). Second, open innovation research has front loaded research examining the leveraging process for obtaining innovations from external sources and neglected research relating to the integration and commercialisation of these innovations (Lichtenthaler, 2011; West & Bogers, 2014). Therefore, we still know very little about how open innovation captures value from external innovation sources (West & Bogers, 2014, p. 825).

Third, Chesbrough’s (2003) original open innovation model along with other open innovation models (Fetterhoff & Voelkel, 2006; Wallin & von Krogh, 2010) present or (mis)represent the process of innovating as a stylized, sequential, stage model which follows a linear unidirectional path (e.g. Bianchi, et al., 2011). This does not capture reverse flows, bidirectional interactions, and other paths along which innovating unfolds and hence does not shed light on how and why firms implement open innovation. According to Huizingh (2011),

> "Two open innovation processes are relevant. First, the process that leads to open innovation, this is the process of opening up innovation practices that formerly were (more) closed. The second process refers to the practices of open innovation: how to do open innovation?" (p. 6).

"What is missing", as he notes, "is a decent cookbook, an integrated framework that helps managers to decide when and how to deploy which open innovation practices" (p. 7).

Lastly, to date, most open innovation research has tended to focus on the level of the firm, with very little attention directed toward project teams that implement the innovation within organisations. As a result, we still know very little about the organisational implications of this emerging paradigm. Prior research has suggested that being involved in open innovation can create tensions with other practices within the organisation (Dahlander & Gann, 2010, p. 707). This suggests that the challenges managers face in organising for open innovation, impacts functions of the firm beyond R&D, requiring managers to align open innovation with existing operations (West, et al., 2014).

To summarise, there exists a paucity of contributions that investigate how firms organise themselves and modify their management practices to ease the implementation of innovation. Current limitations within open innovation research suggest the need for research to go beyond the ''content'' of the open innovation process (Bianchi, et al., 2011, p. 32; Pettigrew, 1990). While such studies provide insight into the organisational modes used to implement open innovation, they remain mute on crucial theoretical and practical questions about the "context" and "process" (Pettigrew, 1990, p. 268) of organising while innovating.

2.2.4 Summary: Innovation as Output

Overall, under the rubric of 'innovation as output', I have considered various theoretical explanations offered by the current literature on innovation to evaluate the extent to which it offers guidance on organising while innovating. My review suggests that the 'innovation as output' literature has done an admirable job of identifying various structural solutions and their theoretical links. However, it also demonstrates that simplistic interpretations of the relationship between various variables, mechanisms and firm innovativeness continue to remain inconclusive (Ahuja, et al., 2008; Keupp, et al., 2012). Whilst acknowledging the complexity and uncertainty associated with the dynamics of innovating, these studies have failed to provide an adequate understanding of how to organise while innovating.

The inability of the 'innovation as output' perspective to offer insights into organisational dynamics is widely attributed to the methodological privilege it accords to "the ubiquitous single-snapshot technique" (Avital, 2000, p. 666). Innovations are reduced to an instant output, an independent variable, which absolves theorists from theorising the emergent and situational features of organising while innovating, allowing them to speculate freely over which dependent variables require integration with the theoretical framework to explain innovation outcomes. Such an approach, as Pettigrew (1985) rightly points, can at best throw light on "the intricacies of particular changes" while innovating, leaving the "dynamics of changing" unexplained (p. 60).

By relying largely on proxy measures and cross-sectional data, the 'innovation as output' perspective has been "adroit at providing an image of dynamics while supressing processes" (Pettigrew, et al., 2001, p. 699). The resulting "acontextual, aprocessual and ahistorical" (Pettigrew, 2012, p. 1307) insights are therefore devoid of the theoretical sensitivity required to explicate the complex, context sensitive organisational dynamics inherent while innovating. Since such an understanding is vital, the 'innovation as process' perspective was embraced, triggering a 'process theory' movement within innovation research (Wolfe, 1994). Here, the theoretical focus shifted from *innovation and organisations* to '*innovation-in-organisations'* (Downs & Mohr, 1976).

2.3 Variance versus Process Theories

The inconclusive findings from the 'innovation as output' perspective highlighted the need for a more dynamic understanding of organising in general and innovating in particular. Such a need arose with the advent of behavioural theories (Cyert & March, 1992/1963). Encouraged by theories investigating the dynamics of "decision making" (Cohen, et al., 1972) and strategic change (Mintzberg, 1972; Pettigrew, 1973; Mintzberg, 1978), scholars began acknowledging the need for greater conceptual, theoretical and empirical clarity on the indissoluble links between structures and processes. Weick (1979) in a seminal contribution reframed the debate on dynamics from organisations as nouns to organising as verbs. This focus on how organising is accomplished, led Mohr (1982) to make a distinction between variance and process theories which triggered the ‘process’ movement within management research.

Variance theories cast explanations in terms of causal links between dependent and independent variables whereas process theories explain a phenomenon by demonstrating how a sequence of events unfolding over time produces a given outcome. Theorists committed to the variance approach seek to provide general, context-independent, theoretical explanations by developing and testing reliable and valid measures for variables. Grounded in the general linear model that underlies most common linear statistical methods (Poole & Van de Ven, 2010, p. 546), variance theories are ill equipped to deal with non-linear dynamics. The explanatory “mechanism” in variance theory is simply a regression co-efficient linking dependent and independent variables. This regression coefficient, assuming the model includes all relevant variables, is supposed to describe the causal influence of the input upon the output. This however, is based on the somewhat dubious assumption that the underlying causal process that generates outcomes, operates continuously over time (Poole, et al., 2000, p. 31). Causal linkage, in other words, is always assumed rather than demonstrated.

According to Poole, Van de Ven, Dooley and Holmes (2000, pp. 31-35), seven assumptions underpin variance theories. One, the social world is made up of fixed entities with varying attributes. Entities here are assumed to maintain a unitary identity through time. The variable attributes of these entities which reflect significant changes in the entity are assumed to be fixed. Two, establishing necessary and sufficient causality provides the basis for explanation. Since features of entities (e.g organisations) are distinct and independent of process or context, it is possible for variance theorists to theoretically identify necessary and sufficient conditions which underpin causal explanations (Steyaert, 2007). Three, these causal explanations utilise efficient or “push type” (Mohr, 1982, p. 40) causality. Mohr explains,

> “ An efficient cause is a force that is conceived as acting on a unit of analysis (person, organisation, and so on) to make it what it is in terms of the outcome variable (morale, effectiveness, and so on) or change it from what it was. It may be thought of as a push-type causality” (p. 40).

Four, the quality of explanations is to be judged based on generality, which is their ability to apply uniformly across a wide range of contexts. Accuracy and simplicity of the theory acquire secondary status in the theorising process. Five, the role of time is expunged from the causal logic, for the temporal sequence in which independent variables are triggered is inconsequential here. Six, explanations emphasise immediate causation meaning "at each point in time, the variables in the model contain all the information needed to estimate their values at the next point in time" (2000, p. 35). Change, therefore is explained as either a deterministic or a stochastic process. And finally, seven, the causal meaning of the attributes remains invariant over time. This point follows from assumptions one, five and six.

Process theories by contrast, treat the *nature of the process* as their central analytical focus. Questions addressed by process theories are typically about "*how and why things emerge, develop, grow or terminate over time*" (Langley, et al., 2013, p. 1; Langley, 1999). Unlike variance theory where variables rather than actors do the acting (Abbott, 1992), process theories explain "outcomes as the result of the order in which the events unfold and of particular conjunctions of events and contextual conditions" (Poole, et al., 2000, p. 36). The analytical distinction between the variance approach and the process approach was further sharpened by Van de Ven, when he clarified the differences between the three commonly prevalent meanings of the term 'process', in organisational theory.

According to Van de Ven (1992), the variance theory approach views 'process' as either "a logic that explains a causal relationship between independent and dependent variables", or as "a category of concepts or variables that refers to actions of individuals or organizations". In contrast, within process theory, 'process' refers to "a sequence of events that describes how things change over time" (p. 169). Now since the process theory approach by definition is context specific, temporal and historically contingent, research adopting this approach has the potential to identify and explain the 'generative mechanisms' (Tsoukas, 1989; Hedström & Swedberg, 1998) shaping the organisational phenomena being investigated.

To summarise, from the above discussion it becomes clear that the 'innovation as output' perspective seeks to generate a variance theory with the implicit goal of establishing the conditions necessary and sufficient to bring about an innovation. Such theories can at best provide causal summaries rather than explanations for the phenomena under investigation (Boudon, 1979, pp. 51-52). Put differently, it fails to specify the social "cogs and wheels" that have brought causal relationships which explain a phenomenon into existence (Hedström & Swedberg, 1998, p. 7). Nor does it illuminate how these relationships evolve over time. The 'innovation as output' perspective, therefore fails to sufficiently account for the dynamics of organising while innovating. Since my research question seeks to explicate the links between organising and innovating as it unfolds over time, this makes the variance approach inflexible and ill-suited for the proposed research question. Process theories which accommodate temporal dynamics into explanations must therefore be explored.

2.4 Innovation as Process

The 'innovation as process' perspective explores theories of both the 'variance' theory and the 'process' theory varieties. Within the variance theory mould, it summarises the contribution and limitations of literature on complexity theories within innovation research. Among process theories, it reviews the contributions and limitations of the literature on 'practice', 'routines' and 'innovation journeys' perspectives for organising and innovating. Specifically, within 'innovation journeys', I explore the literature on Internal Corporate Venturing (ICV), the Minnesota Innovation Research Program (MIRP) and the Narrative perspectives. However, before discussing these, it is important to briefly touch upon organisational change theories. Since dynamics implies change, developing a process theory on innovation require theorists to assume a change theory. Therefore, after providing a brief overview of the predominant theories on change, I shall resume my inquiry into organising while innovating. The structure of this section is summarised in Figure 3 below.

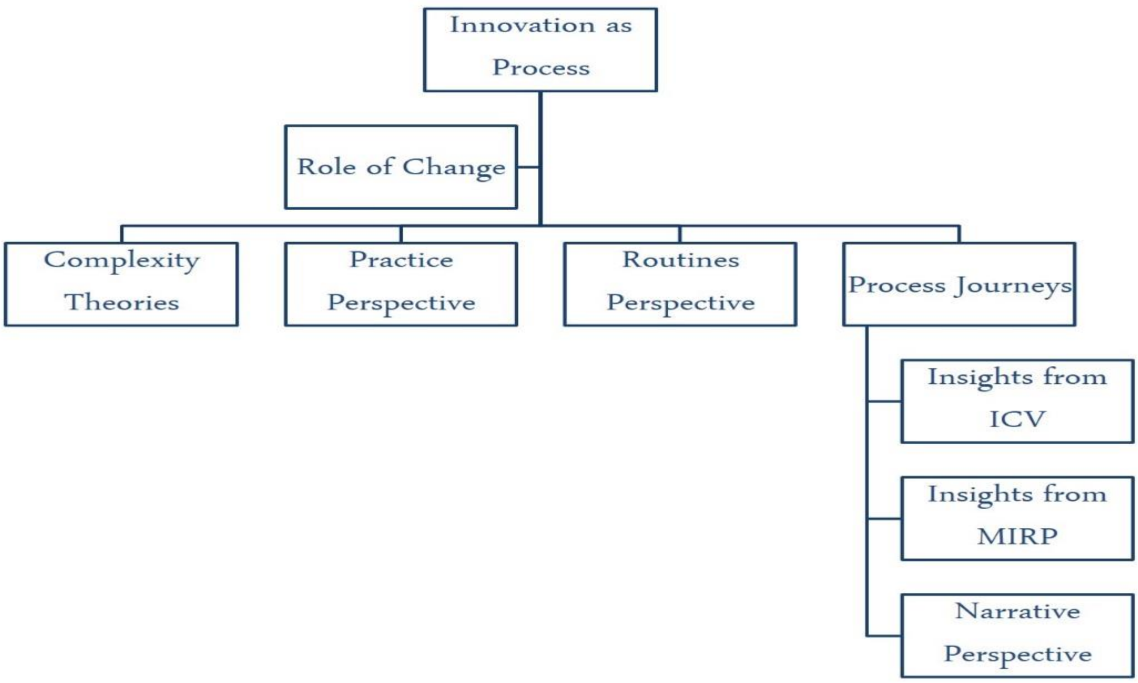


Figure 3: Structure of the literature review for the 'Innovation as Process' perspective

2.4.1 Change and Organisational Dynamics

Since innovating involves change, by and large there is consensus that managing change complexities should be a core organisational competence while innovating (Burnes, 2005; Van de Ven & Sun, 2011). Research on change can broadly be divided into two dominant approaches: planned and emergent (Pettigrew, 1985; Mintzberg & Waters, 1985; Burgelman & Sayles, 1986; Pettigrew, et al., 2001; Burnes, 2005; Van de Ven & Sun, 2011). Early process models on innovation were underpinned by planned change theories like Lewin's (1947) "unfreezing-moving-refreezing" theory. It divided the process of innovating sequentially into various distinct, identifiable, linear stages (Rogers, 1983). This reduced a complex nonlinear process with multiple feedback and feed forward loops into static states. The simple prescriptive rules offered by planned change theories failed to sufficiently resonate with what actually unfolds during the change process (Pettigrew, 1985; Wolfe, 1994).

Research by Mintzberg and Waters (1985) observed that the actual implementation of the change process differed substantially from how it was originally planned to unfold. Similarly, Burgelman's (1983b) study of the internal corporate venturing (ICV) process uncovered, what he calls, 'induced' (planned) strategy and 'autonomous' (unplanned) strategy interacting to influence the observed outcomes (1983c, p. 1350). In light of these findings, an 'emergent' approach to change research was proposed to complement 'planned change'.

While the planned approach entails an 'action strategy' where the role of a change agent is to "intervene in and control a change initiative by diagnosing and correcting difficulties that prevent the change process from unfolding as the change agent thinks it should" (Van de Ven & Sun, 2011, p. 58; Bartunek, et al., 2011) the emergent approach requires change agents to also reflect and revise their change models "to one that better fits the process of change unfolding in the organization" (Van de Ven & Sun, 2011, p. 59). Hence, this approach is also referred to as the 'reflection' strategy. While the former captures the linear dynamics of the change process, the latter approach is better equipped to capture and explain non-linear change dynamics.

Further, the 'action strategy' explains change by emphasising strategic choices that allow organisations to adapt to "environmental changes by restructuring themselves in an intentional, rational manner" (Stacey, 1995, p. 477). The 'reflection strategy' explains change through either one or a combination of four basic change 'motors': life cycle, evolutionary, dialectic and teleological (Van de Ven & Poole, 1995). Breakdowns, refer to the "perceived discrepancies or gaps between the change processes we observe in an organization and our mental model of how the change process should unfold" (Van de Ven & Sun, 2011, p. 58). Nonlinear dynamics are attributed to either disrupting jolts, continuously unfolding step functions or recurring cycles of oscillations within change theories (Meyer, et al., 2005, p. 457).

These assumptions regarding nonlinear change dynamics underpin various 'innovation as process' perspectives. For instance, according to the (neo)-Darwinian evolutionary theories (e.g. Burgelman, 1991), incremental change accumulates to produce jolts of variation which explains 'variation-selection-retention' or its variant 'enactment-selection-retention' (Weick, 1979; Weick, et al., 2005, p. 414). Jolts also underpin explanations for the punctuated equilibrium model (Tushman & Romanelli, 1985; Gersick, 1991; Romanelli & Tushman, 1994) which was introduced to distinguish between revolutionary and evolutionary change (Abernathy & Utterback, 1982; Greenwood & Hinings, 1996). Hence long periods of stability are punctuated by jolts of change. The innovation process theories developed from the Minnesota Innovation Research Program (MIRP) (refer to section 2.4.5.2) were informed by the punctuated equilibrium model (Garud, et al., 2013).

By contrast, step functions and oscillations inform the continuous transformation model of change (Burnes, 2005; Brown & Eisenhardt, 1997), which underpins complexity theories. Proponents of this model, reject both the incrementalist and punctuated equilibrium models by arguing that, in order to survive, organizations must develop the ability to change themselves continuously in a fundamental manner (Burnes, 2005, p. 76). The source of change for them is neither in stability or instability but rather at the 'edge of chaos' (Stacey, 1995, p. 495). The '*edge of chaos*' refers to a zone of emergent complexity and marks a state, perpetually on the verge of instability (Boisot & Mckelvey, 2010, p. 422; Siggelkow, 2002; Siggelkow, 2011).

In addition to the incrementalist, punctuated equilibrium and continuous transformation model of change, the 'practice' (Dougherty, 1992; Dougherty, 2001; Dougherty, 2008; Dougherty & Dunne, 2011) and 'routines' (Feldman & Pentland, 2003; Parmigiani & Howard-Grenville, 2011; Friesl & Larty, 2013) theorists use a 'duality' model of stability and change (Farjoun, 2010) to explain the dynamics of the innovating process. Farjoun (2010) explains 'duality' as follows:

> "I use it (duality) to denote the twofold character of an object of study without separation. Duality resembles dualism in that it retains the idea of two essential elements, but it views them as interdependent, rather than separate and opposed. Consistent with duality, I maintain that stability and change are fundamentally interdependent both contradictory and complementary" (p. 203).

Yet Farjoun's notion of duality which has been embraced by several practice and routines theorists (Feldman & Orlikowski, 2011) appears to be, to paraphrase Dewey, "two monisms stuck loosely together, so that all the difficulties in monism are in it multiplied by two" (Dewey, 1917). Simpson and Lorino (2016) have questioned this understanding of duality. For them dualities are two alternate ways of being in and knowing about the world, ways which like oil and water, cannot be blended. This suggests that Farjoun's notion of duality is therefore logically untenable. All these diverse perspectives on change therefore, as we shall discover in the sections which follow, have at best offered "*synoptic accounts"* (Tsoukas & Chia, 2002, p. 570) of the dynamics of the change process while innovating.

Such accounts, as Tsoukas and Chia rightly point out, have "been useful insofar as they have provided us with snapshots of key dimensions of organisations at different points in time, along with explanations of the trajectories that organisations followed" (p. 750). Gaining new insights would therefore require a fresh re-conceptualisation of change. At this stage, however, any further discussion on this issue would be tantamount to trespassing the 'innovation as process' themes which follow. I shall revisit these arguments in Chapter 3 after closely examining the theoretical and empirical contributions and limitations of current 'innovation as process' research.

2.4.2 Complexity Theories and Innovating

Several organisation and innovation theorists have embraced complexity theories to understand the fundamental logical properties that govern nonlinear processes (Meyer, et al., 2005; McCarthy, et al., 2006). Understanding organisational dynamics, they argue, requires theorists to re-examine several traditional assumptions which underpin their theories. Such assumptions eschew the messy interacting complexities that constitute organisational behaviour by privileging equilibrium over disequilibrium, stability over dynamics, and incremental change over discontinuous change (Meyer, et al., 2005). Complexity theories, therefore study how self-organising systems emerge from multiple elements which interact in complex ways (Frenken, 2006; Lansing, 2003). It argues that systems which are “innovative, creative, and changeable” (Stacey, 1995, p. 490) are far from equilibrium and it is this disorder, irregularity, and difference that allows such systems to change.

Though several theories, ideas and research programs have been brought under the ‘complexity theory’ umbrella, chaos theory (Lorenz, 1993), dissipative structures theory (Prigogine, 1996); and the theory of complex adaptive systems (CAS) (Kauffman, 1993), are the three most prominent theories. The fundamental difference between these three theories is that while the first two theories operate on whole systems and populations by seeking to construct mathematical models of systems at the macro level, CAS theories attempt to model the same phenomena by using an agent based simulation or a bottom-up approach (Burnes, 2005, p. 79; Stacey, 1995). Innovation from a complexity theory perspective is viewed either as a “complex combinatorial optimisation problem” or as “complex interaction structures between agents” problems (Frenken, 2006, p. 139). This latter perspective has been extensively used in organisation theory as ‘fitness landscape’ (N-K) models (Levinthal, 1997; Siggelkow, 2001; Siggelkow & Levinthal, 2003; Siggelkow & Rivkin, 2006). These theories evaluate the trade-offs between search benefits and search costs of different search strategies deployed while innovating.

However, such modelling approaches create variance theories. Theoretical outputs from these models represent ‘state description’ or ‘blueprints’ (Anderson, 1999) rather than ‘recipes’ (Simon, 1962). Blueprints encapsulate the structural logic of a phenomenon by capturing its salient complexity, while recipes capture sequences of specific activities to create *know how* knowledge. Hence, complexity theories which rely on mathematical modelling are not pursued further here as they fail to sufficiently account for the ‘real-world’ dynamics of organising while innovating. (Interested readers could refer to the writings of Stacey (2003; 1995), Anderson (1999), Lansing (2003), Burnes (2005), Boisot and Mckelvey (2010) for excellent reviews on the contributions and limitations of complexity science).

In an attempt to put real world ‘facts’ into complexity science, Brown and Eisenhardt (1997) applied the CAS perspective to understand the organisational challenges of innovating. They identified extensive use of improvised ‘semi-structures’ that combine elements of both flexibility and change as key to success. These “hybrid” organizational forms, they argue, when combined with extensive cross-project communication, explain how organisations organise while innovating. Using the ‘edge of chaos’ argument, Eisenhardt and Brown (1999) provide further justification for ‘semi-structures’ by arguing that “too rigid an organizational structure will create obstructions, whereas too loose a structure will create chaos” (p. 80). Unlike ambidexterity (Tushman & O'Reilly, 1996), which highlights separation between organisational units, semi-structures, according to Eisenhardt and colleagues (2010, p. 1264), emphasize simultaneity by embracing both efficiency and flexibility which makes it better suited to explain innovation.

Nevertheless, ‘semi-structures’, which are strikingly similar to the notion of ‘dynamic tension’ (Jelinek & Schoonhoven, 1990), fall short of fully incorporating the role of the agent or investigating how organisational processes transform inputs into outputs (Crossan & Apaydin, 2010). The actual processes through which these ‘semi-structures’ can be created still remain unspecified. Since Brown and Eisenhardt focus on successful and less successful innovations, which are by definition after the fact, they have little to tell about processes leading to these outcomes. Besides a reference to ‘links in time’ (Brown & Eisenhardt, 1997, p. 3), their work is “practically devoid of temporal dynamics” (Pettigrew, 2012, p. 1322) required to understand process. It fails to sufficiently acknowledge the temporal complexities associated with the “connective, dynamic, turbulent, and fuzzy aspects” (McCarthy, et al., 2006, p. 440) of the process of innovating.

In order to overcome some of these limitations Eisenhardt (2010) and her colleagues advocate a ‘micro-foundation’ based approach where “heuristics-based processes, simplification cycling, and flexibility-injecting structures” (p. 1265), serve as mechanisms for maintaining disequilibrium and simple order-generating rules. Davis and Eisenhardt (2011) have further extended this framework by exploring processes that allow technology collaborations to create innovations. They identify three primary mechanisms that they claim underlie successful innovation in collaborative contexts: marshalling complementary capabilities from partners, conducting deep and broad search for innovations with a common technological trajectory, and mobilizing diverse participants from the boundary-spanning network linking both organizations. Yet *how* these mechanisms are generated or implemented has proved elusive (Davis & Eisenhardt, 2011).

In sum, complexity research and its extension into empirical studies of real world organisations is instructive, insofar as it highlights the need to better understand how “balance between the process order and control emphasized in the linear view and the process instability and creativity emphasized in the recursive and chaotic views" (McCarthy, et al., 2006, p. 438), might be reconciled. Theoretically, the challenge of explaining stability and change along with the temporal dynamics still persists. According to this theory, the stable and unstable equilibrium states result because organisations either change from time to time in predictable ways or they change repetitively which suggests that they are either not inherently changeable or continuously innovative. This logical contradiction is referred to as the trap of "ontological oscillation" (Chiles, et al., 2010, p. 12). Consequently, this calls for complexity to be absorbed and lived with, both theoretically and empirically, rather than reduced (Boisot & Mckelvey, 2010, p. 420). Put differently, the focus of research needs to shift firmly towards understanding process dynamics generated by the activities and practices through which organizations innovate.

2.4.3 Practice Theories and Innovating

The penchant within management research to tackle trackable rather than "relevant" problems led to disconnect between theory and practice (Weick, 1989). This growing sense of theory becoming "entirely self-referential" (Siggelkow, 2007, p. 23) and out of sync with organising and innovating 'practice', led theorists to take practices seriously (Dougherty, 1992; Whittington, 1996; Feldman & Orlikowski, 2011). Since innovating allows stagnant businesses to renew themselves, studying *what* these organisations do to innovate and *how* innovating happens have become pressing issues generating both theoretical and practitioner interest. A practice theory perspective which relates specific instances of situated action to the social world in which this action occurs, therefore, offers an attractive lens to investigate innovation. It allows researchers to "engage with the core logic of how practices are produced, reinforced, and changed, and with what intended and unintended consequences" (Feldman & Orlikowski, 2011, p. 1241). It affords the means to integrate innovation practices with both praxis and practitioners. Practice, according to these scholars is what the practitioners know about innovation and praxis is what they actually do (Seidl & Whittington, 2014; Whittington, 2006).

A vast majority of scholars, operating within the practice perspective build upon either Giddens' (1979) 'structuration' theory or Bourdieu's (1990) 'theory of habitus' (Barley, 1986; Orlikowski, 2007; Jarzabkowski, 2003; Feldman & Orlikowski, 2011; Seidl & Whittington, 2014). In addition to these theories, there are other practice perspectives (e.g Schatzki (2005;

2006) see Chapter 4, also see (Seidl & Whittington, 2014) for details) that have found their way into organisational research. Practice theory has been deployed to investigate several organisational phenomena such as the role of technology in organisational structuring (Barley, 1986), socio-material practices (Orlikowski, 1992; Orlikowski, 2007), temporality (Orlikowski & Yates, 2002; Kaplan & Orlikowski, 2013), strategy (Whittington, 1996; Whittington, 2003; Whittington, 2006; Jarzabkowski, 2003), routines (Feldman & Pentland, 2003; Becker, 2004; Friesl & Larty, 2013), organisational learning (Gherardi, 2006), co-ordination (Jarzabkowski, et al., 2012) and innovation (Dougherty, 2008; Dougherty & Dunne, 2011).

Feldman and Orlikowski (2011) have distilled three key features of mainstream practice theory, which constitute the 'what', 'how' and 'why' of practice. First, the "what" of a practice lens, focuses on the everyday activity of organising, both in its routine and improvised forms. Second, dualisms are rejected in favour of dualities as a way of theorizing. This addresses questions about how practices are produced and sustained. And finally, the third principle is "relationality of mutual constitution" where the "phenomena always exist in relation to each other, produced through a process of mutual constitution" (pp. 1240-1242). Innovation researchers have used this lens to investigate and identify the capabilities and infrastructure used by firms to continuously innovate.

The practice perspective has recognised that sustained product innovation requires practitioners to both differentiate as well as integrate their practices (Dougherty, 2001). Yet, the processes of differentiation and integration remain both unknown and unexplored. The limitation has been attributed to the absence of a unified practice theory that bridges the social constraint-social action divide (Dougherty, 2008). This division between social constraints created by 'structure' and social action generated by 'agency' has been a main stay within the social sciences. It is a manifestation of the action-structure duality adopted by theorists (Hung, 2004; Hellstrom, 2004; Dougherty, 2008; Feldman & Orlikowski, 2011).

According to this view, innovating is explained either by adopting a deterministic position focussing on social structures within various organisational or institutional contexts which collectively shape social action, or by adopting a voluntaristic position focussing on agency where innovators because of their creative risk taking abilities, generate actions that disrupt existing structures by bringing novelty into being (Hung, 2004; Hellstrom, 2004). Thus the capacity (or lack of it) to act or constrain action while innovating is attributed to the presence (or absence) of either structure or agency. However, since social constraints (structure) and social actions (agency) have a fundamentally recursive nature: “social action produces and reproduces constraints, while constraints enable action, so the two are mutually constitutive” (Dougherty, 2008, p. 417). Hence, theories that emphasise only social constraint or only social action are at best partial or worse still, flawed. Adopting a ‘structuration’ perspective, proponents of practice theory argue, allows innovation to be re-conceptualised as a structuration process highlighting both, “the dimension of action (a concept of disorder and change)’, as well as ‘the dimension of structure (a concept of order and stability)” (Hung, 2004, p. 1483).

Structure and agency, therefore are viewed as duality (Farjoun, 2010) rather than dualism where the practice of innovation combines “agency and subjectivity on the one hand and structure and objectivity on the other” (Feldman & Orlikowski, 2011, p. 1245). Working from this theoretical backdrop, Dougherty (2008) identifies fluidity, integrity, and energy as the three properties for designing organisations seeking to sustain product innovation. Fluidity refers to the “ongoing, dynamic adaptations in product teams, among businesses, and within and across technologies and other capabilities and suggests both the loose coupling of structures but also ‘directed flows of activities”. ‘Integrity’, refers to “the sense of pulling things together within and across levels of innovative work, because it reflects the idea of integration as a mind-set and as an outcome” (Dougherty, 2008, pp. 418-419). Energy, according to her, represents the motivating spirit and enthusiasm which allows teams to persist when faced with obstacles or failure.

Now, irrespective of what one makes of Dougherty’s concepts, her practice perspective provides very little insight into the organising challenges established firms encounter while innovating. For instance, is fluidity inherent within organisations or should it be generated? If it requires generating, then how can this be achieved? Does generating ‘fluidity’ challenge ‘integrity’? These are some of the elementary questions that immediately come to mind. Dougherty’s principles offer little insight into the frequent managerial challenge of either integrating or differentiating innovation from their current work. Hence Dougherty and Dunne (2011) call for further research that investigates “how to foster the necessary collaborations” (p. 1214) required for sustaining innovating?

To summarise, despite advocating duality, current innovation theorists who embrace the ‘practice’ perspective appear to be slipping into dualisms like social constraints versus social action and deterministic versus voluntaristic perspectives. As a result, we still don't understand how stability and change are managed while innovating. Also, studies combining social practices with the processual sensitivity to change over time, have received very little attention, despite their significant potential to advance our "understanding on how dynamism and continuity combine in innovation emergence" (Vaara & Whittington, 2012, p. 320). Innovations within organisations are complex processes which combine several activities of differentially positioned managers. This is why organisational processes which emerge from these practices must be taken seriously (Burgelman, 1996). Consequently, the practice perspective raises important questions like "What exactly are the everyday processes of complex new product development, and how can they be enabled?" (Dougherty & Dunne, 2011, p. 1218), which continue to remain unanswered.

2.4.4 Routines and Innovating

Organisational routines, certain scholars argue, form "the crucial nexus between structure and action" required to transform our understanding of organisations as objects to organising as processes (Pentland & Rueter, 1994, p. 484). Understanding organisational dynamics, according to them, requires a deeper inquiry into how certain "recurring action patterns" (Cohen, 2007, p. 773) lead to organizational stability or change (Feldman & Pentland, 2003; Becker, 2008; Parmigiani & Howard-Grenville, 2011; Friesl & Larty, 2013). While routines were initially defined as a "fixed response to defined stimuli" (March & Simon, 1958, p. 142; Cyert & March, 1992/1963) and viewed as sources of organisational stability, they are now defined as "repetitive, recognizable patterns of interdependent actions, involving multiple actors" (Feldman & Pentland, 2003, p. 96) and are seen as sources of both stability and change in organisations (Feldman & Pentland, 2003; Becker, 2008; Friesl & Larty, 2013; Winter, 2013; Parmigiani & Howard-Grenville, 2011). Since innovating requires both stability and change, routines are viewed as crucial for organising while innovating.

The literature on routines is divided into two parallel perspectives: the capabilities perspective and the practice perspective (Parmigiani & Howard-Grenville, 2011; Pentland, et al., 2012). The capabilities perspective has its origins in behavioural theory where routines were first conceptualised as "memory of an organization" (Cyert & March, 1992/1963, p. 101). Nelson and Winter (1982) extended these insights from behavioural theory into evolutionary economics by defining routines as "regular and predictable behaviour patterns of firms" (p. 14) and then likening routines to genetic material. For them, routines act like biological genes in that "they are heritable and selectable by the environment and thus provide the basis for evolutionary change of organizations" (Parmigiani & Howard-Grenville, 2011, p. 416). Just as genetic recombination or genetic mutation explains novelty in biology, similarly the combinatorics of routines and the unreliability of routine imitation are sources for innovation (Becker, et al., 2006).

Therefore, according to Nelson and Winter's (1982) neo-Schumpeterian theory, innovations result from "new combinations of existing routines" (p. 130). However, as Becker, Knudsen and March (2006) perceptively point, this theory fails to explain "the endogenous generation of distinctively novel routines" (p. 361). They write,

> "[A]…neo-Schumpeterian theory of the firm requires a theory of changes in routines that accommodates three rather different kinds of changes: (i) incremental changes in existing routines on the basis of experience; (ii) inter-firm and intra-firm diffusion of routines; and (iii) endogenous generation of new, distinctively novel routines" (Becker, et al., 2006, pp. 360-361).

While the first two kinds of change are accounted for by the capabilities perspective, the third kind of change remains elusive. Besides, change according to this perspective is exogenous to the routine, acting from the outside, thereby neglecting the potential change that is endogenous to the routine due to the agency of its participants (Feldman & Pentland, 2003; Feldman, 2000). For these reasons, the capabilities perspective treats routines as a "black box" (Pentland & Feldman, 2005, p. 794; Parmigiani & Howard-Grenville, 2011), and is therefore unable to sufficiently account for routine dynamics. This theoretical limitation led to the emergence of the practice perspective (Parmigiani & Howard-Grenville, 2011) which focuses on the internal dynamics of how routines are enacted on a day-to-day basis and with what consequences. Since, my interest lies in prying open the 'black box' to explore organising while innovating, I set aside the former perspective which treats 'innovation as output' to explore the latter perspective in greater depth.

Organisational routines, from a practice perspective have been conceptualised as embodying a duality of structure and agency (Feldman & Pentland, 2003, p. 95). By arguing that stability has been the defining characteristic of routines, Feldman (2000) highlighted the potential for endogenous change by applying the practice theory lens to analyse routines at a housing organisation. Inspired by these findings, Feldman and Pentland (2003) propose that routines are made up of two 'parts': the ostensive part which embodies the abstract understanding and knowledge of routines (structure) and the performative part which reveals the actual performance of routines by "specific people, at specific times, in specific places" (agency). According to Feldman and Pentland, the ostensive and performative 'parts' of a routine are "recursively interlinked in practice" and "mutually constitute" each other (p. 95).

While the ostensive aspect, 'represents' the routine (e.g. budgeting, cleaning, hiring, training routine etc), the concrete carrying out of a particular routine within an organisation is specified by the performative aspect. Further, the two parts of the routine must remain distinct since the ostensive part, because of contextual details that remain open, can never fully account for the specific performances of the routines (Feldman & Pentland, 2003; Becker, 2004). "Mutual constitution", as Parmigiani and Howard-Grenville (2011) explain, "implies that structures (e.g, routines, institutions, and other social orders) are the product of human action, yet human action is constrained and enabled by these very structures" (p. 421).

While this dispels the notion of routines being "simple, monolithic objects" (Pentland & Feldman, 2005, p. 794), it raises important questions about the 'content' of routines. If routines, indeed are patterns made up of ostensive and performative 'parts' and not 'entities' as Rerup and Feldman (2011, p. 578) so forcefully argue, then what makes up these parts? Four broad conceptual categories are prevalent in literature. Routines as rules (Becker & Zirpoli, 2008), behaviour (Pentland & Rueter, 1994; Pentland, 1995), disposition (Hodgson, 2008) and action (Pentland, et al., 2012). This lack of consensus and confusion stems from the two layered conception (duality) of routines where the observable performative part is separated from the underlying ostensive part that cannot be observed (Pentland, et al., 2010). "This seems to suggest", as Simpson and Lorino (2016) correctly point out, " a slippage towards the sort of dualistic thinking that would admit both terms, ostensive and performative, as qualifiers of the same underlying concept, namely routines".

If routines are treated solely as 'behaviour', then the tremendous variability in their manifestations undermines the characteristic "routineness" that enables us to identify them as essentially "the same" patterns of action in practice. Put differently, there is nothing merely routine about a task with such variability. On the other hand, if routines are treated solely as 'dispositions', then we still have to explain how such dispositions remain dormant over time without generating any observable performance. We are therefore confronted with what Cohen (2007) calls the "paradox of the (n)ever-changing world" (p. 781):

> "For an established routine, the natural fluctuation of its surrounding environment guarantees that each performance is different, and yet, being a routine, it is 'the same'. Somehow there is pattern in the action, sufficient to allow us to say the pattern is recurring, even though there is substantial variety to the action, variety sufficient to allow us to rule out any two occasions being exactly alike" (p. 782).

Acknowledging the difficulties inherent within these various categories, recent research has urged scholars to focus on 'action' or steps used by actors to accomplish an organisational task (Pentland, et al., 2012). Action, they argue allows for a more complete yet partial reconciliation by combining 'rules' and 'behaviour' within the 'ostensive' and 'performative' parts constituting the routine. More complete, because both rules and behaviour are accommodated in action. Yet partial because, rules or standard operating procedures, as Pentland and Feldman (2005) have argued elsewhere, "are artifacts that may be mistaken for the ostensive aspect of a routine. It would be more appropriate to describe standard operating procedures as indicators of the ostensive aspect or, from another perspective, as efforts to codify the ostensive aspect" (p. 797). Overall, we know *what the 'ostensive' part of a routine is not*. Yet we still know very little about its content, or about its performative dynamics. Here too, the persistence and change of routines in practice are inadequately explained.

Overall, there are four major shortcomings within the current routines literature which makes it unsuitable for theorising organising while innovating. First, routines conceptualised as a duality of ostensive and performative 'parts' offers compelling arguments for routines as a source of endogenous change but it has failed to offer an equivalent explanation for the endogenous stability of routines. This is because the notion of duality does not allow the ostensive and performative 'parts' of the routines to be bolted on to existing, representational notions of practice (Simpson & Lorino, 2016). The very notion of 'parts' (Rerup & Feldman, 2011, p. 578) , as the theoretical physicist David Bohm (1980) explains, implies that "each part is formed independently of the others, and interacts with the other parts only through *some kind of external contact"* (p. 182 my emphasis). It is therefore difficult to understand how routines can at the same time be both stable and changing.

Second, since routines are assumed to be embodiments of knowledge, they have mainly been theorised as primary mechanisms for organisational learning while innovating (Nelson & Winter, 1982; Rerup & Feldman, 2011; Bresman, 2013; Winter, 2013; Zollo & Winter, 2002). Therefore, the replication of routines defined as "the creation of another routine that is similar to the original routine in significant respects" (Szulanski & Jensen, 2004, p. 349) is currently theorised as a process of knowledge transfer. This conflates ‘knowledge’ with innovation where routines are viewed as ‘conduits’ of learning (Friesl & Larty, 2013, p. 108). Hence, the actual replication processes of routines while innovating remains both under theorised and underexplored (D'Adderio, 2014; Bresman, 2013).

Third, the neglect of the role of individual agency in the process of replication means that we still do not understand how routine dynamics leading to adaptation and deviation from rules and templates lead to co-ordination and stability (Winter, 2013). Recent research, has attempted to unravel this ‘replication dilemma’ by highlighting the role played by artefacts in maintaining stability and change (D'Adderio, 2014). However, such research remains rare, highlighting the need to shift the focus from truce and stability to conflict and instability during routine replication. Also, research on routines has so far focussed on specific tasks (e.g in-licencing routines, hiring routines, virtual packaging routines etc) within the organisational phenomena rather than the organisational phenomenon itself. Routines, therefore help illustrate *certain tasks within innovating* rather than *the process of innovating*.

Fourth, there is little research in the extant literature on the temporal dynamics of routine generation and replication. Apart from generic statements like “performative actions are specific actions performed by specific individuals at specific times, and as they are performed over time, these actions make ostensive patterns” (Rerup & Feldman, 2011, p. 579), the role of time has neither been factored into the conceptualisation of routines nor been explicitly examined within empirical research on routine dynamics.

To conclude, although the research on routines provides several insights into organisational stability, change, knowledge transfer and organisational learning, it suffers from several empirical and theoretical constraints. Despite differences in the specific explanations and mechanisms offered by the ‘capabilities’ and the ‘practice’ perspectives, this research under-emphasises the role of endogenous change or stability. ‘That routines have often been associated with stability and inertia’, according to Becker (2004), “has probably made it tempting to frame the discussion in terms of variation *despite* routines, and has hampered research on the variation of routines” (p. 663, emphasis in original). It therefore fails to address “how certain, more distinctively new action emerges within organizations” (Obstfeld, 2012, p. 1571). Consequently, routines research does not adequately theorise the organising challenges confronting innovators.

2.4.5 Process and Innovation Journeys

Organisation scholars, have long understood the benefits of tracking a phenomenon over time, by studying the unfolding events closely, observing “what happens in response to what” (Mintzberg, 1972; Pettigrew, 1973; Burgelman & Sayles, 1986; Van de Ven, et al., 1999; Garud, et al., 2013). Change, within these studies, is allowed to reveal itself in a manner which is substantial, temporal, contextual or all of the above (Pettigrew, 1985). The ‘innovation as journey’ perspective effects a reconceptualisation of innovation by integrating ‘process of choice’ with ‘process of change’ (Sminia, 2009). This genre of process research aims to develop explanatory theories and ‘generative mechanisms’ (Tsoukas, 1989) by capturing organisational reality, either “in flight” (Pettigrew, 2012, p. 1305) or over prolonged periods of time.

Within management research however, the study of organising processes while innovating began gaining popularity after Burgelman’s (1983a; 1983b; 1983c) process theory on internal corporate venturing (ICV). The Minnesota Innovation Research Program (MIRP) setup in 1983 by Van de Ven (1999) and his colleagues added further impetus to this movement and research on innovating from the ‘narrative’ perspective by Garud and his colleagues (Garud, et al., 2011; Garud, et al., 2013; Garud, et al., 2014) attempts to extend this research movement. These three streams are elaborated upon in the sub-sections which follow and this section concludes by outlining a summary of insights and limitations originating from the ‘innovation journeys’ literature.

2.4.5.1 Insights from Internal Corporate Venturing

Burgelman’s (1983a; 1983b; 1983c) process model of ‘internal corporate venturing’ (ICV) marks an early attempt to integrate theories from organisation, innovation and strategy research into a unified theoretical framework. Prior to this study, relatively little was known about the process through which large, complex firms engage in entrepreneurial innovation (Burgelman, 1983c). By illuminating the strategic processes through which R&D activities within organisations are transformed into innovations, Burgelman shifted the theoretical debate from strategic planning to strategy implementation.

Successful implementation requires practitioners to identify and match, what he calls 'induced' and 'autonomous' strategic behaviour with the 'structural' and 'strategic' contexts within which these processes unfold (Burgelman, 1983a). Induced strategy is planned, deliberate and aims to exploit and extend initiatives that are within the scope of a firm's current strategy. Autonomous strategy on the other hand, is emergent and exploits initiatives that develop through exploration outside of the scope of current strategy (Burgelman, 2002; Mintzberg & Waters, 1985). It emerges from internally generated variation as actors 'enact' (Weick, 1979) these strategies (1983a). Induced strategy is controlled by management and enables planning and structuring while autonomous strategy, which by definition is beyond managerial control, provides the variation or diversity required for innovation.

Both 'induced' and 'autonomous' strategies provide the intellectual foundation for Burgelman's subsequent research. These are seen as distinct and not directly related other than through the structural or strategic contexts. The key task of aligning these two 'fundamentally different processes' depends on the 'strategic context' which refers to 'political mechanisms' through which the two strategies are reconciled (Burgelman, 1983c, p. 1352). However, what these mechanisms are and *how* do they unfold within organisations remains unspecified. What is specified, however, are the stages and activities within the ICV process (Burgelman, 1983b). The ICV process was divided into four stages, namely the "conceptual, pre-venture, entrepreneurial, and organizational" (Burgelman, 1983b, p. 228) stages. Also identified are activities like gatekeeping, idea generating, and bootlegging which play an important role in the ICV process.

Overall, this process model indicates *what* the entrepreneurial activities of individuals involved in the ICV process are and *how* these activities link to the various stages within the process. It also identifies "how forces at the level of the corporation influence the entrepreneurial activities of these individuals" (Burgelman, 1983b, p. 224). Yet, what Burgelman's study *reveals* is the *structure of the ICV process and not the process itself*. Merely identifying two distinct, selective processes and labelling them as 'structural context determination' and 'strategic context determination', cannot be regarded as 'generative' mechanisms. By Burgelman's own admission, these are 'broad envelope concepts' used to denote the various administrative mechanisms (Burgelman, 1983a, pp. 65-66). While this approach generates key insights on the interlocking activities and stages of the process, the 'generative' mechanisms which regulate the induced and autonomous strategic processes still remain packed into what Burgelman calls 'strategic context' and 'structural context'. Strategic context and structural context, in other words, is the black box that hides organising while innovating.

In order to better understand how the strategic context determination process is managed and to explicate the ‘generative’ mechanism, Burgelman (1991) adopts the neo-Darwinian ‘evolutionary motor’ of change (Van de Ven & Poole, 1995). He provides a richly detailed picture of how innovation within Intel can be understood as an intra-organizational process of variation, selection, and retention (V-S-R). According to Burgelman (1991), organisations represent an ecology of strategic initiatives where:

> “Variation in strategic initiatives comes about, in part, as the result of individual strategists seeking expression of their special skills and career advancement through the pursuit of different types of strategic initiatives. Selection works through administrative and cultural mechanisms regulating the allocation of attention and resources to different areas of strategic initiative. Retention takes the form of organizational-level learning and distinctive competence, embodied in various ways-organizational goal definition, domain delineation, and shared views of organizational character” (p. 240).

The managerial implication of this finding is that firms must strike a balance between variation-reducing and variation-increasing mechanisms as the former leads to organisational inertia while the latter “expands the firm's domain and renews the organization's distinctive competence base, countering inertia and serving some of the functions of a reorientation” (Burgelman, 1991, p. 257). However, the means to effective internal selection, as Burgelman (1991) writes, “depend on top management's capacities to adjust the structural and strategic contexts in the organization. Discovering the determinants of such capacities and how the latter relate to rates of adjustment and strategic renewal remains an important agenda for further research” (p. 258).

With this conclusion, Burgelman adds nuance to the dilemma between strategic choice attributed to agency and environmental determinism attributed to structure. His V-S-R model demonstrates how variation at the individual level interacts with structural contexts to produce patterns in organisational adaptation. This theory allows for a *partial integration* of the ecological and strategic perspectives. The theory is *integrative* because it helps reconcile choice upon which ‘strategy’ hinges with determinism of the context in which this choice is made. Yet *partial* because the role of strategic and structural contexts, continue to remain unopened black boxes.

To understand why this might be the case, it is important to unravel Burgelman's neo-Darwinian argument. While on the one hand, he attributes variation to autonomous strategy involving individual action, he quickly switches his unit of analysis to 'strategic initiatives rather than individuals' (Burgelman, 1991, p. 240). This move, allows him to switch his analytical focus from the individual level to the organisational level. So while variation operates at the individual level, selection and retention operate at the organisational level. Therefore, while choices are made at the individual level, their outcomes are determined at the organisational level where the role of the individual is underplayed. It is this logical sleight of hand that allows Burgelman to portray 'internal selection' as the organising mechanism in his intra-organisational ecological theory. Additionally, Burgelman's internal selection works *retroductively*, offering no guidance to managers about the form that their current strategies might take in the future. It is for these reasons that Van de Ven (1992) rightly classifies the V-S-R model under explanatory rather than predictive process theories (p. 181).

Since **V**ariation-**S**election-**R**etention link particular historical circumstances to particular consequences, it can at best answer why, in the given circumstances, things turned out the way they did (Ingold, 1986). Strategic initiatives, on the other hand involve not just an interpretation of the past but also prophesy for the future. But when it comes to the future, Burgelman's 'internal selection' just like its biological counterpart 'natural selection'[1] is silent. The V-S-R model of change and adaptation, therefore, offers little forward guidance to managers who want to know how they must organise while innovating. This is because variation, selection and retention occur within the evolutionary process but does not explain it. If progress, indeed has taken place, then its cause or explanation must be found within the circumstances and not, as Burgelman does, in the V-S-R mechanism (Ingold, 1986, p. 17).

Further, this evolutionary "model assumes a tight association between stability (change) manifested as mechanisms and stability (change) manifested as outcomes" (Farjoun, 2010, p. 204). This focus on *ends* rather than on the *means*, fails to explain how organisational stability is maintained even as innovation triggers change. Unravelling this puzzle makes systematic research on the intra-organizational processes leading to innovation an important research agenda (Burgelman, 1994; Burgelman, 2011). Burgelman also contributes towards a better

[1] Referred to by Barnett & Burgelman (1996) as 'external selection' (p. 7)

understanding of temporal complexities by challenging the punctuated equilibrium model of change (Gersick, 1991; Romanelli & Tushman, 1994). His study demonstrates how strategic change that looks 'punctuated' at the corporate level of analysis might indeed have resulted from more gradual change taking place at lower levels within the organisation (Barnett & Burgelman, 1996, p. 16; Burgelman, 1996). This finding raises questions about the traditional dichotomy between 'synchronic' temporality cutting across 'levels' of an organisation and 'diachronic' temporality which captures the progress of the phenomenon within the organisation over time.

Overall, Burgelman's ecological strategy frameworks and process models have illustrated several interesting organisational phenomena ranging from intra-organisational processes associated with strategic business exit (Burgelman, 1994), aligning strategy and action using 'strategic vectors' (Burgelman, 2002), balancing organisational 'fitness' and 'evolvability' when confronted with nonlinear strategic dynamics (Burgelman & Grove, 2007), and last but not the least, his 'theory of method' used to carry out process studies (Burgelman, 2011). All of these studies have contributed towards a richer understanding of organisational dynamics. Yet, as the above discussion notes, Burgelman's theories are yet to fully integrate traditional antinomies like stability and change, synchronic and diachronic temporal complexities and individual choice and contextual determinism into a unifying framework. Consequently, as Burgelman (1996) himself notes, his process models provide "windows into the 'black box'" (p. 206) of organising while innovating without prying it open.

2.4.5.2 Insights from MIRP

The Minnesota Innovation Research Program (MIRP) was initiated and led by Andrew Van de Ven (1999) and his colleagues in collaboration with 3M Corporation. It is arguably the most significant body of process research scholarship in the area of innovation management and set out an ambitious three pronged research agenda. First it sought to understand the development of innovations over time. Second, it sought to identify characteristics which lead to innovation success or failure. Third, it attempted to develop a process theory of innovation. Innovation management was reconceptualised as a process of change management unfolding over time, from conception to implementation (Van de Ven & Angle, 1989; Van de Ven, et al., 1999; Poole, et al., 2000; Poole & Van de Ven, 2010). Van de Ven's subsequent focus, however, switched from innovation to change and process research in general (Van de Ven & Poole, 1995; 2005; Sminia, 2009).

By tracking ideas, outcomes, people, transactions and contexts (Van de Ven, et al., 1999, p. 6) over time, a key finding from this study was that the process of innovating may be understood in terms of a non-linear dynamic model with partially stable outcomes which then dissolve into spin off ideas and projects. The people developing the innovation assumed a variety of roles over time, moving to and from fluidly forming teams. These findings were significant for it offered empirical evidence confirming that far from its conventional linear, static representation, innovating is actually a highly complex non-linear dynamic process. The research also made significant contributions to the literature on organisational learning (Garud & Van De Ven, 1992; Van De Ven & Polley, 1992), leadership (Van De Ven & Grazman, 1997), inter-organisational relationships (Ring & Van De Ven, 1994) and technological evolution (Garud & Rappa, 1994), while innovating.

On organisational change, Van de Ven and Poole (1995) develop a typology consisting of four ideal type change models which they refer to as 'motors'. They define change as, "a difference in form, quality, or state over time in an organizational entity" (Van de Ven & Poole, 1995, p. 512; Van de Ven & Sun, 2011). The four 'change motors' they identify, namely, the evolutionary, life-cycle, teleological and dialectic motors, correspond to the various attributes of change captured within their definition. To elaborate, within the evolutionary motor, an organisation is assumed to be stable until its equilibrium is unsettled by some external cause that triggers the variation-selection-retention mechanism. This in turn allows the organisation to settle into a new equilibrium.

In the life cycle model of change, the identity of the entity is assumed to be stable as it passes through various fixed and defined stages of development adhering to an internal logic which governs its progression. Similarly, stability within the teleological model depends on a common goal and all the change here is directed towards meeting this identifiable end state. Finally, the dialectic model, assumes internal tension or contradiction between two unreconciled positions (thesis-antithesis). Change, here deals with the process of reconciliation (synthesis) (Van de Ven & Sun, 2011; Sminia, 2009; Meyer, et al., 2005).

These broad meta-theories of change serve as a useful starting point to explore various organisational processes. However, as Van de Ven and Sun (2011) caution, the interacting complexities between the various 'motors' of change and the various organisational levels across which they operate, have to date received very little theoretical or empirical attention. Pettigrew (2012), however, attributes this paucity of empirical research using the change motors to their inability to sort out the practical problem of competing explanations. As he puts it, these motors "rarely supported the substantive problem of identifying the generative mechanisms that cause events to happen, or the particular circumstances or contingencies behind these causal mechanisms" (p. 1321).

On temporal dynamics, the MIRP studies were informed by the punctuated equilibrium model of change (Tushman & Romanelli, 1985) and viewed the emergence of novelty as disruptive and discontinuous (Garud, et al., 2013, p. 778). Their notion of temporal dynamics was anchored in chronological time along which their event sequences were referenced. Hence, they focussed on identifying the temporal stages or cycles of organisational change (Hargrave & Van de Ven, 2006). This focus on temporal stages or cycles did not allow them to delve deeper into the temporal dynamics of innovating since the stages and cycles represent the structure of the dynamic rather than the dynamic itself. Therefore, although they discovered that most innovation processes do not unfold in orderly steps, the fact that the process was neither random nor ordered was a source of great puzzle to them. The intertwined challenges of explaining stability and change, temporal complexity of convergence and divergent cycles and the tension between determinism and choice is succinctly summarised when Garud, Van de Ven and Tuertscher[2] (2013) write:

> "Rather, innovation processes are characterized by repeated cycles of divergent and convergent phases. Divergence is driven by the expenditure of resources (people, time, ideas, and money) above and beyond the system's normal sustenance. Convergence is driven by exogenous constraints (such as institutional rules and organizational mandates) and endogenous constraints (such as resource limitations and the discovery of possibilities that focus attention)" (pp. 777-778).

Additionally, the MIRP studies also made significant methodological contributions to process research (Burgelman, 2011; Pettigrew, 2012; Poole & Van de Ven, 2010; Czarniawska, 2007; Langley, 1999; Pentland, 1999) and enhanced the visibility of process scholarship within the field of management research (Langley, et al., 2013). Yet, it is ironical, as Sminia (2009) rightly points out, that Van de Ven's subsequent methodological orientation following MIRP veered at least in part towards 'variance theory' (Dooley & Van De Ven, 1999; Van de Ven & Poole, 2005; Poole & Van de Ven, 2010). This is primarily because Van de Ven (with Poole)

[2] Both Garud and Van de Ven were members of the original MIRP team whereas Tuertscher wasn't.

views variance theory and process theory as complements along an explanatory continuum. In fact, after making clear distinctions between the various definitions of 'process', they blur these boundaries when they write,

> "However, the other two definitions also have their own parts to play in process research. To understand their combination, it is useful to map the three definitions into each other. The third definition of process can be mapped into the second (which regards process as a category of concepts and variables referring to individual or organisational actions) by defining variables that describe attributes of the event sequence. On the second view of process, cyclicity would be a variable describing the process occurring between inputs and outputs. The third definition can also be mapped into the first one (which views process as a logic explaining causal relationships between independent and dependent variables) by distilling the general narrative from the event sequence to create a "story" that accounts for the impact of a variable earlier in the sequence on subsequent dependent variables" (Poole, et al., 2000, pp. 22-23).

Hence, it is evident that they view process research as a data gathering exercise, the first step in the quest towards a robust variance theory, rather than a theory or explanation in its own right. The implications of this understanding of 'process' must be reserved for the next chapter where the meta-theoretical assumptions underpinning these studies will be looked into with greater scrutiny.

At the start of MIRP, Van de Ven (1986) had warned of the dangers of "old questions remaining unanswered" and of the "premature abandonment of ideas because even if problems are not being solved, the appearance of progress requires moving on to the next batch of problems" (p. 593). Now of the three goals, the MIRP with its methodological clarity and empirical rigour has successfully achieved the first goal by mapping out the 'innovation journey' along with its key characteristics and phases. The second goal was partially met for this study highlights how the "easy use of partial explanations" (Pettigrew, 2012, p. 1321), prevalent in so many innovation theories, prevents the development of a richer understanding of the complexities of organising while innovating. Most MIRP studies begin at the project level of analysis, and they work outward from there to the industry level. Therefore, the role of intra organisational processes and team dynamics, crucial while innovating, are underemphasised (Edmondson, 2000). All of these, along with the theoretical challenges described earlier led to the abandonment of the third goal, which was to develop a general process theory of innovation.

To summarise, the MIRP research exercise established the promise and legitimacy of process studies within organisation theory in general and innovation research in particular. Its contributions and insights have been valuable insofar as by treating innovation as a process and revealing the theoretical pluralism of the phenomena, it has, to some extent, served to integrate insights from several rapidly compartmentalising branches of organisational theory. True to Van de Ven's original premonition, the old questions remain unanswered and a process theory on organising while innovating still awaits development.

2.4.5.3 The Narrative Perspective

While Van de Ven embarked on developing 'variance theory' from process data, applying methodologies which can deduce hypothesised process patterns; Raghu Garud (Garud & Van De Ven, 1992; Van de Ven, et al., 1999; Garud, et al., 2013), his colleague and collaborator from MIRP, began veering towards a more descriptive style of theorising by embedding analytical constructs within narratives. Realising the benefits of the richer understanding which can be obtained by studying how technologists, innovators and engineers within organisations shape the social and technical dimension of innovation, he advocates what he calls a 'narrative' perspective to study how to organise while innovating (Garud, et al., 2014; Garud & Giuliani, 2013).

Use of the narrative methodology for process research has several advocates (Pentland, 1999; Czarniawska, 1997) and it was originally inspired by theoretical developments within the sociology of technology. The sociology of technology is a broad field comprising of three dominant approaches, social construction of technology (SCOT) (Bijker, et al., 2012/1987), Large-Scale Technological Systems (LTS) (Hughes, 2004), and Actor Network Theory (ANT) (Latour, 1987; Latour, 2005). While there are commonalities and differences between these three approaches, right now, it is sufficient to say that Garud's narrative perspective builds upon ANT (Garud, et al., 2014).

"Narrative", here, refers "to a set of events and the contextual details surrounding their occurrence" (Bartel & Garud, 2009, p. 108). The central theoretical issue which the narrative perspective seeks to illuminate is the emergence of 'co-ordination' or organising while innovating (Bartel & Garud, 2009; Garud, et al., 2014). Scholars sympathetic to this perspective realise that negotiating the innovation journey requires mechanisms which bring together facets of co-ordination. This co-ordination can be achieved either through organisational design or by enabling processes that facilitate productive social interactions (Bartel & Garud, 2009). Like ANT from which this perspective derives inspiration, agency is conceptualised "as an emergent property of relational processes involving ongoing associations between humans and artifacts" (Garud & Giuliani, 2013, p. 158).

More recently, Garud, et al (2014) have urged scholars to develop constitutive theories of innovation using the narrative perspective by considering three intertwined facets which they call relational, temporal and performative respectively. According to them,

> "The relational facet refers to the constitution of agency through existing and anticipated relationships across social and material elements. The temporal facet refers to the various accounts of the past, present and future that are offered as innovation unfolds. The performative facet highlights how narratives serve as triggers for action towards goals that are forever changing" (p. 1181).

Garud, Gehman and Kumaraswamy (2011) have applied this lens to develop a typology of complexities which require management while innovating. By theoretically reconstructing the process of innovating for two new product innovations at 3M, the authors identify four distinct types of complexities which they call relational, manifest, regulative and temporal complexities, respectively. According to them, exploring and elaborating the mechanisms (which they do not identify or specify) through which these complexity arrangements are intertwined, provide the clues for sustaining innovations within large corporation like 3M. The approach has also been used to identify, compare and contrast several distinct and valuable innovation concepts. These include, among others, the contrast between 'transaction' and 'transformation' costs involved while innovating (Garud & Munir, 2008) and highlighting how design while innovating is both a medium and outcome of action (Garud, et al., 2008).

However, two keenly debated concepts which divide scholarly opinion are the distinction between 'bricolage' versus 'breakthrough' innovation (Garud & Karnoe, 2003) and on whether innovation journeys are better understood as 'path-dependence' (Schreyögg & Sydow, 2011; Vergne & Durand, 2010) or 'path creation' (Garud, et al., 2010) processes. I first explore the 'breakthrough' versus 'bricolage' debate. Just like the 'incremental' versus 'radical' innovations discussed earlier, the 'breakthrough' versus 'bricolage' perspectives on the innovation journey also harbour implicit assumptions about persistence vs change, and agency vs structure.

Garud and Karnoe (2003) chronicle the technology paths pursued by US and Danish firms within the wind energy industry. They find that despite considerable deployment of technical and financial resources, the actors in the US were unable to create a viable technological path. Their Danish counterparts on the other hand, became world leaders in wind energy by following an incremental approach, deploying modest resources to progressively build up a viable wind turbine technology path. Garud and Karnoe (2003) present a compelling argument explaining the differing fortunes for the Danish and US wind energy firms by likening the first strategy to bricolage and the second to breakthrough innovation. They write,

> "Bricolage was characterized by co-shaping of the emerging technological path as actors in Denmark sought modest yet steady gains. In contrast, actors in the US pursued a path that we label as breakthrough. We use the term breakthrough to evoke an image of actors attempting to generate dramatic outcomes. Rather than adaptiveness, an unyielding vision to leap-frog the Danish initiative characterized the involvement of actors in the US" (pp. 278-279).

By doing so, the authors re-inject the significant role played by agency which until then was mostly under theorised within mainstream innovation research. The lesson that they draw however, is that a high-tech breakthrough approach is riskier compared to the bricolage approach because the former stifles the learning processes leading to adaptation whilst the latter preserves the "emergent properties which lead to the mutual co-shaping of emerging technological paths" (Garud & Karnoe, 2003, p. 296). This conclusion is puzzling because even though the research is a study of processes, the analysis and conclusion are framed based on innovation outcomes. While the 'breakthrough' and 'bricolage' journeys are portrayed as mutually antithetical, couldn't they also be complementary? Put differently, could bricolage not lead to breakthrough or vice versa?

The inability of their study to answer this question suggests what historians call, the 'retrospective' fallacy in reasoning. This refers to the tendency within this case study "to view earlier events as though they were controlled by their subsequent outcomes, when at the time of their occurrence any number of outcomes might have been equally probable" (Ingold, 1986, p. 15; Mandelbaum, 1971, pp. 134-135). Put differently, the retrospective fallacy while studying processes is the idea that "because things happened in a certain way they could not have happened in any other way. A priori, the set of possible sequences that *could* occur included both the sequence that *did* occur and its opposite" (Ingold, 1986, p. 131 emphasis in original). The 'narrative' perspective can only redress this tendency by reverting to 'real' time investigation of the phenomena. With those brief remarks, let me now turn to the 'path dependency' versus 'path creation' debate.

The corollary to the distinction between 'breakthroughs' versus 'bricolage' is the debate on whether the journeys leading to these outcomes are 'path dependent' or are they 'path creation'? According to the 'path dependence' camp, inspired by Giddens' (1984) structuration theory, technological paths are constituted by structurational processes wherein structure is both medium and outcome of practices (Sydow, et al., 2009; Vergne & Durand, 2010; Schreyögg & Sydow, 2011). Innovating, according to the 'path dependence' view, is a complex 'non-ergodic' process; that is processes "unable to shake free of their history" (David, 2001, p. 19; Hung, 2004). Implied here is a duality of persistence and change as well as structure and agency. The 'path dependence' perspective, as Garud, et al., (2010) rightly point out, underemphasises the free will of actors who become 'locked in' "by self-reinforcing mechanisms into paths whose evolution is determined by contingencies (chance events). Once locked in, actors cannot break out unless exogenous shocks occur" (p. 760).

By criticising this conceptualisation of 'paths' as one rooted in, what they call, the 'outsider's' ontology, Garud along with his colleagues propose the 'path creation' perspective which they root within an 'insider's' ontology (Garud, et al., 2010, p. 761). Consistent with ANT which theorises 'agency' as being distributed and emergent through the interactions of actors and artefacts that constitute networks, the 'path creation' perspective introduces human agency into evolutionary models of economics and organisations (Koput, 2003). It highlights how innovators actively shape new markets by introducing new products and services to create opportunities where none may have previously existed (O'Connor & Rice, 2013, p. 212; Garud, et al., 2010).

Actors, according to this perspective, "who become entangled in these action nets can modulate their spheres of interactions with other actors and artefacts, knowing that they can only attempt to influence (but not determine) the processes that unfold" (Garud, et al., 2010, p. 770). As such, 'path dependency' studies are retrospective and backward looking whereas the 'path creation' perspective is framed as 'a forward-looking approach to studying path dependencies that might lay to rest some of the red herrings that have arisen in the path-dependence debate' (Koput, 2003, p. 155). In sum, the 'path creation' perspective sees individual free will and structural determinism, "not as balancing acts, but as mutually constitutive elements" (Garud, et al., 2010, p. 770) within the process of innovating.

Yet, real time studies using the narrative perspective have been scarce. A major limitation of the narrative perspective is that while it paints a very rich 'know why' picture of the process of innovating, it has very little 'know how' knowledge to offer. Most studies rely on largely retrospective reconstruction of innovation journeys. Therefore, it does not sufficiently explicate the dynamics of the processes as they unfold and are experienced in real time. As a result the specific means through which innovation narratives maintain the coherence and flexibility that are required while innovating remain understudied (Bartel & Garud, 2009). In order to understand organising while innovating dynamically, researchers must gather data in real time by following the "events implicating actors, artefacts, and institutions over time" (Garud, et al., 2013, p. 803).

Stated differently, the need of the hour is to pry open abstract, 'black-boxed' concepts like relational, temporal and performative facets which constitute innovation dynamics. In fact, notions like 'performativity' which equates discourse with action - *"in which to say something is to do something"* (Garud, et al., 2014, p. 1182) might be the root cause of the analytical problem. In fact, Burgelman (1994; 1996) while researching innovation strategy at Intel was forewarned against using such tactics by Intel's then CEO Andy Grove. To quote Grove,

> "Don't ask managers, What is your strategy? Look at what they do! Because people will pretend......." (quoted in Burgelman, 1994, p. 43; 1996, p. 199).

To conclude, as this short overview reveals, existing theories from the narrative perspective fall short of explaining temporary, emergent collaborations that shape organising while innovating. The plethora of social dynamics involved with implementing the complex innovation process continue to remain under examined. What the narrative perspective does, however, is that it calls into question some of the received wisdom and orthodox positions which are now entrenched in organisational and innovation theory. In sum, it is a refreshing 'constitutive' approach (Garud, et al., 2014), differing significantly from the atomising approach on which much of the mainstream innovation research is based. Yet, as the debates suggest, further conceptual and empirical integration is required to iron out some of the identified inconsistencies within the narrative perspective.

2.4.5.4 Summary

Within this sub-section on innovation journeys, I have explored three distinct genres of pioneering process scholarship. First, I examined Burgelman's detailed process models studying the ICV process within various organisations. Then, I presented the MIRP led by Van de Ven which, as I have argued, led to several significant insights and paved the way for process scholarship into mainstream innovation research. Finally, I presented the contributions from Garud's narrative perspective. Common to these three genres is the fact that these researchers have explicitly focussed on innovation as journeys. Among the three, Burgelman (1991; 1994; 1996) and Garud (2011) have specifically focussed on intra-organisational process while innovating. Van de Ven's empirical work is largely restricted to the inter-organisational level of analysis. Studying innovation and change over time is a common thread which runs through all of these works. Yet, as the limitations of each of these genres reveal, significant gaps in our understanding of organising while innovating still remain.

2.4.6 Summary: Innovation as Process

I began this section with the aim to develop a clearer understanding of the various 'innovation as process' perspectives within organisational research. Since the 'innovation as process' perspective is either implicitly or explicitly underpinned by a complementary theory of change which it invokes, it became absolutely necessary to begin the discussion with an overview of the various change theories which inform organisational dynamics. Broadly speaking, I have identified the notion of gradual change driven by the 'evolutionary' motor, the continuous transformation model which underpins complexity theory, the punctuated equilibrium model which has enjoyed hegemony within a significant number of process studies, and finally, the 'duality' model of stability and change which underpins the practice and routines perspectives within 'innovation as process' theories.

Next, I presented the contributions and limitations of complexity theories on innovation. Here, I dedicated some space to review and critique the oeuvre of Eisenhardt (Eisenhardt & Brown, 1999; Eisenhardt, et al., 2010) whose contributions still remain influential among several scholars of change, innovation and organisational dynamics. Next, I turned to review the 'practice' perspective from organisation theory in general and innovation research in particular. Here, special attention is paid to review and critique the contributions of Dougherty

(1992; 2008; Dougherty & Dunne, 2011), whose extensive research on practice has attempted to integrate practice theory with the literature on innovation. This was followed by highlighting the promises and gaps within 'routines' literature. Here particular attention was paid to routines conceptualised as a duality of structure and agency (Feldman & Pentland, 2003). The 'ostensive' and 'performative' distinction between the 'parts' of the routine was subjected to particular scrutiny. This distinction, the review found, contained assumptions which make it difficult to do sufficient justice towards the dynamics of innovating.

Finally, I turned to the 'journeys' perspective which presents innovation more holistically and with greater empirical clarity by tracking the unfolding of events over prolonged periods of time. Here I discussed the contributions of Burgelman's research on ICV, Van de Ven's MIRP studies and finally the Narrative perspective offered by Garud. While, I believe that the 'journeys approach' (Garud, et al., 2014) has come the closest thus far when it comes to developing process theories which combine elements of organising and innovating in an embedded manner, several conceptual and empirical gaps, as the review suggests, remain. These require investigation and integration if we are to further our understanding of organising while innovating. In the next section, I synthesise the persistent challenges that have emerged from this literature review, both from the 'innovation as output' and 'innovation as process' perspective into four specific theoretical puzzles.

2.5 Theoretical Puzzles

This review has highlighted several antinomies like structure and agency, stability and change, cross sectional analysis and longitudinal analysis, synchrony and diachrony, exploration and exploitation, 'ostensive' and 'performative', action and behaviour, breakthrough and bricolage, and finally path dependence and path creation. In this section, I synthesise the theoretical insights and current debates, identified here, into four specific puzzles. These puzzles capture four ongoing dilemmas with which social science in general and innovation research in particular has long grappled. Clarifying these four puzzles, I argue, is vital for theoretical progress which can greatly enhance our understanding and appreciation of the complex process of innovating.

The fundamental difference between the 'innovation as output' and 'innovation as process' perspectives is the varying degrees to which each of these perspectives currently incorporates the role of change and time into theories. A major limitation of the 'innovation as output' perspective, as this review reveals, is that whilst it has enjoyed considerable success identifying 'what' changes (or the 'content' of change, as Pettigrew (2012) calls it), it has been less successful at specifying *how* this 'content' changes as innovating unfolds. Process theories, on the other hand, have had considerable success answering 'how' change unfolds but have yet to satisfactorily specify how organising was actually accomplished while innovating.

Since change has by and large been viewed as 'episodic', the "precipitating" and "enabling dynamics" (Greenwood & Hinings, 1996, p. 1044) of organising used to overcome the implementation problems while innovating remain underexplored (Tsoukas & Chia, 2002). Therefore, we still know little about how organisations simultaneously manage to remain stable yet change while innovating. To recall, organisational change is defined as a "difference in form, quality, or state over time in an organizational entity" (Van de Ven & Poole, 1995, p. 512). Now as 'practice' and 'routines' theorists, who with their ostensive and performative 'parts' of routines (Feldman & Orlikowski, 2011) would like to have us believe, it is not possible or logical for an 'entity' or 'parts' to simultaneously change and yet retain form, quality or state. Because the very notion of change has been defined as 'difference' in these attributes. Hence as long as form, quality or state *persists*, there can be no difference and hence no change. Therefore, our first puzzle, the relationship between persistence and change.

A second pressing antinomy between 'innovation as output' and 'innovation as process' perspectives is the role of time. Specifically, while the former mostly deals with 'single snapshot' data gathered through cross-sectional surveys or longitudinal panel surveys (in which case you have 'multiple snapshots', the latter deals with 'episodic' events from longitudinal field studies (Avital, 2000; Poole, et al., 2000; Pettigrew, 1990). This reveals three plausible explanations about the treatment of time. Within the 'innovation as output' perspective, either "time is perceived as an atomic element or as a "black-box" that does not require further inquiry" or "time is perceived as an environmental factor that has merely a secondary importance or effect on social action" (Avital, 2000, p. 670). As for the 'innovation as process' perspective, time is the reference along which events are pegged. This varying treatment of time sets up our next puzzle, the antinomy between synchrony and diachrony. As Avital (2000) explains,

> "Whereas a diachronic analysis refers to the study of dynamic processes and social change over a period of time, a synchronic analysis pertains to the study of social stability and takes a "timeless snapshot" of society as it exists at one point in time without any reference to its history" (p. 670).

The debate between 'ambidexterity' (O'Reilly & Tushman, 2008) which favours the synchronous pursuit of exploration and exploitation and 'punctuated equilibrium' (Romanelli & Tushman, 1994) which favours the diachronic pursuit of exploration and exploitation in order to counter 'strategic' inertia (Gupta, et al., 2006, pp. 693-694), is a classic manifestation of the synchrony-diachrony antinomy. Clarifying this dilemma will require a deeper analysis into the synchrony-diachrony relationship.

A third concern is the role played by necessity and chance. Is the process of innovating a process of 'discovery' or is it a process of 'creation'? (Garud, et al., 2014; Venkataraman, et al., 2013; Alvarez & Barney, 2007). These twin perspectives build on the 'agent-centric' and 'context-centric' approaches by extending these perspectives across multiple level of analysis. The fundamental distinction between the two perspectives involves the conceptualisation of agency: Should agency be located in specific individuals, or should innovators be conceptualised as part of a larger process where agency is distributed and emergent? (Garud & Giuliani, 2013, p. 157). According to the 'discovery' perspective, the clearest manifestation of which lies in the individual-opportunity nexus theory (Shane & Venkataraman, 2000; Venkataraman, et al., 2013), innovations are conceptualised as pre-existing opportunities within contexts, waiting to be discovered by alert and agile individuals who have the right skills to capitalise on such opportunities.

Innovation opportunities, in other words, are exogenous to the innovating process and pre-exists within markets or industries, which innovators then discover by chance. The focus, therefore is on individual and organisational capabilities such as 'absorptive capacity' (Cohen & Levinthal, 1990; Zahra & George, 2002) and 'knowledge brokering' (Hargadon & Sutton, 1997). Organisations exploit their positions within an industry network to innovate by recombining knowledge originating from two different organisations to increase their innovation chances. In contrast, opportunity creation theory (Alvarez & Barney, 2007; Alvarez, et al., 2013), such as the 'bricolage' perspective (Garud & Karnoe, 2003) discussed earlier, stresses 'necessity' by suggesting that innovators create new opportunities, with the outcomes, in part shaped by the contexts in which they are embedded. Circumventing this dilemma will require clarifying the necessity-chance relationship that underpins studies from both perspectives.

Finally, the dilemma between 'path dependency' and 'path creation' requires greater clarification. 'Path dependence' explains organizational persistence by developing concepts like "structural inertia, imprinting, institutionalization, commitment or trajectories" (Schreyögg & Sydow, 2011, p. 322). As Schreyogg and Sydow (2011) explain, "persistence is treated either as a starting point or process outcome, but the logic of the very process producing organizational persistence remains under-explored, by and large" (p. 322). 'Path creation' explains organisational change and novelty but the processes that underpin stability allowing individual agency to flourish, remain under-theorised and underexplored. Thus we are confronted with a conceptual impasse that pits structural determinism, social structure and 'ostensive part' against the individual will, social action and 'performative' part which drives distributed agency. Circumventing this dilemma will require clarifying the determinism- free will relationship that underpins current studies.

In sum, advancing our understanding of the dynamics of the complex process of innovating hinges on the extent to which we can satisfactorily embrace a perspective that allows us to circumvent these four theoretical dilemmas which are now entrenched within innovation literature. These are the relationships between persistence and change, synchrony and diachrony, necessity and chance, and determinism and free will. These persistent dilemmas have hemmed in the explanatory potential of innovation theories. Moreover, these antinomies are vigorously contested by innovation theorists from all camps. The task of clarifying these antinomies and why they have arisen within current theories will require an explicit meta-theoretical analysis examining the very conceptualisation of organisations within management research.

2.6 Conclusion

This chapter discusses and evaluates the contributions from the growing body of research on organising and innovating. The objective of this chapter is to synthesize the state of knowledge and highlight some persisting theoretical puzzles in current research. Specifically, we see that current theories are hemmed in by their theoretical commitments and fail to sufficiently explain the dynamics of innovating. While both the structuralist and process approaches have their strengths, neither of them appear well suited or adequate to explore the question "How does one organise while innovating?" Why might this be the case?

Might this be a result of the conceptual fog clouding our understanding about what exactly is it that we mean by "process" and "change"? Put differently, could embracing a theorising approach which focuses on 'organizational becoming' as opposed to organizational 'being', where organising is re-conceptualized as an "emergent property of change" (Tsoukas & Chia, 2002, p. 570), avoid these difficulties? Understanding why these puzzles have arisen requires a thorough evaluation of the meta-theoretical assumptions that underpin current theorising. Doing so might also open up a research trajectory where such antinomies can be avoided.

When Erving Goffman, was criticised for being too specific and too ready to wrap a concept around every situation he analysed, his blunt yet eloquent response was "it is better perhaps (to have) different coats to clothe the children well than a single, splendid tent, in which they all shiver" (Goffman, 1961, p. xiv). Organisation theorists researching innovation have often been guilty of building the splendid tents in which theory suffers. The need of the hour is more coats and fewer tents.

Overall, this literature review suggests that a deeper inquiry into reasons for the current deficiencies in our understanding requires a detour into philosophy. Since the primary concern of philosophy is the rigorous establishment, regulation and improvement of the methods of knowledge-production in all fields of intellectual endeavour, including management research; it becomes necessary to undertake such an inquiry. To paraphrase the mathematician turned philosopher Alfred North Whitehead's (1925, p. 17) concern, if innovation research is not to degenerate into a medley of ad hoc hypotheses, it must become philosophical and must enter upon a thorough criticism of its own foundations. Chapter Three which follows, aims precisely to undertake such a criticism.

3 Threading Along New Lines

A man's reach should exceed his grasp,
Or what's a meta for?

Gregory Bateson[3] (1988)

"Thus life, in the process ontology, is not an emanation but a generation of being, in a world that is not pre-ordained but incipient, forever on the verge of the actual"

Tim Ingold (2000) in *The Perception Of the Environment* (p. 113)

3.0 Introduction

I concluded the previous chapter by speculating whether the switch from 'organisational being' to 'organisational becoming' will allow me to circumvent the dilemmas that were articulated through the four theoretical puzzles that emerged from the review? In other words, would treating change not as a property of organisations but rather, organisations as the emergent properties of change (Tsoukas & Chia, 2011; Tsoukas & Chia, 2002; Chia, 1997), allow me to avoid the antinomies articulated through the four puzzles? Could such a switch also open up new and exciting trajectories for innovation research? The task of examining such fundamental assumptions, "assumptions which appear so obvious that people do not know that they are assuming them because no other way of putting things has ever occurred to them" (Whitehead, 1925, p. 48), requires a foray into metaphysics. These are questions that I shall explore in this chapter.

Metaphysics, or concern with the nature of reality and by implication knowing, is the starting point for such a reassessment. Reality is a much contested word within the social sciences. Derived from the Latin word *res as in resistance; "*reality is *that which resists trials of strength"* (Latour, 1987, p. 93). Reality, put differently, is that which resists the strength of our thought trials. Speculation on the nature of reality has arguably been the oldest and yet to

[3] Bateson, letter to John Brockman, a play on Browning's poem.

be settled metaphysical debate. Is absolute reality a permanent and unchanging thing or is it a continuous, fluxing and transforming process? These two competing notions of reality have gained momentum within the realm of management research (Tsoukas & Chia, 2002; Van de Ven & Poole, 2005; Langley, et al., 2013). Whilst the former view is grounded in 'substantialist' metaphysics, the latter view constitutes 'process' metaphysics. The resurfacing of this ontological debate can be ascribed to the dissatisfaction confronting scholars of various persuasions who seek to understand and theorise the impact of time, movement, sequence and flux, the "inescapable reality" of the phenomena under investigation (Langley & Tsoukas, 2010, p. 10). Metaphysics allows us to make transparent the scholarly procedures that creates theories according to their ideas and their affinities with philosophical systems. Hence, a thorough study of the metaphysical underpinnings is required to keep organisational research alive and vital.

This chapter is organised as follows. First, I explore the substantialist and the process metaphysical traditions, each of which profoundly influences our notion of reality. Following this, I introduce and contrast the 'being' and 'becoming' ontologies along with their guiding assumptions. For this, I have relied extensively on the writings of William James (1909/2011), Henri Bergson (1998/1911; 1912/1999), Alfred North Whitehead (1925; 1929/1978) and Nicholas Rescher (1996). The writings of these scholars provide profound insights that highlights the limitations of substantialist ontology.

The next section highlights the implications of these insights for organising and change. Having established the potential of the 'becoming' ontology for my research question, I turn to British social anthropologist, Tim Ingold (1986; 2000; 2007; 2011; 2013b) whose writings, as I shall argue, provide a critical springboard to further probe the dynamics of organising and innovating. I conclude by revisiting the four theoretical puzzles I raised in the previous chapter. Using Ingoldian insights, I deconstruct current process theories and trace the dilemmas articulated through these puzzles to a 'substantialist' ontology. Since these dilemmas cannot be resolved within the 'substantialist' ontology, an alternate Ingoldian becoming perspective which avoids these dilemmas is proposed. This alternative 'processual'[4] conceptualisation is then be taken up to investigate organising while innovating.

[4] 'Processual' here refers to a combination of process ontology and epistemology. This must be distinguished from 'process' research which is, by and large, substantialist in ontology and process in epistemology.

3.1 Metaphysics: Substance or Process?

Organisational theorists for some time now have debated the theoretical implications of two competing worldviews: the substantialist and the process worldviews (Tsoukas & Chia, 2011; Van de Ven & Poole, 2005). In the substantialist worldview, whose origins are attributed to the writings of pre-Socratic Greek philosopher Parmenides, substances or 'things' are the basic building blocks of the universe. Here, primacy is accorded to substance over process. Since substance is all there is, process and change are considered epiphenomenal. Change and process are, as Rescher (1996) puts it, "simply a matter of how things appear (in the mind) to certain substances" (p. 2). Parmenidian substantialist thinking is firmly entrenched within Western thought and its popularity is widely attributed to Aristotle's insistence on the world of nature as being made up of a multitude of discrete objects and things, "each with its own integrity and essential properties" (Ingold, 2000, p. 96; Whitehead, 1925).

Process metaphysics, by contrast, conceptualises the universe as being fundamentally constituted of processes, rather than substances or 'things'. Here, processes have primacy over substances or things. Since substance is subordinate to process, things are simply regarded as temporarily stabilised instances of unfolding processes (Rescher, 1996). Although the processual worldview in Western philosophy is associated with the writings of Heraclitus, it has been the dominant tradition within Eastern, mainly Indian and Chinese philosophy (Whitehead, 1929/1978, p. 7). There is no denying the reality of substances among process philosophers. However, substances here are reconceptualised as manifolds of process. A stone, for example, is nothing but an instant within the process of erosion. Process philosophers, therefore "are perfectly prepared to acknowledge substantial things, but see them rather in terms of processual activities and stabilities" (Rescher, 1996, p. 52).

In substantialist metaphysics, the world is imagined as being made up of discrete, individual entities and events, each of which is linked through an external contact – "whether of spatial contiguity or temporal succession" – that leaves its basic nature intact (Ingold, 2011, p. 236). Process metaphysics, by contrast, conceptualises the world as a sea of fluxing processes where change refers not to "a clear-cut replacement of one hard-edged state by another but rather a melting and fusing of boundaryless processes leading into one another" (Rescher, 1996, p. 15; James, 1909/2011). The distinctive feature of a processual worldview, as Rescher (1996) forcefully argues, "is not simply the commonplace recognition of natural process as the active initiator of what exists in nature but an insistence on seeing process as constituting an essential aspect of everything that exists – *a commitment to the fundamentally processual nature of the real*" (p. 8 my emphasis). The world, in other words, is seen as an "unbroken and undivided movement" where all "things" are to be understood as limited abstractions (Bohm, 1996, p. xxix).

The contrasting metaphysical distinctions can be illustrated through the following three examples. First, let us take the example of wind. It is customary for us to say "the wind blows", but in truth the wind *is* its blowing (Ingold, 2011, p. 17). For how else could we know of the 'wind' other than by experiencing its blowing? It is not as if the wind were actually a thing at rest which, at a given point in time, begins to move and blow. Yet, we speak as if there exists a wind which did not blow. Second, consider the statement, 'It is raining'. The 'it' here implies an 'entity', that is doing the rain*ing* (Chia, 1996, p. 159). But in reality, *we cannot separate the rain from its falling*. In fact, in several oriental languages, especially from India and China, the equivalent expression takes the form "Rain is falling". Here, like the wind, the rain *is* its falling. As a third and final example, consider the perpetual flowing of the water which we observe while walking along a river bank. In order to conceptually grasp the phenomenon and to communicate it to others, we do not think and say, "Look at the perpetual flowing of the water"; we say, "Look how fast the river is flowing." (Elias, 1978, pp. 111-112). Each of these examples contrasts substantialist metaphysics with process metaphysics. In the former, 'things' are accorded primacy by reducing processes to a series of static conditions whereas in the latter, 'things' *are* their processes.

3.2 From Being to a Becoming Ontology

The difference between the 'substantialist' and 'process' metaphysics pits the 'ontology of being' against the 'ontology of becoming'. (Chia, 1999, p. 215). The 'ontology of being' originates from a substantialist worldview that accords theoretical priority to stability, permanence and order. Here, movement, change and transformation are absorbed into its immutability and rendered in static terms as forms of mere appearance, necessary to transition from one relatively stable state to another. In contrast, the 'ontology of becoming' is firmly rooted in a processual worldview. By privileging movement, change, emergence and transformation, it treats stability, order and organisation it encounters as exceptional states. In doing so, it “does not assume certainty”, rather, “to the best of its ability, pursues uncertainty, cautiously untangling an otherwise tangled world” (Hernes, 2008, p. xviii). It encourages thinking in terms of *heterogeneous becoming,* of transformation within the *immanent continuity* of life. Consequently, the ‘being ontology’ prioritises structures and states whereas movement and action are bestowed primacy in the ‘becoming ontology’.

These profound differences have implications for the social science we develop. The implications are not because of the ‘ontologies’ per say, but rather by reason of the temperament that gives these ontologies their theoretical expression. “One side”, observes Whitehead (1929/1978), “makes process ultimate; the other side makes facts ultimate” (p. 7). Since things or entities are accorded primacy within the ‘being ontology’, the properties of these things or entities, given as ‘facts’, is taken as the starting point for analysis. Therefore by focusing on what something *is* or *is not* in contrast with what goes on, these theorists feel as if they have fulfilled their intellectual duty (James, 1909/2011, p. 17). So how are these ‘facts’ established? James (1909/2011) explains,

> “Intellectualism in the vicious sense began when Socrates and Plato taught that what a thing really is, is told (to) us by its *definition*. Ever since Socrates we have been taught that reality consists of essences, not of appearances, and that the essences of things are known whenever we know their definitions. So first we identify the thing with a concept and then we identify the concept with a definition, and only then, inasmuch as the thing *is* whatever the definition expresses, are we sure of apprehending the real essence of it or the full truth about it” (p. 73 emphasis in original).

‘Essences’ refer to the ‘qualities’ or properties of the ‘thing’ or phenomenon we are attempting to analyse. Therefore, what a ‘thing’ is or is not; can only be understood by comprehending its ‘essences’. These ‘essences’ of ‘things’ are then distilled into their *definitions*. The definition, now becomes a ‘fact’ from which reasoning can proceed. Only by doing so can nature be revealed for detached human reasoning as a domain of things in themselves (Ingold, 2000, p. 108). So far, so good. However, James (1909/2011) writes:

> “Concepts, first employed to make things intelligible, are clung to even when they make them unintelligible. Thus it comes that when once you have conceived things as ‘independent,’ you must proceed to deny the possibility of any connexion whatever among them, because the notion of connexion is not contained in the definition of independence. …………The definition of A is changeless, so is the definition of B. The one definition cannot change in to the other, so the notion that the concrete thing A should change into another concrete thing B is made out to be contrary to reason” (pp. 73-74).

Instability and movement are thereby rendered in stable and immobile terms respectively. Such difficulties and illusions, inherent in the 'being ontology', are generally because we accept as final, a definition that is essentially provisional. Essences of *things*, constituting a definition are in fact, the many "stable views that we take of its instability" (Bergson, 1998/1911, p. 302). It is to this temperament within the 'being ontology', which denies the possibility of change by reifying it into static terms, that both the mathematicians turned philosophers Bergson (1912/1999; 1998/1911) and Whitehead (1925; 1929/1978) take exception.

Both Bergson and Whitehead recognise that theorising involves abstraction and view the intolerant use of abstractions as the major vice of the intellect (Whitehead, 1925, p. 18). Mistaking what is originally a conceptual abstraction, for an actual vital agent, is what Whitehead (1925) calls the "The Fallacy of Misplaced Concreteness" (p. 58). Likewise, Bergson (1912/1999) recognises that "thinking usually consists in passing from concepts to things, and not from things to concepts" (p. 38). Knowing a reality, as he explains, "involves taking 'readymade concepts', to portion them out and to mix them together until a practical equivalent of the reality is obtained" (p. 38). However, a concept, is a symbolic representation of the thing and not the thing itself. Mistaking it for the thing itself is *the fallacy of misplaced concreteness*. It is for this reason that these operations are called '*re*presentations' of reality and not reality itself.

As Bergson (1912/1999) points out elsewhere, "the very idea of reconstituting a thing by operations practiced on symbolic elements alone implies such an absurdity that it would never occur to anyone if they recollected that they were not dealing with fragments of the thing, but only, as it were, with fragments of its symbol" (p. 33). The impoverished understanding obtained through this genre of reasoning, which proceeds by reducing the world to the realm of manipulable objects and variables, is well summed up in the following analogy offered by Bergson (1912/1999),

> "Were all the photographs of a town, taken from all possible points of view, to go on indefinitely completing one another, they would never be equivalent to the solid town in which we walk about" (p. 22).

The axioms of the 'being ontology', have been well summarised by Chia (1997, p. 690). The salient points from his summary are the following: First, reality is conceptualised as discrete, conceptually isolatable 'things' or 'entities', which exist independent of our perception. Second, primacy is bestowed upon 'things' or 'entities', processes are secondary. Thus, here it is possible to study 'blocks' of change, or divide the change into periods which can then be converted into blocks. Third, the notion of time, is mechanical and so is reversible. Progress, therefore is inferred from states, where time is broken down into discrete instants.

Four, rest, stability and equilibrium are the presupposed natural state. "Movement occurs only when things are 'disturbed' or 'perturbed'" (p. 690). Fifth, change, movement and adaptation are viewed as doings of an external, exogenous force. The widely assumed notions of 'causation' and its attendant effects are imputed to this external force. Finally, the 'being ontology' commits itself to the subject-predicate forms of thought where the presupposition is that form is a "direct embodiment of the most ultimate characterization of a fact" (Whitehead, 1929/1978, p. 7). This means that linguistic terms and categories can adequately represent reality, an ontological commitment to the 'representationalist epistemology' shared by positivism.

In contrast to the 'being ontology' where concepts are all discontinuous and fixed, the 'becoming ontology' recognises the 'essence of life' to be its "continuously changing character" (James, 1909/2011, p. 84). In this dynamic conceptualisation of the real, as James (1909/2011) wrote,

> "What really exists is not things made but things in the making. Once made, they are dead, and an infinite number of alternative conceptual decompositions can be used in defining them. But put yourself *in the making* by a stroke of intuitive sympathy with the thing and, the whole range of possible decompositions coming at once into your possession, you are no longer troubled with the question which of them is the more absolutely true" (p. 87 emphasis in original).

In the 'becoming ontology', reality is continually in the process of *becoming.* It simply cannot be understood, as Chia (1997) in his perceptive critique correctly notes, "to be composed of discrete, static, and isolatable entities with distinctive properties that can be straightforwardly represented by linguistic terms and systematically classified and compared in an objective manner" (p. 693). Thus the 'becoming ontology' accords primacy to activities, process, change and novelty over substance, products, persistence and continuity (Rescher, 1996, p. 31). In order to make transparent the radically different theoretical priorities of the 'becoming ontology', I once again expand on Chia's (1997, pp. 696-697) succinct summary.

First, privileging activity and movement requires that we eschew thinking in terms of 'discrete individualities' in favour of process and relatedness. A vivid illustration of this contrasting mode of thought can be found in the following example offered by James (1909/2011),

> "When a chemist tells us that two atoms of hydrogen and one of oxygen combine themselves of their own accord into the new compound substance 'water', he knows (if he believes in the mechanical view of nature) that this is only an elliptical statement for a more complex fact. That fact is that when H2 and O, instead of keeping far apart, get into closer quarters, say into the position H-O-H, they affect surrounding bodies differently: they now, wet our skin, dissolve sugar, put out fire, etc; which they didn't in their former positions. 'Water', is but our name for what acts peculiarly. But if the skin, sugar and fire were absent, no witness would speak of water at all. He would still talk of the H and O distributively, merely noting that they acted now in the new position H-O-H" (p. 63).

Here, the 'discrete individualities' of hydrogen and oxygen is radically different from their 'relatedness' as water. Nor can the 'properties' of water be extrapolated from the individual properties derived from isolated hydrogen and oxygen atoms. The difference is akin to the difference between holding twelve thoughts, each of a single word, and one thought of the whole sentence comprising the twelve words (James, 1909/2011, p. 63). More recently, organisational scholars have pinned this 'irreducibility of properties' by contrasting the 'emergent' notion of novelty with its 'resultant' equivalent (Garud, et al., 2015). Whilst the latter can be predicted by using the sigma principle: sum of the various parts (or properties) *result* in the novel output, the former cannot, as the emergent whole is more than the sum of the constituent parts.

Second, thinking in terms of end-states and outcomes is discarded in favour of the *process of becoming*. Specifically, it means reversing a bent, evident in much of organisational studies, especially literature on innovation, to read the phenomena 'backwards', starting from an outcome and tracing it, through a sequence of antecedent conditions, to a source. This patching together of fragments, after the fact, "can no more dip up the substance of reality than you can dip up water with a net, however finely meshed" (James, 1909/2011, p. 84). An 'ontology of becoming' *cannot* treat becoming and change by what Bergson (1998/1911) calls, "*the cinematographic method*" (p. 317). According to the cinematographic method, the lived experience is divided in discrete 'chunks' called events, with each 'event' succeeding the next like frames on a reel of film. Such an approach can only produce a re-constituted continuity, what Bergson (1912/1999) calls 'counterfeit movement'. Movement, for Bergson is fundamentally constitutive of reality, "all that is positive in becoming" (p. 317). Yet, this *becoming* is not simply a homogeneous process. The variations in becoming which underpin the heterogeneity of processes are eloquently articulated by him,

> "That which goes from yellow to green is not like that which goes from green to blue: they are different *qualitative* movements. That which goes from flower to fruit is not like that which goes from larva to nymph and from nymph to a perfect insect: they are different *evolutionary* movements. The action of eating or of drinking is not like the action of fighting: they are different *extensive* movements. And these three kinds of movement themselves – qualitative, evolutionary, extensive – differ profoundly" (Bergson, 1998/1911, p. 304).

Third, by assuming movement as constant, process theorists strive to explain stability. Stability, as Chia (1997) explains, is a result of the deliberate conceptual intervention of the intellect onto what is essentially a 'mobile' reality. Conceptualisation using thought, in other words 'arrests' the 'mobile' reality by 'slowing it down' (p. 696). A processual relationship between stability and change is well expressed by Whitehead (1925) when he writes,

> "There can be nothing real without the spirit of change and the spirit of conservation. Mere change without conservation is a passage from nothing to nothing. Its final integration yields mere transient non-entity. Mere conservation without change cannot conserve. For after all, there is a flux of circumstance, and the freshness of being evaporates under mere repetition" (p. 201).

The fourth and final axiom relates to novelty articulated through the Whiteheadian notion of *immanence* (1929/1978, p. 93). The principle of immanence, where the past is immanent in the present, as Chia and King (1998) explain, "implies that each outcome, each situation or state, always necessarily incorporates the events of the past. Thus, the present is not merely the linear successor of the past but a novel emanation of it" (p. 470). The principle of immanence runs counter to the mechanical conception of time inherent in the 'being ontology' where duration merely refers to a succession of instants. For if time were indeed 'mechanistic' then, as Bergson (1998/1911) writes, "there would never be anything but the present – no prolonging of the past into the actual, no evolution, no concrete duration. Duration is the continuous progress of the past which gnaws into the future and which swells as it advances" (p. 4).

It is this unity between the past and future within the present of an unfolding process which ensures that novelty, "doesn't arrive by jumps and jolts, it leaks in insensibly, for adjacent in experience are always interfused, the smallest real datum being both a coming and a going" (James, 1909/2011, p. 153). According to some scholars, this view of temporality also finds resonance, within the writings of George Herbert Mead (Simpson, 2009; Hernes, 2014). These four axioms taken together constitute the central tenets of the 'becoming ontology'. In conclusion, we see that the divergence between the 'being' and 'becoming' ontologies, rooted in substantialist and process metaphysics respectively, is of such fundamental significance that it cannot be glossed over within the realm of management research. The manifestations of this divergence are explored in the next section.

3.3 Ontology and the Realm of Organisation Studies

The distinction between the 'being' and 'becoming' ontologies manifests in organisational studies through the competing conceptualisation of 'organisations'. In the substantialist 'being' ontology, organisations are regarded as individual entities consitituted from a specific configuration of elements. Organisations, according to this view, are clearly defined, isolable, empirical entities with discrete structures which can be 'objectively' analysed. The processual 'becoming' perspective, in contrast, conceptualises organisations as an embodiment of dense complexes of socio-technical processes, sustained by a never resting stream of organising activities.

The substantialist view of an 'organisation', as Chia (1997) so aptly points out, "foregrounds organizations as clearly circumscribed, legitimate objects of analysis, whilst at the same time deny the status of the network of organizing processes from which this theoretical object has been abstracted" (p. 691). The processual view of organisations, on the other hand, embraces the notion of 'organisations' as dynamic and precariously balanced by adopting transience, flux and transformation over the dominant notions of permanence, stability and endurance which have been the central characteristics of discourse in organisational theory (Chia, 1999). Therefore, adopting a particular perspective on 'organisations' can have a profound impact on how we research and understand the phenomena we investigate.

In order to comprehend how the collective activities of a group of people became reified into a firm or organisational level analyses, we need to understand a crucial distinction between what Rapoport and Horvath (1968) call 'organization theory' and 'theory of organizations'. A 'theory of organizations', according to them, is what, broadly speaking, may be described as a sociological approach to organisations. It explores *how* unorganised complexity is transformed into organised complexity, perhaps best articulated through the notion of organising (Weick, 1979). Organisational theory, on the other hand, for them, is better understood as the study of organisational principles applicable to any system exhibiting ‘organised complexity’. These organisational principles, by taking the transformed ‘organised complexity’ for granted, focus on building external complexity into internal organising networks (Hernes, 2008, p. 84).

It is this reification of organising processes into social ‘entities’ that allow ‘substantialist’ theorists to think of organisation theory as having to do with which variables should be included in the equations and how these variables relate to other variables and not as something about which mechanisms produce the observed associations in the variables (Hedström & Swedberg, 1998). Researchers subscribing to this mode of thought, elevate the discovery of correlations between different ‘entities’ as explanations by completely downplaying the processes from which the co-related entities are abstracted (Tsoukas, 1989).

The processual argument becomes incontrovertible when one applies Woolgar’s (1988, p. 69) logic of ‘The Splitting and Inversion Model of Discovery’ to the logical and the rhetorical strategies used by ‘substantialist’ theorists to justify ‘organisations’ as the unit of analysis. The model demonstrates how the ontological commitments to the ‘being ontology’, which underpins much of social scientific theorising, including mainstream theories on organising and innovating, succeeds in representing the deepest reality of the world as static and aprocessual (James, 1909/2011, p. 38). The five stage logic, which offers useful insights into the substantialist mode of theorising within organisation studies, is laid out in Figure 4 below.

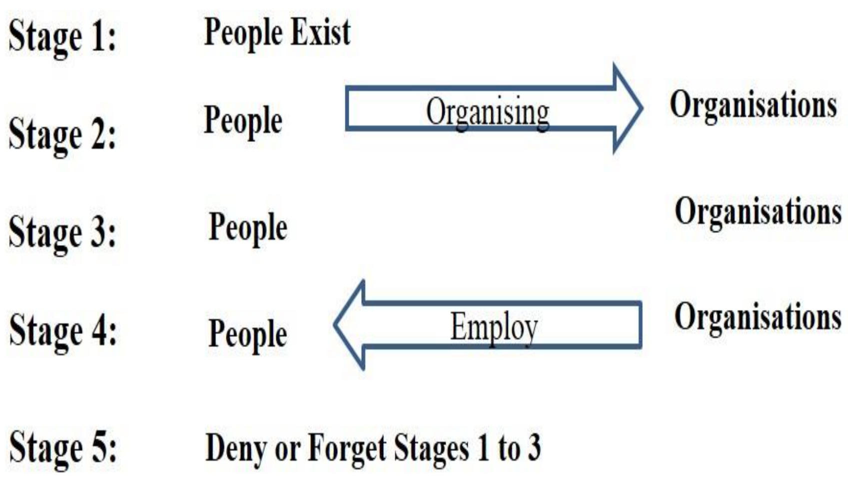


Figure 4: Logic of Inversion

As with any theorising process, the model begins with a speculation about the social world we inhabit. So, in Stage One, people exist. This initial speculation allows us to project a particular object which can then be subsequently legitimised as the focus for our investigation. In Stage Two, organisations are projected as outcomes of organising processes, undertaken by people who exist. In Stage Three, the ‘formed’ object takes a life of its own and is treated as being separate and independent of our notions of it. Organisations are now separate and exist independently of the organising processes which gave rise to it. In Stage Four, an inversion of this relationship occurs which suggests that it was the presence of this object which drew our attention to it in the first place. Organisations, because they employ people, are accorded theoretical priority as legitimate, isolable, empirical entities which can and must be investigated by researchers. Finally in Stage Five, the researchers, being habituated to these inverted terms forget or strongly deny the conception and reifying processes which brought the object into being.

This ‘logic of inversion’, demonstrates how the actual work of organising is subordinated to the outcome; here the organisation. The former is hidden from view so that the latter alone now becomes an object of contemplation. It is this ‘fallacy of misplaced concreteness’ that siphons off the most succinct insights that appear useful for illuminating the process side of organisation. The renowned Californian painter Robert Irwin refers to this process as ‘compounded abstraction’. “The essence of compounded abstractions” as Weick (2006) points out, “is found in one of Irwin’s favourite maxims: seeing is forgetting the name of the thing seen” (p. 1726). Organisation, thus conceptualised is no longer a subject, but rather is an object of study. It does not, as research should, put the “ongoing accomplishment” (Feldman, 2000, p. 613) of organising processes under scrutiny, but instead, leaves us theorists with too comfortable a sense of complete comprehension.

The 'becoming ontology', by reminding us of this forgetting serves as a de-reifier. By turning “stone into lava” (Nachmanovitch, 2009, p. 14), it dissolves our hardened conceptual abstractions, thereby allowing us to re-examine organisational phenomena, not through conceptual labels and linguistic categories but by getting closer to the phenomenon as they are. It refines our theorising instincts by making us mindful of the fact that the theorising process, whether in science, history or the arts involves abstraction (Trilling, 1976). Therefore, if we want to understand and design innovative organizations, we need a better grasp of *how people organise while innovating*. That means eschewing the ‘entitative’ conceptualisation of organisations (which is a prerequisite for variance theories (Mohr, 1982) that share a rather blind infatuation for methods transplanted from natural science), in favour of understanding organising and innovating as becoming.

To summarise, in this section I have demonstrated the modus operandi of the substantialist 'being' ontology. This 'entitative' disposition holds sway, even among 'process' theorists of the substantialist mould (Chia, 1996; Chia, 1997; Tsoukas & Chia, 2002; Bakken & Hernes, 2006; Nayak, 2008; Hernes, et al., 2013; Chia & Holt, 2009; Chia & MacKay, 2007; MacKay & Chia, 2013). As an explanation for the dynamics of organising while innovating, the substantialist, being ontology, by focussing on 'entities' or 'things', does not exfoliate the organising processes in a manner which sufficiently connects with what practitioners actually do. It can by no means be ignored, but of itself it cannot give an adequate answer to our question. It is this oversight which allows theorising from a 'becoming' ontology "to challenge the value of a theory and to explore its weakness and problems in relation to the phenomena it is supposed to explicate" (Alvesson & Karreman, 2007, pp. 1265-1266). This elusive understanding is vital for any intelligent comprehension of the dynamics of organising while innovating.

3.4 A Primer on Tim Ingold

Translating these metaphysical insights on process into a practical theoretical framework requires deeper conceptual integration between 'process' ontology and 'process' epistemology. Without this integration, the 'process' ontology will, by and large, remain confined to philosophical writings. Incorporating 'process' ontology into the practice of process scholarship, therefore, means that it is now time to turn to the works of British social anthropologist, Tim Ingold (1986; 2000; 2007; 2011; 2013b).

Prior to Ingold's conscientious scholarship, 'process' ontology within social science research (henceforth referred to as processual research) was largely confined to matters of mere pedagogical utility. It certainly was a neglected branch of scholarship within management research and had become, as Kubler (1962) might put it, "more and more the prerogative of a handful who live at the crumbling edge of convention" (p. 62). Refreshingly, Ingold's oeuvre, grainy and knotted with insight, practicality and detail, paves the way for us to begin building a genuinely 'processual' theory on organising while innovating. I shall devote some attention to his ideas, since they provide a useful foundation for clarifying the four theoretical puzzles that I presented in the previous chapter.

Ingold, like his British predecessor and intellectual maverick Gregory Bateson (1972; 1979; 1988), is a polymath whose writings cut across traditional disciplinary boundaries. He has written extensively about, to mention a few, the evolutionary paradigm within social sciences (Ingold, 1986; 2013a), the philosophy of technology and the role of skill (Ingold, 2000; 2011), the psychology of perception (Ingold, 2000; 2011), a history of lines (Ingold, 2007) and more recently inquires which cut across, what he calls the 4As, anthropology, archaeology, art and architecture (Ingold, 2013b).

The common thread, which runs through all these seemingly diverse fields of inquiry, is an unwavering commitment to 'processual' research. For this he has extensively borrowed, synthesised, extended and expanded upon the philosophical writings of among others, James (1890; 1909/2011), Bergson (1998/1911; 1912/1999), Whitehead (1925; 1929/1978), Heidegger (1926/1962), Gibson (1979) and Deleuze and Guattari (1983; 1988). A key insight that emerges from the Ingold's scholarship is that rather than assuming, as is traditionally done, a distinction between an organism and its environment (equivalent to the distinction organisation scholars draw between the firm and its environment), it is more useful to consider 'organism plus environment', not as bounded entities but as a process in real time: "a process, that is, of growth and development" (Ingold, 2000, p. 20).

Embracing the notion of 'organisation plus environment' as a process in real time within management research allows us to explore organising while innovating by situating the "practitioners right from the start, in the context of an active engagement with the constituents of his or her surroundings" (Ingold, 2000, p. 5). This is what Ingold (2000), following Heidegger (1926/1962), calls the 'dwelling perspective' (also see Chia & Holt, 2006). Such a 'processual' reconceptualization, where structures are regarded, merely as outlines of processes (Bergson, 1998/1911), allows us to investigate how the unfolding of activities situated in a richly structured environment shape organising and innovating. Further, Ingold (2007) offers lines, as shown in Figure 5 below, as a metaphor for process.

Figure 5: Process as Lines adopted from Ingold (2007, pg 72)

However, his lines are not to be interpreted through the rather narrow lens of Euclidian geometry. In Euclidian geometry, 'lines' are synonymous with '*straightness*', connecting one point to another. Such a connector line, commonplace in much of the current 'process', 'practice' and 'routines' models within management research, for Ingold (2007) "has neither body nor colour nor texture, nor any other tangible quality: its nature is abstract, conceptual, rational" (p. 47)[5]. The straight line, for Ingold (2007), therefore, is an icon of 'modernity'. Nor can his lines be broken into fragments. The fragmented dashed lines, for him, by proceeding from 'one point of rupture to another', is a hallmark of 'postmodern' thought (p. 167).

Lines for him (Figure 5) are continuous, meandering and wayfaring, embodying in "their very formation the past history, present action and future potential of a thing" (Ingold, 2007, p. 129). Etymologically, a 'thing' as Ingold (2007) astutely observes, originally "meant a gathering of people and a place where they would meet to resolve their affairs. As, the derivation of the word suggests, *every thing is a parliament of lines*" (p. 5 emphasis in original). Paraphrasing the American-born landscape geographer. Kenneth Olwig (2002, pp. 52-53), Ingold (2007) writes,

> "…the line of wayfaring, accomplished through the practices of dwelling and the circuitous movement they entail is *topian*; the straight line of modernity, driven by a grand narrative of progressive advance, is *utopian*; the fragmented line of post-modernity is *dystopian"* (p. 167 emphasis in original).

Process, as these rather brief remarks highlight, unfolds *neither across 'horizontal' nor across 'vertical'* (Pettigrew, 1985, p. 64) levels but rather *along lines*. Lines, in fact, *are* their processes. Now 'process' understood as continuous, '*alongly'* (Ingold, 2007, p. 89) lines is not

[5] Ingold was quoting from Jean-François Billeter (1990, p. 47)

quite the same as 'process' conceptualised as the joining up of straight lines. Joined up lines aptly describe actor network theory (Latour, 2005) and its off shoots within management research such as Czarniawska's (2004) action nets and Garud's narrative perspective (Garud & Giuliani, 2013; Garud, et al., 2014). Here, the task of organising is to join up a set of inter-connected points representing 'things' or 'entities'.

Organising *alongly*, by contrast, means that each line describes a flow of socio-material substance in a space that is topologically fluid (Ingold, 2011). These constitute, what Ingold (2011, p. 64; 2013b, p. 132) aptly calls, 'a meshwork' of interwoven lines, which I have represented in Figure 6 below. As Ingold (2013b) explains,

> "By this (meshwork) I mean an entanglement of lines. These lines may loop or twist around one another, or weave in and out. Crucially however, they do not connect. This is what distinguishes a meshwork from a network. Where the network has nodes, a meshwork has knots. Knots are places where many lines of becoming are drawn tightly together" (p. 132).

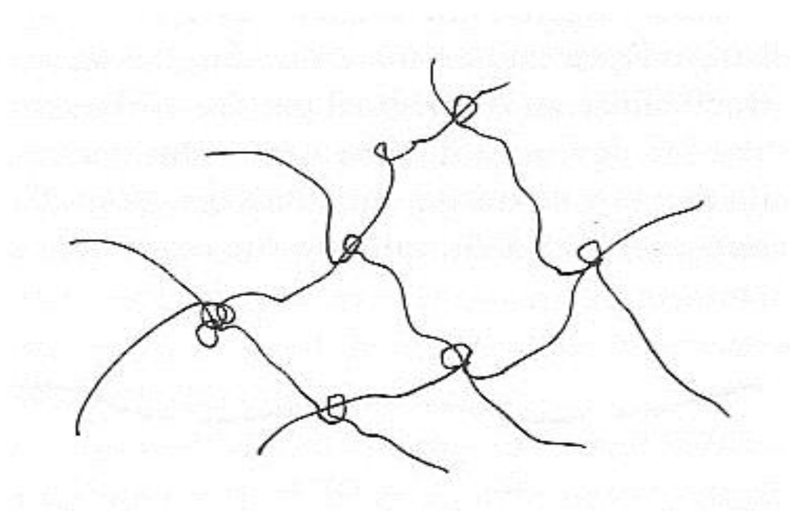


Figure 6: Meshwork of Interwoven lines (Ingold 2013b, pg 132)

Organising, from a meshwork perspective, entails a 'progressional ordering of reality' (Jarvis, 1997, p. 69 cited in Ingold (2007) p. 88). A reality constituted by, what Chia (2000) calls, an "initially undifferentiated flux of fleeting sense impressions, the brute aboriginal flux of lived experience, from which attention carves out and conception names" (p. 517). Organisations, then are like eddies cast in a flow (Bergson, 1998/1911). The fallacy of misplaced concreteness, as Bergson reminds us, is to treat "it as a thing rather than as progress, forgetting that the very permanence of its form is only the outline of a movement" (p. 128). So if processes do not connect, then how do they mutually shape one another? The answer to this lies in the notion of *correspondence* (Ingold, 2013b, p. 105).

The notion of *interaction*, which we have seen in the section on routines, denotes closure between the 'ostensive' and 'performative' 'parts' (Rerup & Feldman, 2011). The very prefix *inter-* conjures up the notion of a bridging operation where the two 'parts' can only come together through external contact. According to Ingold (2013b),

> "Any such operation is inherently detemporalising, cutting across the paths of movement and becoming rather than joining along with them. In correspondence, by contrast, points are set in motion to describe lines that wrap around one another like melodies in a counterpoint" (p. 107).

Correspondence, in other words is a 'movement' in real time where each process *co-respond with* one another. In other words, the same distinction which differentiates points from lines, distinguishes interaction from correspondence. While interaction reads process *across* contexts, correspondence reads '*process-with-contexts*' *alongly*, in movement, flow and transformation. The contrast is summarised in Figure 7 below.

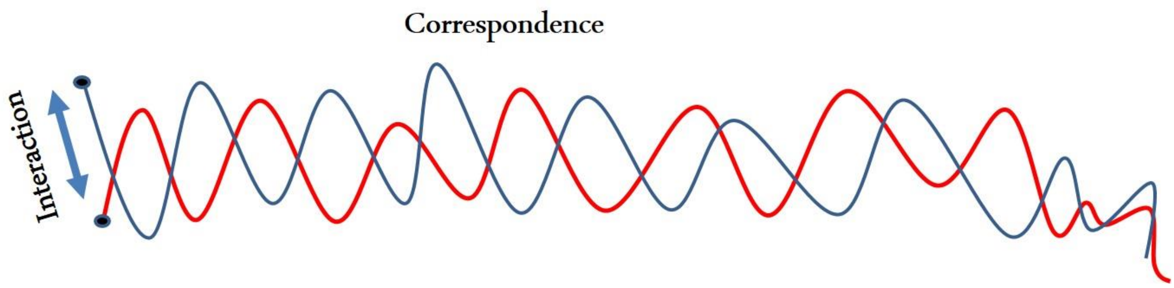


Figure 7: Correspondence and interaction adopted from Ingold (2013b, pg 107)

In sum, we have seen how Ingold's perceptive and imaginative scholarship opens up new lines of inquiry, ideally suited for 'processual' research. By discarding organisation and its environment in favour of 'organisation plus environment' as a process in real time, we can do away with problematic assumptions like ideal 'level of analysis', or terms like external and internal or intra and inter, now entrenched within organisational research. Further, by likening process to continuous, meandering lines, we can now observe how stability is accomplished through organising activities by following these processes in real time. Finally, the notion of the 'meshwork' with knots combined with the theory of correspondence, allow us to break free from ‘substantialist’ notions like networks and interactions, to embrace a truly processual paradigm.

3.5 Event, Evolution and History in Process Research

The difference between ‘process’ as an ontology and ‘process’ as an epistemology leads us to a crucial question. If indeed, process research involves considering a phenomenon dynamically, “in terms of movement, activity, events, change and temporal evolution” (Langley, 2007, p. 271), then how exactly does ‘process’, understood from the ‘substantialist’ perspective differ from the ‘processual’ perspective? Exploring this question is an important first step towards clarifying the theoretical dilemmas that are conveyed through the puzzles. In order to do this and for the section which follows, I rely wholly on Ingold (1986). Ingold’s penetrating analysis allows me to trace the origins of the theoretical dilemmas conveyed through the puzzles to a ‘substantialist’ ontology. Since these dilemmas cannot be resolved within the ‘substantialist’ ontology from which they originate, an *alternate becoming perspective* rooted within the processual worldview is proposed. This could extend the ‘process’ ontology into empirical research.

Since process research, focuses “empirically on an evolving phenomenon” (Langley, et al., 2013, p. 1), practitioners of ‘process’ research are confronted with two conflicting concepts of the modus operandi of change: the ‘historical’ and the ‘evolutionary’. Now if we are to adopt the ‘historical’ approach for studying process, then changes are consequent upon ‘events’. In the ‘evolutionary’ approach by contrast, “changes are produced by slow, continuous modification of an eventless world” (Teggart, 1972, pp. cited in Ingold, 1986, p. 74). Yet, Langley, Smallman, Tsoukas and Van de Ven (2013) explicitly insist that process theories must incorporate “temporal progressions of activities as elements of explanation and understanding” (p. 1). A ‘historical’ approach insists that, *progression is contingent* upon ‘events’ whereas the ‘evolutionary’ approach insists on *necessary progression*. Therefore, are we to understand process as either absolute advance ‘stage-by-stage’ (evolutionary) or advance relative to circumstances (historical)? The answer to this crucial question hinges on our understanding of the term ‘event’.

‘Events’ are central to process research because a sequence of ‘events’ constitutes the building blocks or ‘conceptual entities’ within the current practice of process scholarship (Pettigrew, 1990; Pettigrew, 1997; Langley, 1999; Poole & Van de Ven, 2010; Burgelman, 2011). In fact, Poole and Van de Ven (2010, p. 560) add granularity to this notion by building on the insights of Abbott (1984) who made a distinction between an *incident* (a raw datum) and an *event* (a theoretical construct). According to them, while an incident can be observed, an event can never be directly observed. Therefore, even though an event is constituted by a number of incidents which lead to it, different incidents can be chosen by theorists as indicators for the same event (Poole & Van de Ven, 2010).

For example, consider a meeting where the actors are discussing the specifications of the new product to be developed. Sitting through this meeting will allow researchers to capture what is being said and who is saying what. But the event here might be interpreted as ‘creation of customer requirements document’, ‘clarifying customer requirements’ or ‘negotiating product functionality’. Put differently, while *incidents can be observed*, *events are always inferred* from the empirical material. Poole and Van de Ven (2010) write,

> “Incidents are descriptions of happenings, documentary records of occurrences. Events are meaningful parsings of the stream of incidents. They are constructions based on more or less systematic interpretation by the researcher of what is relevant to the process. The stream of incidents, a first-order construction, is translated into a sequence of events, a second order construction” (p. 560).

Having inferred the events, majority of process research, as is currently practiced, takes two forms. It either attempts to identify the effect of a contextual variable on the evolution of events (Eisenhardt, 1989; Eisenhardt, 1991; Eisenhardt & Graebner, 2007) or it attempts to ‘follow the action’ to understand the effect of events on the state of an entity (Pettigrew, 1990; Pettigrew, 1997; Langley, 1999; Poole & Van de Ven, 2010; Burgelman, 2011). While the former attempts to identify “common progressions in sources of influence”, the latter is more concerned identifying “common sequences of events” (Langley, 1999, p. 702). Now as long as each incident is treated as a unique, isolable entity and its appearance a discrete event, then evolution understood, either as common progressions in sources of influence or as common sequence of events, consists of an accumulating concatenation of such entities and events. This is no different from Bergson’s ‘cinematographic method’ discussed earlier. In such an event sequence, as Ingold (1986) explains,

> "The semblance of continuity is created by running through the sequence on a time-scale just as the continuous motion of figures on a film screen is achieved by projecting in rapid succession a very large number of separate images, each minutely different from those both preceding and following" (p. 24).

According to this treatment, "*Process is to event as continuity is to discontinuity, and change exists only in the opposition between the two*" (Ingold, 1986, p. 24 my emphasis). Put differently, process marks the transition between two discontinuous events. Those practicing 'process' research are therefore left with two options. They can, as did Eisenhardt (1989; 1991; Eisenhardt & Graebner, 2007) and Burgelman (2011), start with process (as a property of the whole) and discover change by cutting it up into events, or they can, like Van de Ven and Poole (2005; 2010), Pettigrew (1990; 1997; 2012) and Langley (1999; 2007), start with particular events and discover change by aggregating them into processes. Only by doing so, is it possible for scholars in both camps to talk about how discrete events lead to "process of change" (Pettigrew, 1990, p. 273; Van de Ven & Huber, 1990, p. 216), or alternatively of "change events" (Van de Ven & Poole, 2005, p. 1381; Meyer, et al., 2005), as though 'change' were inherent in either one or the other.

Yet clearly, Eisenhardt, Poole and Van de Ven, Burgelman and Pettigrew, all have different notions of process. Process for Eisenhardt (1989, p. 546), who is a self-confessed positivist, is merely an explanation for how a set of independent variables provide a statistically significant explanation for change, often represented as a dependent variable. In this regard, her notion of change dynamics is more compatible with variance theory (Mohr, 1982) rather than process theory (Van de Ven, 1992). Her method for investigating process, relies heavily on cross sectional data, a 'fragmenting comparativism' (Ingold, 1986, p. 43) rather than an 'empathetic' longitudinal approach, favoured by the other three scholars. Variance theory, as discussed earlier, is grounded in a 'substantialist' ontology and therefore process and change, for Eisenhardt, are *something* that occurs between two stable states or events.

Burgelman (1983b), on the other hand, recognises the limitation of Eisenhardt's "comparative method" (p. 224). As he rightly observes, too often, "cross-sectional comparative analysis of cases without much explicit concern for the longitudinal dimension" (Burgelman, 2011, p. 594) of the process, tend to suppress organising dynamics. Process, for him, refers to "the pattern of activities of differentially positioned managers that, together, produce outcomes" (Burgelman, 1996, p. 194; Barnett & Burgelman, 1996, p. 16). His process models therefore document key activities of people at different hierarchical levels within the organisation to capture the flow of these interlocking activities.

Yet, his view of process is still 'substantialist' because the "ecological" approach to process which he advocates, "refers explicitly to the relationship between systems and their environments" (Burgelman, 2011, p. 600). Therefore, firms and environments are bounded entities *connected by process*, rather than *a process in real time*. Further, methodologically, he relies heavily on a historical approach, which he describes as, "inherently concerned with longitudinal development, and involve reconstructing the unfolding of individual and collective action patterns leading up to relatively unique events" (Burgelman, 2011, p. 594). Again, the notion of *'unique' events* gives his position away for process and change for him is marked by the discontinuity between these unique events. That is why Burgelman (2011) could present 'process' as a kind of history that endeavours to provide a 'descriptive integration' of phenomena perceived in terms of their totality, a totality whose reduction into elements would be the first task of objective, 'scientific' analysis (Ingold, 1986, p. 78).

Van de Ven and Poole (1989; 2005) too, harbour a 'substantialist' ontology where process refers to the impact of 'change events' on organisational 'entities' (Van de Ven & Poole, 1995, p. 512). Process, for them 'takes an event-driven approach' (Van de Ven & Poole, 2005, p. 1381) where progress and change are contingent upon 'events'. Thus, for Van de Ven, it is possible to measure change "by observing the same entity over two or more points in time on a set of characteristics and then observing the differences over time in these characteristics" (Van de Ven & Sun, 2011, p. 60). This clearly suggests an exogenous, view of process (Hernes & Weik, 2007) based on the stringing together of discrete events. Process is therefore apprehended by accumulating a series of discrete, empirical events. This is precisely the reason why Van de Ven and Poole (2000) have no problems reducing a 'process' theory into 'variance' theory. The former, for them, consists of an assiduous collection of discrete empirical facts whose dissolution into a framework of general principles constitutes the latter (Ingold, 1986, p. 77).

Pettigrew (2012) is a trenchant critic of research on organisational change that is "acontextual, aprocessual and ahistorical" (p. 1307). His statement illuminates the distinction he draws between ‘process’ and ‘history’, with regards to change. The distinction is based on a founding dichotomy between a processual history of conscious subjects or ‘persons’ and an eventful history of entities, objects or ‘things’. Ingold (1986) explains,

> “This dichotomy has an important bearing on the vexed question of whether it is possible to divide history from science. Many choose to emphasise the importance scientists attach to objectivity, with the implication that observers must take up a position wholly external to the phenomena they are investigating. To appreciate the lived experience of historical agents is to enter subjectively into their social world rather than to remain a spectator on the sidelines. On the other hand, the externalisation of the object is a precondition for the establishment of the history of things, be they natural or cultural. Their concern is with the reconstruction of particular chronological sequences” (p. 76).

It is this ‘externalisation’ that allows Pettigrew to make a distinction between the ‘content’ and ‘process’ of change. Content refers to what actually changes in an organisational entity, while process examines how the change occurs (Barnett & Carroll, 1995). Pettigrew can then present a historical account of the *‘change process’* by combining content which focuses on the antecedents and consequences of organisational change with process which examines the sequence of events over time as change unfolds in an organisation. Therefore, this too is an ‘exogenous’ view and can provide only a ‘spectator’s’ view of the change process (Tsoukas & Chia, 2002). Processes, here, are epiphenomenal, confined to something that happens *between* states, events, things or entities. Thus, Pettigrew’s ‘process’ scholarship is without doubt ‘substantialist’, rooted within the ‘being’ ontology.

Now contrast this with a ‘processual’ understanding of events. It may be agreed that events, indeed are made up of incidents and activities. But rather than conceiving each incident or activity which makes up an event as an isolable, empirical entity, we could regard each particular as a moment or ‘nexus’ in the unfolding of a total process (Ingold, 1986, p. 79). The activities and incidents which constitute the events, from this perspective are then ‘*processional*’, whereas from substantialist perspective, they are ‘*successional*’ (Ingold, 2011, p. 53). The difference between the ‘processional’ and ‘successional’ views is succinctly summarised by Ingold (1986) in the passage below:

> “If we take the former view, our ‘descriptive integration’ – will be partial depiction of the whole as seen from a particular vantage point in an unbounded, spatiotemporal continuum. To focus on the event is then to contemplate it as one would a crystal ball, whose outer surface appears to vanish as the eye penetrates even further within. The whole world is there within that event, if only one can

> just see far enough. But place the ball somewhere else in space and time and the image will be different, like a photograph taken from another angle. Concentrating thus solely on the exteriority of events, and finding nothing of significance within, we could proceed with a reconstitution of (dead) process" (p. 79).

Therefore, from a substantialist being conception, the totality of a phenomenon is seen to be constituted by the aggregation of discrete interacting elements each of which exist as a static, independent entity prior to its incorporation. In a 'processual', becoming conception, by contrast, "elements have no existence apart from the total, continuous process of which they are but particular points or moments of emergence" (Ingold, 1986, p. 43). A phenomenon from a 'processual' perspective, therefore, is conceptualised not as a cluster of variables but as *a total process* with the variables being a determinate point within its unfolding (Ingold, 1986, p. 44). A 'processual' comprehension of a phenomenon, therefore, requires the researcher to assume a position *within* the social process itself. The contrast between the 'substantialist' and 'processual' accounts of history is expressed as follows:

> "According to the first, history consists of a concatenation of discrete and transitory entities or events, each unique in its particulars. It is a sense that attributes a great deal to chance, contingency or 'happenstance', and little or nothing to purpose or design. The second view holds that history begins with consciousness, or to impose a further limitation, with self-consciousness. History, they say, does not just happen; it is made through the intentional activity of conscious purposive subjects – by people. But as historical agents, we act from within, as participants in our own creation" (Ingold, 1986, pp. 74-75).

The fundamental characteristic of history from a 'processual' perspective, as the above passage reveals, lies not in the chronological relation of events but in their descriptive integration. Stated differently, 'processual' history, as Ingold (1986) correctly points, "is a kind of evolution, if the latter be understood in the sense of a continuous unfolding, as directed movement rather than changeful sequence" (p. 98).

With these observations, it is now time for us to reconcile the 'evolutionary' and the 'historical' *modus operandi* of change. What appeared within 'substantialist' process research as divergent, is actually reconciled from a 'processual' perspective. Four points are salient. First, as the 'processual' perspective suggests, both historical and evolutionary change deals with processes rather than events. Second, unlike the reconstituted continuity of Bergson's motion picture, they both start out from the premise of *continuity*, as it is immediately given to the conscious experience. Third, rather than the atomistic approach to events, adopted by the current mainstream process theorists, the ‘processual’ perspective embraces a *holistic* or totalising approach. Events are therefore moments in the unfolding of an essentially invisible process. Fourthly and finally, as Ingold (1986) observes, “both history and evolution are given direction by the agency of consciousness. Far from ‘just happening’, they are made. In other words, they embody *teleology* or purpose” (p. 102 emphasis in original).

To summarise, I began this section by speculating about the implications of ‘substantialist’ being ontology and the ‘processual’ becoming ontology for the practice of ‘process’ research. I then compared and contrasted how ‘events’ have been understood and adopted by several prominent practitioners of ‘process’ research. ‘Events’ were seen as central to the development of a process theory. I then demonstrated the contrast between a ‘processional’ and ‘successional’ process theory. This distinction was based on a divergent understanding of ‘events’, ‘process’ and ‘history’. In the ‘successional’ view, the world is composed of a large number of autonomous entities whose chronological succession, as a series of discrete empirical events constitutes a process. In the ‘processional’ view, the world is brought into being by heterogeneous processes, a continuous, creative movement *conducted through* events and not contained within them. Figure 8 below summarises the arguments from this section by demonstrating the ‘logic of inversion’ along Ingoldian lines.

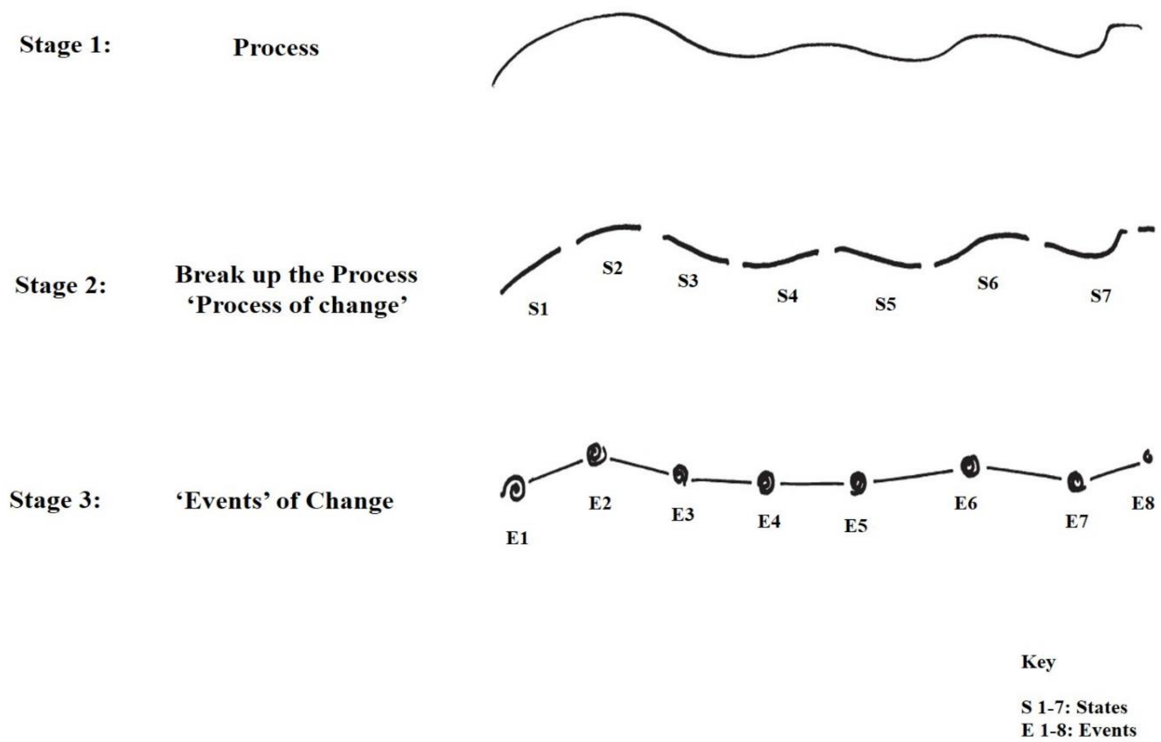


Figure 8: Revisiting the Logic of Inversion, adapted from Ingold (2011, pg 150-151)

As Figure 8 illustrates, what is originally a continuous process is broken up. All movement is enfolded (Bohm, 1996), either into 'processes' of change or 'events' of change, to reconstitute the change process. History from the 'processional' perspective is 'becoming', integrative and totalising. From the 'successional' perspective, however, it is static, analytic and atomising. In the latter, theorists "confront the whole already broken into discrete fragments that can then be strung out in temporal succession to reconstitute process" (Ingold, 1986, p. 76). In the former, theorists "aim to grasp the movement of the whole by a direct leap of intuition, by living it in their minds" (Ingold, 1986, p. 76; Bergson, 1998/1911). History, in the 'processional' view, in Ingold's (1986) words, "is like art, and the task of historians is to describe, translate and interpret, but not to dissolve it into elements" (p. 77). In so doing, the evolutionary and the historical notions of change are united within this 'processual' worldview.

3.6 Revisiting the Theoretical Puzzles

The previous chapter, concluded by summarising the dilemmas confronting innovation theorists into four seemingly insurmountable and vigorously contested puzzles. To recall, the first involved the relationship between persistence and change. Put simply, how do organisations remain stable while innovating? The next puzzle involved the temporal distinctions between synchrony and diachrony. Are temporal dynamics and their associated trade-offs better captured using synchronic or diachronic techniques? The third puzzle involves the role of necessity and chance. Are innovations discovered or are they created? (Garud, et al., 2014; Venkataraman, et al., 2013; Alvarez & Barney, 2007). The fourth puzzle relates to the third puzzle by calling into question the relationship between 'path dependence' and 'path creation' (Vergne & Durand, 2010; Schreyögg & Sydow, 2011; Garud, et al., 2010). What is the relationship between structural determinism and agentic free will, especially while innovating? In this section, I apply Ingoldian (1986; 2013a) insights to trace and clarify the origins of these dilemmas to a 'substantialist' worldview. I then demonstrate how embracing an alternate processual worldview allows us to circumvent these dilemmas. This alternate Ingoldian becoming perspective which emerges I argue, is better suited to tease out the dynamics of organising while innovating.

3.6.1 Persistence versus Change

A fundamental dilemma in organisational theory is the relationship between stability and change. As we have seen earlier, change has been defined as difference in quality, form or state over time on an organisational entity (Van de Ven & Poole, 1995; Van de Ven & Sun, 2011). I've also shown how the substantialist ontology, by distinguishing between evolutionary and historical change, pits stability against change. This is because despite their adherence to a process epistemology, substantialist theories identify stability with the persistence or continuity in form, state or quality. The discontinuity in these qualities over time represents change (Meyer, et al., 2005; Burnes, 2005).

Let us first consider the continuous transformation model of change proposed by Brown and Eisenhardt (1997). By focusing on multiple product innovation and the 'continuous change' (p. 25) that makes it possible, they reject both the incrementalist and punctuated equilibrium models of change (Romanelli & Tushman, 1994; Gersick, 1991). They recognise that change cannot be linked to the occurrence of particular events because focusing on such events, as the punctuated equilibrium model does, would come at the expense of "understanding the kind of rapid, continuous change" (Brown & Eisenhardt, 1997, p. 32) which managers encounter during new product development. Eisenhardt's solution therefore is to focus on 'interruption', understood as discontinuities within the process. According to her, "interruption enables flexibility because it creates a pause in the flow of activity that can trigger reassessment and change of direction" (Eisenhardt, et al., 2010, p. 1269). Thus, for her the opposition between *persistence and change is congruent* to the opposition between *continuity and discontinuity*.

Burgelman (Barnett & Burgelman, 1996; 1996; 2011) too, like Eisenhardt, is a critic of the 'punctuated equilibrium' model of change. However, his epistemology, unlike Eisenhardt's is thoroughly 'process' oriented, tracking change longitudinally. Yet, his substantialist ontology becomes explicitly evident in his detailed 'stage-by-stage' process models (Burgelman, 1983b; Burgelman, 1996) which arrange 'activities' within defined stages to chart the course of general process. So, the 'historical' and the 'evolutionary' views of change, cannot be completely reconciled here because a 'processual' perspective requires a rejection of the essentialist taxonomies that underpin Burgelman's process models. Put differently, Burgelman, envisages change as the serial replacement of 'stages' judged by difference in either quality, form or state, longitudinally, on an organisational entity. Thus, here too, the opposition between *persistence and change is congruent* to the opposition between *continuity and discontinuity*.

Both Pettigrew (1990; 2012) and Van de Ven (along with Poole), like Burgelman and unlike Eisenhardt, embrace a 'process' epistemology. They favour longitudinal field studies over cross-sectional studies to identify organisational dynamics. Yet they treat their data very differently. While Pettigrew favours the 'descriptive' idiographic approach, Van de Ven and Poole favour the analytical nomothetic approach (Tsoukas, 1989). Hence, Pettigrew's explicit concern with 'ahistorical' process research, because process for him emerges from the reconstitution of history as an authentic account of the succession of events in a particular firm, in defined contexts, over a particular period of time. Poole and Van de Ven (2000), however, were more concerned with the formulation and validation of 'laws of social statics' and 'laws of social dynamics'.

Yet, these scholars are united in their 'substantialist' ontologies. By observing empirically a world already dissolved into structures and processes, they explicate change dynamics, to borrow Ingold's (1986) words, "from the processing by induction[6] of events as seen by an intellect that stands outside the world, rather than from the experiencing of events by an intuition installed within it" (p. 79). Thus structure and process is viewed by Pettigrew (1990) as a duality. Hence his recommendations to scholars to "look for continuity and change" (p. 271) within contexts and structures. He writes,

> "The more we look at present-day events the easier it is to identify change; the longer we stay with an emergent process and the further back we go to disentangle its origins, the more we can identify continuities" (Pettigrew, 1990, p. 272).

Thus, for Pettigrew too, the opposition between *persistence and change is congruent* to the opposition between *continuity and discontinuity*.

For Van de Ven and Poole (1989), the notion of stability and change present a paradox. They write,

> "It is evident that organizations are admixtures of stability and change: Organizations are relatively stable, enduring features of life, yet when we look closely they do not appear stable at all. They are

[6] Although Poole and Van de Ven also suggest the use of 'abduction' (Poole, et al., 2000, p. 121) in their reasoning.

> continuously changing, continuously being produced and renewed by member activities. Nevertheless, an argument can be made that stability is primary; any change is observable only in contrast to some stable state. Organizational change also can be explained as aberrations from the stable state, as sudden upheavals which disrupt organizational stability" (p. 564).

For them, not only are the notions of stability and change antithetical, but the opposition between *persistence and change is also congruent* to the opposition between *continuity and discontinuity*. The practice and routines theorists claim that their ostensive-performative distinction is a duality. Yet while theorising they reduce this duality to a dualism by pulling structure and agency closer and stressing their interdependence without merging them (Farjoun, 2010, p. 204; Feldman & Orlikowski, 2011). By doing so, they again equate change with discontinuity and stability with continuity. The challenges faced by these theorists to integrate the 'historical' and 'evolutionary' modus operandi of change within their theories is a direct consequence of the 'substantialist' ontology.

We can no longer continue to postpone confronting this apparent paradox. It was noted earlier that organisations can be regarded, either as an individual entity embodying a specific configuration of elements (Eisenhardt, et al., 2010; Pettigrew, 2012; Burgelman, 2011; Van de Ven & Sun, 2011), or as an embodiment of organising processes which consist of a never resting stream of interlocking activities (Tsoukas & Chia, 2002; Hernes, et al., 2013). Again Ingold (1986, p. 155) presents a very eloquent work around for this paradox. An organisation exists as a definable entity only in so far as it exists in a stationary state. Change then, like in Burgelman's process models (1983b; 1996), involves the abrupt substitution of one state for another. Thus nothing can change where nothing persists; nor can we know, as Van de Ven and Poole (1989) rightly point, *what* has changed except in the context of an assumed equilibrium. That is why it is contradictory to say, like Brown and Eisenhardt (1997) do, that an organisation – or any kind of entity –is *constantly* changing. We must, therefore, for the same reason conclude that *the opposition between persistence and change is not congruent to that between continuity and discontinuity.*

"It is a fatal error", as Ingold (1986) so perceptively points out, "born out of a tendency to conceive a world already parcelled up into discrete blocks, to equate continuity with the persistence of form" (p. 155). Thus from a 'processual' perspective, the substantialist opposition between persistence and change is unified into 'movement'. In a processual world, as Bergson (1946/1992) explains,

> "There are changes, but there are underneath the changes no things which change: change has no need of a support. There are movements, but there is no inert or invariable object which moves" (p. 147)

To conclude, in this section I have analysed the treatments of change within various 'process' theories in organisational research. I have shown how the 'substantialist' ontology by equating persistence with continuity and change with discontinuity, approaches a logical impasse. This logical impasse is circumvented when we adopt a 'processual' perspective where the opposition between persistence and change is not congruent to the opposition between continuity and discontinuity. Put differently, it is perfectly possible to have continuous change and discontinuous persistence, if we are prepared to embrace process, rather than substance as the fundamental constituent of reality. In other words, stability and order are transient and are accomplished through deliberate acts of organising within a fluxing and flowing reality. So while a 'substantialist' worldview pits persistence against change, a processual worldview unifies persistence and change within 'movement'.

3.6.2 Synchrony versus Diachrony

The treatment of time, as we have seen in the literature review, is what separates the 'innovation as output' from the 'innovation as process' perspective. Innovation research, in recent years has urged scholars to take the 'temporal' complexities encountered by innovators seriously (Garud, et al., 2014). I'm yet to find a practitioner of 'process' research who does not, at least in their writings, pay heed to the temporal aspect of 'process' research (Pettigrew, 1985; 1990; 2012; Burgelman, 2011; Langley, 1999; 2007; Langley, et al., 2013; Van de Ven & Poole, 2005; 2010; Garud, et al., 2014). By presenting theoretical accounts devoid of time, aprocessual management research, they argue, supresses dynamics by failing to account for the role and interconnectedness of time, history and change, captured by the notion of temporality (Langley & Tsoukas, 2010; Langley, et al., 2013).

So what exactly do we mean by temporality? It certainly is not chronology, for a chronological account merely represents a regular system of dated time intervals in which events take place. Nor can temporality be understood as history, where history is treated as a series of events set within a system of chronological time (Ingold, 2000, p. 194). The relationship between chronology and history is succinctly summarised by Kubler (1962) when he writes,

> "Our actual perception of time depends upon regularly recurrent events, unlike our awareness of history, which depends on unforeseeable change and variety. Without change, there is no history, without regularity, there is no time. Time and history are related as rule and variation: time is the regular setting for the vagaries of history" (p. 65).

Now temporality *cannot* be understood, either by accounting for the mere succession of dates in which case we have no events as everything repeats or by the mere succession of events in which case we have no time as nothing repeats (Ingold, 2000, p. 194). Temporality, refers to the experience of time and is therefore 'lived' time (Bergson, 1998/1911). In order to capture temporality, the researcher must be able to perceive "*the continuity of the social process as it was experienced by people'* while innovating, '*which is lost in the mere record of events – however complete*" (Ingold, 1986, p. 95).

A common criticism from the current, 'process', 'practice' (Barley, 1986; Orlikowski, 2007; Jarzabkowski, 2003; Feldman & Orlikowski, 2011; Seidl & Whittington, 2014) and 'routines' (Feldman & Pentland, 2003; Becker, 2004; Friesl & Larty, 2013) scholars towards 'variance' theorists is that the "temporal structure of social practices and the uncertainty and urgencies that are inherently involved in them are passed over in the search for empirical regularities and contingency models of explanation" (Langley, et al., 2013, p. 4). Broadly speaking, organisation theorists have captured temporal dynamics either implicitly by compressing temporal complexities into variables like fast and slow or dynamic and stable (Langley & Tsoukas, 2010), or explicitly by studying the temporal evolution of the phenomena under investigation. The former provides us with a synchronic account of the phenomena while the latter provides us with a diachronic account of the phenomena.

Here too, we are confronted with the dualism between synchrony and diachrony. This dualism is seldom acknowledged by practitioners of process research. The most explicit articulation of this distinction I have found so far has been made by Barley (1990). In his study of technology structuring within the radiology departments of two American hospitals, Barley

(1990), who by his own admission is a 'structuration' theorist and views structure and process as a duality, spells out the implications of structuration for the practice of process research. According to him,

> "Any social setting can be read as a historical document of itself shelved momentarily between past and present. Whatever the current social order, we know it became so from what it was in the past. Whereas a synchronic analysis would freeze time and look across a radiology department as a whole, a diachronic analysis would seize time and examine the developmental path of a specific technologies use" (p. 222).

Put differently, a synchronic analysis, by capturing a 'timeless' snapshot of cross-sectional data, allows an intra-organizational comparison of a phenomenon. On the other hand, "longitudinal and diachronic both", as Barley (1990) points out, "refer to chronologically arrayed data. However, the former does not carry the latter's evolutionary connotation. An evolutionary perspective is especially important if one wishes to analyse transformations of action rather than merely identify and examine historical trends" (p. 224). The surfacing of this dilemma between historical and evolutionary change is a consequence of embracing a 'substantialist' ontology. This suggests that Barley's notion of duality is actually a dualism between persistence and change, which in Farjoun's (2010) words, "feed one another diachronically—in an ongoing dialectic process of renewal and dynamic interplay" (p. 224).

Generality of research findings within synchronous accounts (Eisenhardt, et al., 2010; Brown & Eisenhardt, 1997) depends on the uniformity of findings across contexts, whereas generality of diachronic, longitudinal research, like those conducted by Burgelman (2011), Pettigrew (2012) and Van de Ven and Poole (2005, p. 1382), depends on versatility of the findings across cases. The temporal dynamics which emerge from the process methods of Burgelman, Pettigrew and Van de Ven and Poole have the longitudinal depth and the accompanying historicity which Eisenhardt's multiple case study method lacks.

However, even though "longitudinal depth is gained by virtue of using a multiple snapshot method, and historicity is granted through a deeper understanding of events as situated in their historical context" (Avital, 2000, p. 670), this is still not enough to explicate the temporal dynamics. Why? This is because the synchronic and diachronic temporalities which emerge from the multiple snapshot method, deals in simultaneities and successions respectively. Both invoke a chronological – hence mechanical, eternal and abstract Newtonian sense of time, whereas social life, as Ingold (1986) convincingly argues, "is a process in real, Bergsonian time" (p. 138) that is creative and cumulative.

This notion requires some unpacking. Time, in organisational research has been understood from two specific perspectives, the Newtonian and Bergsonian perspectives respectively (Chia, 2002; Nayak, 2008; Hernes, et al., 2013; Hernes, 2014). Ingold (1986) again offers a crisp distinction which contrasts the two perspectives,

> "Were time considered intrinsic to the life-process, the moments spun by a Newtonian machine would be but segments of a timeless eternity; if on the other hand, time is regarded as an eternal thread, the life process would dissolve into a multitude of events suspended *in* time" (p. 164).

The former refers to Bergsonian time and is identified with the duration of being. It refers to the flowing movement of life and consciousness and therefore is cumulative and creative. Cumulative because when a person is identified with the trajectory of his or her past experience, then in their "particular cumulative biographies, we must admit first that no person can be quite the same from one moment to the next, and second that there is no obvious point at which we should begin" (Ingold, 1986, p. 107). Creative, because it is above all an oriented and progressive movement (Bergson, 1998/1911; Whitehead, 1929/1978). Duration, or durée as Bergson (1998/1911) calls it, denotes the temporal flow of social life. In contrast, the latter perspective by invoking 'an eternal thread', refers to the familiar 'clock' time or Newtonian time. It is identified as the mechanical, eternal time of non-being.

Newtonian time manifests itself in both synchronic and diachronic accounts of process. In synchronic studies, such as those of Eisenhardt (Eisenhardt, et al., 2010; Brown & Eisenhardt, 1997), time is merely a medium in explanations of organisational change. In diachronic studies, like Langley (1999; 2013) and Van de Ven and Poole (2005), time is like the metaphorical temporal clothes line on which events are pegged chronologically. As Van de Ven and Poole (2005) write, "it conceptualizes change as a succession of events, stages, cycles, or states in the development or growth of an organization" (p. 1389). Both perspectives assume time as a linear continuum divisible into uniform units that are all equivalent to each other and independent of the objects and people who experience it. Therefore, this notion of time is abstract, reversible (we can after all reset a clock) and utterly opposed to time as duration.

Yet, we cannot treat *time*, as Van de Ven and Poole (2005) do, *as the substance of becoming* and in the same breath treat *becoming as a succession of events in time*, "without – as it were – turning time inside out, so that what was immanent in a real process is converted into an abstract container for events” (Ingold, 1986, p. 132). Nor is research on *duration* from the ‘processual’ perspective, as Van de Ven and Poole (2005) seem to suggest, about researchers using “socially meaningful metrics such as the calendar, which measures time in equal units that are socially meaningful to the participants involved in the process being studied” (p. 1391). Both these oversights, stem from a profound misreading of the ‘process’ ontology and temporality. While it is true that we ‘think’ in terms of dates in the calendar, we do not ‘live’ them. Thus Van de Ven and Poole’s ‘socially meaningful’ dates, “far from constituting the foundation of becoming, are superimposed on it by the intellect” – we pin dates to process data rather than process data to dates. Therefore, as Ingold (1986) notes, the accumulation of all possible dates, “hovers over rather than underlies the real historical process” (p. 138).

We can now confront the challenges of capturing ‘temporal evolution’ (Langley, et al., 2013) in process research. Neither can we proceed by embracing synchrony, as Brown and Eisenhardt (1997) do, for the temporal complexities would only capture ‘simultaneities: relations of co-existing things and from which the intervention of time is excluded’, nor can we proceed by embracing historic (Burgelman, 2011; Pettigrew, 2012) or longitudinal (Barley, 1990; Pettigrew, 2012; Poole & Van de Ven, 2010; Langley, et al., 2013) diachrony, for the only temporal complexities captured would be successions: only one thing can be considered at a time but upon which are located all the things on the synchronous axis together with their changes. Synchrony corresponds to the *state* of the phenomena at a given time and diachrony corresponds to its *evolution* over a period of time (Ingold, 1986, pp. 138-139 emphasis in original).

We again arrive at our original conceptual impasse between the historical and evolutionary modus operandi of change. To quote from Ingold (1986),

> “That is to say, it (evolution) is not a movement, but a succession of states each of which is momentarily fixed. The jump from one state to another is always brought about by an instantaneous event which is purely fortuitous and wholly unintended. Each move is absolutely distinct from the preceding and subsequent equilibrium. The change effected belongs to neither state: only states matter” (p. 139).

We are therefore, stuck with diachronic ‘evolution’ which consists merely of a concatenation of discontinuous states, punctuated by events. Yet in practice, positions while organising and innovating are not fixed but fluid. Each move unfolds not as an instantaneous event but rather the culmination of a continuous process of conscious (though not necessarily self-conscious) deliberation (Ingold, 1986, p. 140). So how can this impasse be overcome? Once again, Bergson (1998/1911) illuminating prose penetrates our conceptual fog. He writes,

> “If the state which remains the same is more varied than we think, on the other hand the passing from one state to another resembles, more than we can imagine, a single state being prolonged; the transition is continuous. But, just because we close our eyes to the unceasing variation of every psychical state, we are obliged, when the change has become so considerable as to force itself on our attention, to speak as if a new state were placed alongside the previous one. Of this new state, we assume that it remains unvarying in its turn, and so on endlessly. The apparent discontinuity of the psychical life is then due to our attention being fixed on it by a series of separate acts: actually there is only a gentle slope; but in following the broken line of ours acts of attention, we think we perceive separate steps” (pp. 2-3 also cited in Ingold (1986) pg 156)

Therefore, just like the paradox between persistence and change, a synchronic account, by treating an organisation as though it were persisting in a steady state, ignores any changes that are taking place in its features. The diachronic account, by contrast is concerned with demonstrating ‘how change unfolds in organizational entities’ (Van de Ven & Poole, 2005, p. 1389) over a period. “Synchrony and diachrony”, as Ingold (1986) writes, “are not to be taken as co-ordinates of the real world, but rather are to be applied in social analysis for resolving conceptually, the flux of experience into relatively constant and relatively variable components” (p. 156).

Change can therefore, not be apprehended by stringing together into sequence, what are really discontinuous entities. Theories of ‘punctuated equilibrium’ (Gersick, 1991; Romanelli & Tushman, 1994), which influenced the MIRP studies (Garud, et al., 2013), proceed by cutting into segments what is really a continuous flow. The result is a series of punctuated equilibria. Once we, following Bergson’s lead, admit that reality, far from the ‘substantialist’ cry, is actually a fluxing, flowing movement, we can concur with his observation that passing from one state to another, is essentially no different from persisting in the same state. On approaching reality, consistent with the ‘processual’ view, the distinction between synchrony and diachrony simply dissolves to yield duration.

Before I conclude, it is also crucial to clarify the relationship between objective Newtonian time and subjective Bergsonian time within a processual worldview. Doing so would integrate the notion of chronology and history expressed by Kubler (1962), with duration. Central to objective Newtonian time is the notion of recurrence. Our ordinary experience of time is filled with recurrences – of days, seasons, years so on and so forth. Without recurrence and repetition, both new knowledge (Whitehead, 1925, p. 31), as well as measurement of time (Van de Ven & Poole, 2005) would be impossible. Impossible in the former because, new knowledge can be deemed new only when referred to our past experience. Impossible in the latter because measurement requires imposing fixed intervals on something which recurs.

Yet, *experiencing repetition*, requires both a person who experiences and something that repeats. Consequently, "it follows that repetition is perceived through the superimposition of a mechanical chronology, establishing a system of fixed intervals, upon the duration of consciousness" (Ingold, 1986, p. 164). Thus, the distinction between Newtonian time and Bergsonian time is congruent to the difference between self-consciousness and consciousness. Ingold (1986) sums it up well when he writes,

> "Time must therefore be distinguished from the awareness of time just as consciousness must be distinguished from self-consciousness, the former being intrinsic to life and the latter distinctive of human life. Reflection requires cutting out past states from the stream of consciousness and hold them over for re-presentation as objects of attention in the here and now" (p. 166).

To conclude, in this section I have analysed the treatment of time within various 'process' theories in organisational research. I have shown how the 'substantialist' ontology, by equating synchrony with state and diachrony with evolution, approaches the same logical impasse encountered between persistence and change. This logical impasse is circumvented within a 'processual' perspective where synchrony and diachrony merge to yield duration. Whereas in Newtonian time, events are isolated happenings, succeeding one another, frame by frame, each event in Bergsonian time "is seen to encompass a pattern of retentions from the past and protentions for the future" (Ingold, 2000, p. 194). Thus temporality and historicity from a 'processual' perspective are not opposed but rather merge in the experience of practitioners who, through their activities, carry forward the process of organising and innovating. This clarifies the relationship between synchrony and diachrony and we can now examine the relationship between necessity and chance.

3.6.3 Necessity versus Chance

The role of necessity and chance, while innovating was the third puzzle to emerge from the literature review. This dilemma is evident within two distinct yet complementary streams of innovation research. The first stream, pits the 'discovery' perspective against the 'creation' perspective on innovation (Garud, et al., 2014; Venkataraman, et al., 2013; Alvarez & Barney, 2007). In the second stream which is concerned with 'search' processes for innovation, it pits the 'search scope' strategy (Ahuja, 2000) against the 'search depth' strategy (Maggittia, et al., 2013). The main contention pertains to the treatment of agency. While the 'discovery' and 'search scope' perspectives are complementary and attribute innovation to pre-existing opportunities in exogenous contexts, the 'creation' and 'deep search' perspectives which are complementary insist that innovation opportunities do not pre-exist but rather are created endogenously. Innovation therefore, within both perspectives emerges from a mixture of pure chance and mechanical necessity.

According to the 'discovery' perspective, well captured in the individual-opportunity nexus theory (Shane & Venkataraman, 2000; Venkataraman, et al., 2013), innovators are atomistic actors working within exogenous, established contexts. The creation theory (Alvarez & Barney, 2007; Alvarez, et al., 2013) recognizes that opportunities are not always exogenous, but could be endogenously created by the action of people seeking ways to develop new offerings (O'Connor & Rice, 2013). Here, even though innovators are atomistic actors confronting an exogenous context, the context rather than providing an *ex-ante* source of opportunity (necessity), acts as the *ex post* arbiters (chance) of the innovator's efforts (Garud, et al., 2014). In both perspectives, agency is located within individuals facing the world out there. The *world out there* creates not just the necessities to innovate but also performs the role of censorship from which the efforts of individuals emerge *by chance*.

Within the 'broad' versus 'deep' search debate, largely confined within the 'networks' perspective on innovating, innovations are seen to be resulting from either a 'broad' search strategy panning multiple networks (Ahuja, 2000) or from a 'deep' search strategy where the depth of the network (knowledge) structures is exploited by individuals. Here, the search 'process is largely context-driven' (Maggittia, et al., 2013, p. 97). Actors in these networks are implicitly assumed to be "cognitively hollow, passive vessels through which information and knowledge flow unimpeded and unchanged" (Phelps, et al., 2012, p. 1148). Here too, networks are viewed as exogenous, acting as the ex-*post* arbiters of the innovator's efforts. Agency is once again assigned to the individual innovator who through a combination of necessity and chance, negotiates the search terrain (Maggittia, et al., 2013). The *networks out there* exogenously create the opportunities for actors to innovate. Actors, react to these opportunities through a variety of responses. Networks then engage in the role of censorship from which innovations emerge *by chance*.

Both these debates underemphasise the role of creativity in the process of innovating. In the literature review, we have seen that all definitions of innovation insist on novelty or newness. It is however possible to distinguish between two kinds of novelty. Within novelty of the first kind, creativity is inherent and it denotes the transitive usage of the verb 'to create'. To create, in other words, is to cause to exist, make or produce and implies subjective agency (Ingold, 1986, p. 177). Novelty of the second kind, the kind implicated in the above debates, rather than being created is actually only *revealed*. This distinction between two very different understandings of novelty is what separates resultant processes from emergent processes (also see Garud, et al., 2015 for an excellent discussion on this point). Within resultant processes, novelty can be reduced to the properties of its individual parts. Not unlike our hydrogen-oxygen-water example. Innovation then is essentially a mere recombination or reshuffling of pre-existing elements.

The necessity versus chance debates are a result of *reading innovation backwards*. By this I mean "starting from an outcome in the form of a novel object and tracing it, through a sequence of antecedent conditions, to an unprecedented idea in the mind of an agent" (Ingold, 2011, p. 215). Since almost all studies where these debates surface are *ex-post*, theorists essentially retrace the chain of causal connections from the novel object to an agent. In the absence of an identifiable agent, the result is attributed to chance. "But chance alone", as Ingold (1986) astutely observes, "is not an agent, rather we use the word 'chance' to fill the blank in the sentence that would otherwise be occupied by the name of the agent, if one existed. Through such substitution, chance deputizes as creative subject, whilst actually signalling its absence" (p. 177).

To invoke 'necessity', on the other hand, is to suppose that the ends are already given in advance of the process. This argument can take the form of either radical mechanism or radical finalism. Ingold (1986) sums it up well when he writes,

> "The finalist asserts that all things come to be as parts of a pre-arranged program, and therefore that their appearance amounts only to revelation. The mechanist too, reduces all performance to a programme, but it is one that came into being with the machine, rather than prior to its realisation in the mind of a creator, and that consequently remains to be discovered and comprehended by the

> human intellect. Either way, to say that something 'necessarily' follows is to affirm that it reveals or replicates what already *is*, and therefore that its appearance attests to the *persistence* of a particular state of affairs. If in the event, something else quite unexpected comes to pass, the mechanist would be led to conclude that – by chance – a novel state has come into being, of which the unexpected is a necessary consequence. Thus we find again that persistence is to change as necessity is to chance" (p. 204).

We are thus brought back to our original logical impasse. Overcoming this recurring dilemma requires us to give up thinking about reality as a succession of states and embrace the notion of continuous process. In this fluxing flowing reality, nothing persists which means we need not invoke necessity in our explanation. Nor can we put it down to chance, since chance, by referring "to an event happening in the absence of any obvious design (or randomly), one that is irrelevant to any present need or of which the cause is unknown" (De Rond & Thietart, 2007, p. 536) is constituted by its opposition to necessity. We therefore have to conclude that the 'substantialist' opposition between necessity and chance dissolves into the *immanent creativity* of the process.

This observation is not as surprising as it seems. Past studies within innovation 'process' research, though 'substantialist', have alluded to this notion. For example, Burgelman (1983a), observed that the autonomous strategy within ICV always escaped "the selective effects of the structural context by mere chance or because alert actors are able to circumvent, or play to their advantage, the selective mechanisms" (p. 67). Similarly, Van de Ven and Sun (2011) acknowledge their inability to reconcile institutionalism ('the rules of the game that make life predictable') with individualism which celebrates 'individual freedom, creativity, and self-governance' within their life cycle motors of change (p. 70). Similarly, the 'breakthrough' and 'bricolage' approaches (Garud & Karnoe, 2003), discussed earlier, are not so much 'contrasting approaches', as the authors suggest, but rather different outcomes which because of creativity, turned out the way it did. Within the 'narrative' perspective, too often, the notion that things could have easily turned otherwise is lost as the accounts are retrospective (Hoholm & Araujo, 2011, p. 935).

To conclude, in this section I have analysed the role of necessity and chance within the 'discovery' versus 'creation' and the 'search scope' versus 'search depth' debates on the innovation process. I show that the debates are based on two competing understandings of novelty. It is the tendency to read innovation backwards that pits necessity against chance. Since the flux of continuous experience is being analytically dissected, only to be reconstituted as antecedent and consequent conditions within a succession of states, creativity is *re-presented* as necessity and chance. A 'processual' perspective, by contrast does not discount the fact that creative, "in situ responses of agents themselves, rather than pre-existing external environmental conditions, can create unanticipated consequences that eventually end up facilitating or thwarting" (MacKay & Chia, 2013, p. 209) the process of innovating. Thus, the 'substantialist' perspective denies the role of creativity by pitting necessity against chance whereas a 'processual' perspective celebrates the role of creativity by uniting necessity and chance.

3.6.4 Determinism (Structure) versus Freedom (Agency)

Clarifying the relationship between 'structural' determinism and 'agentic' freedom, emerges as a corollary from the necessity versus chance debate. Even though the structure versus agency debate is most explicitly evident in the framing of the 'path dependence' versus 'path creation' perspectives of the innovation process, it is also latent within the 'practice' theory inspired perspectives on innovating. While on the one hand 'practice' theorists talk about bridging the social constraints / social action divide (Dougherty, 2008), on the other hand routine theorists frame the debate by dividing routines along ostensive and performative 'parts' (Feldman & Orlikowski, 2011). So what is the underlying logic that leads to this division between structure and agency?

Within the previous section, we discovered that 'novelty' while innovating can be explained either with or without the notion of a creative agent. I also showed how the 'substantialist' ontology fails to sufficiently emphasise the role of creativity by invoking necessity and chance as an alternate explanation for novelty and innovation. Now in the absence of immanent creativity, the emergence of novelty can only be *revealed* either by pure chance (limiting structure), or by a spontaneous free will (unlimited agency). And in both instances, since the 'path', at least in theory, is already laid out, every innovation is really only a discovery – the probable realization of an imminent possibility (Ingold, 1986, p. 206). Consequently, we are allowed to *represent* acts and intentions as aggregates of discrete, unities or elements constituting a performance. Here, what begins as a succession of discrete intentions ends up translated into a string of performance.

The innovator, thus appears as a "thread on which is hung a series of discrete acts and intentions' and not 'as a locus of creative growth with a total field of relations" (Ingold, 1986, p. 207). Once this is achieved, it is now possible to resolve each of these discrete acts into two components. The first component is repetitive, constant and rule bound (necessity) and the second is variable, contingent and idiosyncratic (chance). The former is therefore socially determined and labelled structure and the latter being free willed or undetermined is labelled agency. It is this logic that allows theorists to misrepresent practices and routines as a combination of 'ostensive' and 'performative' parts (Dougherty, 2008; Feldman & Orlikowski, 2011).

But then, as Ingold (1986) observes, so long as agentic freedom is constituted by its opposition to structural determinism is cannot be wilful or purposive. "It is one thing", he writes, "to have an infinite generative capacity and quite another to be able to put it to purposive use in the practical business of life" (p. 209). It is the *reconstruction of conduct* by concatenating several such discrete acts, "each containing a 'free' act of choice followed by its 'determined' execution" (Ingold, 1986, p. 210), which leads us to this 'substantialist' dilemma (see Chia and Holt (2006) for a similar argument on 'purposeful' versus 'purposive' acts). On the other hand, if innovating is viewed as 'processual' then the path is not pre-given or laid out in advance of the execution of a specific project. The only given is the *having to make it*.

In this sense, innovating is 'path creation' (Garud, et al., 2010), where paths emerge *alongly*, as a *meshwork of corresponding lines*, rather than as an *inter*acting 'network' of joined up lines. Here, all 'ends' are merely transit points in a never ending journey. The innovation journey then means that "we constantly overtake our prior purposes – even in their execution – so our best laid plans are necessarily engulfed in the very processes we seek to direct. Every act or increment of conduct, is also an increment of advance in the evolution of purpose in the acting self" (Ingold, 1986, p. 212). Thus the *opposition between 'deterministic' structure and 'agentic' freedom*, on approaching reality is resolved into *purpose*. Intentionality, here, "resides in the very movement of consciousness of which 'thoughts' are an inessential by-product, recursively constituted by the intellect" (Ingold, 1986, p. 210). The *'deterministic' structure versus 'agentic' freedom* debate originates from "a failure to discriminate between two classes of event: those that in aggregate constitute a life process and those that mark changes in the objective structures channelling this process" (Ingold, 1986, p. 152).

The social constraint-social action divide (Dougherty, 2008) in the practice of innovating emanates from ‘substantialist’ thinking, which views acts as the mechanical execution of prior intention (deliberation separated from the actual execution). To paraphrase from Ingold (1986),

> “On the one hand there is the motivated pursuit of value-goals presumed common to all members of an organisation, governed by rules of procedure that are either constricting or enabling. On the other hand, there is the unmotivated substitution of one set of goals for another, held to mark an abrupt transition to a new social state. The first subjects freedom to the determination of a collective will; the second subjects such determinism to an unwilled freedom” (p. 212).

However, if acts are conceptualised as a continuous process of *intention-in-action* (no separation of deliberation and execution), then “*prior intentions are, like memories, but inessential snapshots artificially cut out from experience by the operation of the intellect and held up to view, in the rationalist reconstruction of conduct, as a series of discrete antecedents”* (Ingold, 1986, p. 313 my emphasis). Put differently, *prior intentions* are *re*-presentational whereas *intention-in-action* is presentational. The opposition between a deterministic structure and agentic freedom from a ‘substantialist worldview is thus dissolved into purpose from a ‘processual’ worldview.

To conclude, in this section I have analysed the tension between structural determinism and agentic freedom, invoked by the path dependency versus path creation and the practice perspectives on innovating. I show that the debate hinges on two competing understandings of action. In the ‘substantialist’ perspective each ‘act’ is a discrete, physical execution of a prior intention. In the ‘processual’ perspective, by contrast, intention and action unfold as a continuous process. Since the flux of continuous experience from *intention-in-action* is being analytically dissected, into a fixed component (structure) and an idiosyncratic component (agency) reconstituted as a succession of discrete acts, purposiveness is re-presented as either determinism, freedom or a combination of the two. Thus, determinism and freedom which are pitted against each other within a ‘substantialist’ worldview are from a processual worldview, united into purpose.

3.6.5 Summary

I began this section by revisiting the puzzles that emerged from the previous chapter. The puzzles were seen to originate from a ‘substantialist’ worldview which pits persistence against change, synchrony against diachrony, necessity against chance and determinism against freedom. These tensions originate from a 'substantialist' ontology that attempts to accommodate what is essentially a moving reality into a fixed framework of cognitive categories (Ingold, 1986). Therefore, these tensions cannot be resolved within a 'substantialist' worldview. However, embracing a 'processual' worldview has allowed me to transcend these puzzles. *These oppositions dissolve when we embrace the processual perspective and accord primacy to the movement, duration, creativity and purpose.* Taken together, these constitute a processual worldview of alongly unfolding corresponding processes. Table 1 below, summarises these arguments by contrasting the substantialist with the processual perspectives.

Table 1: Substantialist versus Processual perspectives from Ingold (1986, pg 209)

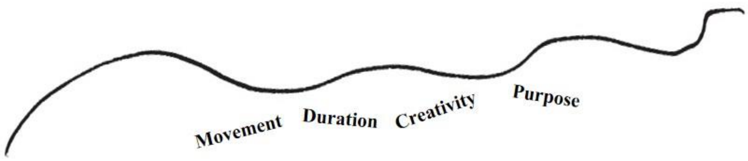
Substantialist		**Processual**
Persistence	Change	Movement
Synchrony	Diachrony	Duration
Necessity	Chance	Creativity
Determinism (Structure)	Freedom (Agency)	Purpose

3.7 Conclusion

I began this chapter by questioning whether the puzzles that emerged from the literature review are the result of our "trained incapacity" (Poole & Van de Ven, 1989, p. 564) to appreciate alternate conceptualisations of organisations? A foray into the metaphysical debates within organisation theory allowed me to establish two competing conceptualisations of organisations. The first is rooted within the 'substantialist' being ontology where *processes represent change in things.* The second is rooted within the 'processual' becoming ontology where organisations *are reifications of processes*. (Poole & Van de Ven, 1989, p. 564; Langley, 2007; MacKay & Chia, 2013).

In order to better understand the implications of embracing a ‘processual’ approach for social science research, I consulted the writing of Ingold (1986; 2000; 2007; 2011; 2013b). By likening processes to lines, I have demonstrated how the ‘substantialist’ understanding contrasts with a ‘processual’ understanding of process. The former can embrace the ‘process’ epistemology, whilst the latter by embracing the ‘process’ ontology and epistemology is more congruent with ‘organisational’ becoming. Following this, I have deconstructed the works of some prominent practitioners of mainstream ‘process’ research.

The insights that emerges from this exercise, allow us to side step the opposition between persistence and change, synchrony and diachrony, necessity and chance and determinism and freedom. In this alternate Ingoldian becoming perspective, *a process is reconceptualised as an alongly unfolding line embodying movement, duration, creativity and purpose.* Lines, knots, correspondence and meshworks, in other words, equips us with the conceptual tools required to investigate the dynamics of organising while innovating from an organisational becoming perspective. I have summarised this perspective in Figure 9 below.



Ingoldian becoming perspective
Movement
Duration
Creativity
Purpose

Figure 9: Ingoldian becoming perspective

Organising and innovating, therefore, are reconceptualised as alongly unfolding lines of becoming. Consequently, embracing this Ingoldian becoming perspective allows us to investigate *correspondence* between organising and innovating as they become. This in turn opens up a new line of inquiry into the dynamics of organising while innovating.

4 Outlining the Theory of Method

‘To the individual social scientist who feels himself a part of the classic tradition, social science is the practice of a craft’

C.W. Mills in *The Sociological Imagination* (1959, p. 215)

“My whole work has come to resemble a terrain of which I have made a thorough, geodetic survey, not from a desk with pen and ruler, but by touch, by getting down on all fours, on my stomach, and crawling over the ground inch by inch, and this over an endless period of time in all conditions of weather”

Henry Miller in *Reflections on Writing* (1941, p. 27)

4.0 Introduction

So how might one go about investigating innovating marked by its spontaneity, complexity, and variety along Ingoldian lines? My aim for this chapter is to provide the reader with a full disclosure on the “theory of method” (Pettigrew, 1990, p. 267) which informed my field study. Such a disclosure is important to judge what Edmondson and McManus (2007) call the 'methodological fit' (p. 1155), which refers to the internal consistency among interconnected elements of a research project, including the research question, prior work, research design and the intended theoretical contributions of the research exercise. The absence of ‘methodological fit’ can result in a lack of coherence between the research design, data collection, analysis and reporting of the results (Ropo, et al., 1997). The goal here, of course, is to build a processual theory which explains organising while innovating.

The previous chapter laid out a process philosophy inspired Ingoldian becoming perspective. In this chapter, I translate those insights to develop a research methodological framework which can be deployed to investigate innovating as organisational becoming. This chapter is organised as follows. I first provide an overview of process methodologies used to build theory within organisational studies, focussing particularly on their methodological limitations. I next turn to the impact of the ‘practice turn’ on process methodologies. The ‘practice turn’ examines and clarifies what practice really is in relation to process and individual activities. These insights, then guide the research strategy deployed to investigate the research question. The sections which follow expand on the research setting, data sources and the methods deployed for gathering data. The penultimate section describes the two stage process of data analysis. Finally, the chapter concludes by summarising the research strategy and acknowledging its limitations.

4.1 Process Methodology: An Overview

Process methodologies attempt to create knowledge that is concrete, practical and context-dependent (Flyvbjerg, 2001, p. 66; Langley, 1999; Van de Ven, 2007). The methodology must therefore check the boxes of theoretical rigour and practical usefulness by paying close attention to how *innovating-in-practice* within an organisational context, is carried out *through* events that unfold over time. This, I believe requires a methodological orientation that allows the researcher to capture the lively sense of the practical, workaday world of innovating, of the welter of ordinary undistinguished things and people; the tangible and the quirky, the unrefined elements constituting organising while innovating over a significant period of time. Process methodologies, unlike purely inductive or deductive research methodologies, combine rich theory with rich data to create rich knowledge (Orton, 1997). Investigating process methodologies therefore becomes a useful starting point for research design.

4.1.1 Ontology and the Process Methodology

The distinction between the substantialist and process ontologies impacts process methodology. The process methodologies described by early scholars like Pettigrew (1990), Leonard Barton (1990), Van de Ven and Poole (1990; 2010), and Langley (1999) are all designed to view process from the outside where processes are conceptualized as something occurring between two states or two entities. These early developments were important to effect a shift in research focus from measuring *if* a change occurred in a variable measured at different points in time, to *how* change unfolds over time (Van de Ven, 1992, p. 170). However, when processes are conceptualised as *interaction* between stable entities, then the apriori assumption is of a world consisting of stable entities whose interaction constitutes processes. Therefore, the knowledge generated by these approaches, which are epistemologically "process", typically takes the form of stage models in which the entity that undergoes change is shown to have distinct states at different points in time.

The other group of process methodologies rooted in a 'substantialist' ontology such as those used by Feldman (2000), Pentland (1999) and Barley (1990), originate within a 'structuralist' framework (Rasche & Chia, 2009), which look for universal and ahistoric codes guiding action. Thus when the routines they investigate are abstracted from their context and labelled, the acts which sustained the 'process' are engulfed under the label. Such methodologies capture "lexical evolution" (new moves) and "syntactic evolution" (new patterns of existing moves), but the source of these changes would be exogenous to the model and thus elude it. (Pentland & Rueter, 1994).

A third group of process methodologies such as Weick (1995) and Chau and Witcher (2005) subscribe to a 'process' ontological reality where the act is made of verbs, "whereas the epistemological reality in which we make sense of things is made of nouns" (Bakken & Hernes, 2006, p. 1606). The onto-epistemological relationship between 'acting' and 'sensemaking' is for Weick, in a state of mutual tension, a kind of dialectical relationship. (Bakken & Hernes, 2006, p. 1602). Hence, his inadvertent advice to "stamp out nouns" (Weick, 1979, p. 44), because his methodological framework cannot simultaneously accommodate both the act of organising and the resulting outputs of those actions. But as pointed out by Bakken and Hernes (2006), and later acknowledged by Weick (2010), this dialectic tension vanishes when we shift our attention from nouns to nounmaking.

It is this fourth version of process, where reality manifests through the continuous correspondence of verbs and nounmaking that is congruent with the process onto-epistemology. In other words, the apriori assumption is that of a world made up of processes in the making. The majority of research that subscribes to a process ontology, has been conceptual in nature with very little being said or written about its impact on the way empirical research is carried out (Van de Ven & Poole, 2005, p. 1390; Pettigrew, 2012; Steyaert, 2007). As Pettigrew (2012), himself a highly distinguished practitioner of 'process' research, points:

> "Latterly, philosophical writing by Tsoukas and Chia (2002) and Chia and MacKay (2007) has attempted to bifurcate the process field into weaker and stronger views of process by positing a different ontology for the stronger view. However, as yet this interesting distinction has failed to have much impact on the practice of process scholarship, which is our main interest here" (p. 1316).

By his own admission, Pettigrew's scholarship does not differentiate between the 'substantialist' and 'processual' notions of process (alluded to as 'weaker' and 'stronger' respectively). But the remark also suggests the difficulty of adopting a *'process' ontology* in empirical research. Research design should therefore be tailored to do justice to this 'ontological' reality of process.

4.1.2 The Practice Turn and Process Methodology

The need to bridge the gap between the formal academic knowledge and applied knowledge which practitioners need (Van de Ven, 2007) led to the 'practice turn' in management research (see Whittington (1996; 2003; 2006), Jarzabkowski (2003) and Simpson (2009) for details). The 'practice turn' opens up exciting possibilities and challenges for doing process research. Whilst on the one hand, it does away with the artificial "macro-micro distinctions by insisting on the primacy of a dynamic and emerging field of practices as the starting point for social analysis" (Chia & MacKay, 2007, p. 224), on the other hand it muddies the distinction between activities, practices and processes by treating them interchangeably. The question confronting the praxis of process research then becomes, do we treat 'practice' as something reducible to the actions and intentions of individual agents? Or, are practices non-individualist phenomena with features expressed through the open-ended set of actions which constitute them? (Schatzki, 2005, p. 480).

The former view of practice entails methodological individualism which pits structural determinism against agentic free will. Since, individuals are treated as discrete, bounded "causal agents" *interacting* with their environment, "the presupposition is that practices are what actors 'do', individual agents are initiators of practices rather than themselves products of social practice" (Chia & MacKay, 2007, p. 219). Put differently, 'practice' here shares the same basic philosophical presupposition with the substantialist ontology in process methodologies. Subscribing to the latter view of practice, however, is consistent with the process ontology described in the previous section. Here methodological individualism is eschewed by making the social practices, themselves the loci of analysis. The analytical focus is on *'individual-in-the-environment'* to be understood, not as a bounded entity but a process in real time. To clarify, it is people who perform the actions that constitute a practice, "but the organization of a practice is not a collection of properties of individual people" (Schatzki, 2005, p. 480).

This distinction between the two profoundly different conceptualisations of 'practice' can be sharpened by understanding the Heideggerian (1926/1962) distinction between the '*building perspective*' and the '*dwelling perspective*'. In the '*building perspective*', individuals pre-exist their engagement with the world and worlds pre-exist before they are lived in. This view is consistent with the 'substantialist' practice perspective where actors (whether individual or organisational) are configured as distinct entities deliberately engaging in purposeful activities. What is overlooked or misrepresented here is a more residual 'dwelling' mode in which actions emerge non-deliberately through everyday practical coping (Chia & Holt, 2006). In the '*dwelling perspective*', our involvement with practice is so intimate it is not perceived as an object we apprehend but rather it is an extension of us. Practice here is, above all, the performance of its constituent actions. The *dwelling perspective of 'practice'*, which sees the social world as brought into being through everyday activities, is consistent with the 'process ontology'. For it is from these activities that we infer processes. In other words, the mode of activities, become the unit of analysis from which we discern processes.

'Building mode' methodologies start by separating the perceiver from the practice such that the perceiver has to first construct mental representations and models of the practice, prior to any meaningful engagement with it (Ingold, 2000, p. 178). Hence the assertion that it is possible to observe processes (Poole & Van de Ven, 2010; Pettigrew, 2012). This can be contrasted with the 'dwelling mode' of engagement, where the researcher engages in iterative 'wayfinding' (Chia & Holt, 2009) by tracing chance incidents, noticing peripheral happenings, acknowledging dispersive serendipity and unintended consequences, all of which manifest in the unfolding pathways traced by phenomena being tracked. Here, processes are inferred from the activities of the actors. To quote Ingold (2000), the researchers "feel their way through a world that is itself in motion, continually coming into being through the combined action of human and non-human agencies" (p. 155).

Such an autopoetic dwelling mode, is a necessity to capture the generative property of richness (Weick, 2007), evoked through the "coming-into-being' of the actors who through their activities are a 'part and parcel of the process of coming-into-being of the world' (Ingold, 2000, p. 168). This distinction has at least three major implications for the research methodological framework. One, it requires us to now dissolve the entrenched analytical distinction made by Van de Ven (1992, p. 169) between processes as "a category of concepts or variables that refers to actions of individuals or organizations" and processes as "a sequence of events that describes how things change over time". Rather, the empirical focus should now be on how activities are conducted *through* events which unfold over time. Incidents and events crystallise from this flow of activities. One can at best, experience constituent actions as they happen and make inferences about the remainder.

Two, methodologies which adopt an independent observer-oriented mode of engagement (Pettigrew, 1990; Van de Ven & Poole, 1990; Langley, 1999) are not adequately equipped to capture the internal logic of practices constituting processes. Empirical contributions using such process methodologies are often based on what people say they do or have done (Paroutis & Pettigrew, 2007; Van de Ven, et al., 1999; Leonard-Barton, 1990), mostly retrospective reasoning, rather than on a direct observation of engagement. Other empirical methods used include attending strategy meetings as a guest, interviews (Jarzabkowski, et al., 2007; Jarzabkowski, et al., 2012; Van de Ven, et al., 1999; Paroutis & Pettigrew, 2007), historical narratives (Burgelman, 2011; Garud, et al., 2014) and practitioner diaries (Balogun & Johnson, 2005).

These methodologies rely on reported accounts and thus make it hard to understand and unravel the tacit and deeply embedded contextual-contingent nature of organising processes at play. The texts studied are mostly "past-participled, hind sighted, stilled, and closed" (Dening, 1996, p. 17). No doubt, these methodologies all have richer explanatory powers than methods suited for 'variance' theories. However, the theorising still glosses over much of the plurality of possibilities of what might have happened, to the unity of what happened, thus stripping away the temporal reality of practice. Some exceptions to this trend have been research on temporal work by Kaplan and Orlikowski (2013) and research on micro-processes through which institutionalised practices are maintained by Lok and De Rond (2013).

Three, the methodology must be sensitive to the difference between "objective time and real time of the objective sort" (Schatzki, 2006, p. 1866). As Schatzki explains, "Whereas objective time is a before and after ordering of events or moments, real time of the objective sort is the passage of a not instantaneous event that is contained in that ordering" (2006, p. 1866). A 'processual' methodology, in keeping with the 'dwelling mode', requires an orientation that is open, pragmatic, dispersive, and opportunity seeking. It is guided by a 'nomadic' logic which "situates itself within the milieu of practices and responds to the exigencies of situations through a reliance on an internally cultivated habitus or style" (Chia, 2004, p. 33). What it tries to grasp is "the apparent patterned consistency of everyday absorbed practical coping" (Chia & MacKay, 2007, p. 234).

Adopting a particular perspective can have profound impact on the design and execution of a process research methodological framework. Research outputs in a substantialist 'building' mode can at best generate a spectator theory of knowledge: a bouquet of abstract concepts which are, as flowers gathered, "only moments dipped out from the streams of time, snap-shots taken, as by a kinetoscopic camera, at a life that in its original coming is continuous" (James, 1909/2011, p. 78). Such a methodological orientation, as Bourdieu (1990) so poignantly expresses, "lets slip everything that makes the temporal reality of practice in process…" (p. 80). Research situated in the processual 'dwelling' mode on the other hand is based within a framework of "practical rationality" (Sandberg & Tsoukas, 2011, p. 339), a practical logic that is internally coherent and plausible to the world of practitioners, that does not require "practice to speak itself in a language foreign to its application" (Chia, 2004, p. 33).

4.1.3 Pilot Study

In order to deduce the practical implications of these theoretical insights for empirical fieldwork, I undertook a pilot study. The study was carried out within the Information Technology (IT) department of a Glaswegian construction company and lasted for three months. I tracked a project to upgrade the internal IT server within this organisation. I would visit the site once every week for twelve weeks and interview the IT department staff as well as various stakeholders. This was not really an innovation per say, but it familiarised me to the challenges of doing field work from a process onto-epistemology. It soon became clear that to be able to capture non-linear process dynamics, traditional methodologies like grounded theory (Strauss & Corbin, 1998; Suddaby, 2006; Glaser & Strauss, 1967) will not work because, as Weick aptly summarises, "you can't build grounded theory while the ground is moving" (quoted in Meyer, et al., 2005, p. 463).

The pilot study identified the need to observe organising activities through contextual immersion rather than interviewing people to capture or record what people say they are doing. This requires that I empirically investigate how activities are carried out *through* events which unfold over time. Without this, it was not possible to capture the ambiguities, contradictions and ambivalences which manifest while innovating (March, 2006). The difference, if you will, is between understanding organising and innovating as practical engagement in a complex world as opposed to rational involvement in a conceptually simplified world (Heidegger, 1926/1962). Insights from the above arguments were distilled into four specific guidelines which influenced my research design.

4.1.4 Process Onto-Epistemology

Four principles guided the design of my methodological framework. One, the research design should be able to capture all types of activities which constitute organising while innovating. Two, it should be able to explicate the generative mechanism linking the organising and innovating processes as they unfold. Three, data to the extent possible, must be captured directly, in real time, as these activities from which the processes would be inferred, unfold. And four, data analysis should be able to identify 'patterns of activity' and the processes they constitute for a processual explanation. As Schatzki (2006) points, "The real time of an organization is the unfoldings of the performances of the organization's actions. To experience an organization in real time is, thus, to experience the movements of its performances and events; to understand an organization in real time is to grasp, explain, or theorize these interrelated and patterned passages." (p. 1866).

To summarise, adopting a process inspired practice perspective (Chia & MacKay, 2007) on innovating allows researchers to theorise the links between organising and innovating in empirical terms, grounded in managerial actions. Since innovating exists in the realm of action, one cannot hope to understand the implications of innovating for organising and vice versa, without investigating how it is carried out in real time on an ongoing basis. The research strategy should therefore be sensitive to the contextual dynamics though which innovating unfolds. This would allow us to develop an alternative framework to explain the links between organising and innovating. Understanding how these processes intertwine in practice can shed light on how organising and innovating become.

4.2 Research Setting

In order investigate the dynamics of organising while innovating, I draw on my seven month long field study of two new product development projects at Peak Scientific Limited. The selection of this research site was shaped by the choice of research topic and question being investigated. While there was a lot of forethought and intention that went into choosing the research site, it would be utterly disingenuous for me to downplay the role of a judicious mixture of chance, opportunism and serendipity which played their part in gaining site access. On 23rd May 2013, I was invited to attend a Leadership Clinic organised by the Centre for Engineering Development and Education, better known as CeeD Scotland. CeeD is a growing community of businesses and academics that aims to pool together talents, expertise, experience and resources in the pursuit of operational excellence within organisations. Mr Robin MacGeachy, the Managing Director of Peak Scientific was the keynote speaker at this clinic.

Robin shared his experience about running Peak Scientific in a talk titled 'The Transformation of a Scottish SME'. Some of the issues he touched upon during this talk happened to resonate deeply with my research question. During the savoury buffet that followed Robin's talk, I approached him and shared some my ideas on what I then suspected were Peak's innovation challenges. Robin seemed interested in my research and redirected me to his Engineering Director. The Engineering Director then invited me to Peak Scientific where I presented him with my analysis and research question. Sensing the mutual benefits that could result from undertaking “engaged research” (Van de Ven, 2007), Peak's Engineering Director ran my proposal by the organisation's board. After obtaining clearance from Peak Scientific's Board of Directors, I was invited to join Peak as a resident innovation academic. I began my field work in August 2013 and exited the field in March 2014. There was a three week break from the field during Christmas in December 2013. This did not have a significant impact on the data gathering process as the level of activity within Peak was low during the holiday season.

Peak is a privately owned company headquartered at Inchinnan, a suburb on the south-west of Glasgow, in Scotland. They are a leading manufacturer of gas generators for scientific applications in the Analytical Instruments industry. Peak’s products are used by drug discovery labs of leading universities, research and production labs of the pharmaceutical industry the petro-chemical industry, the food and drink industry, firms and agencies responsible for providing environmental reports, forensic labs and hospitals around the world. They have a presence in six continents with established offices in the UK, Germany, USA, Brazil, Mexico, India, China, Japan, Singapore, Taiwan, South Africa and Australia respectively.

Field research at Peak offered several advantages for carrying out empirically informed theory building of innovation management in practice. First, Peak had substantial experience in new product development (NPD) and several ongoing NPD projects. This afforded that all but rare opportunity to gather data about innovation in real time. This advantage is crucial from a methodological point of view because the researcher now has an opportunity to learn about innovating-in-practice based on what practitioners actually do rather than on what they say they do. Second, the organisation itself was neither too small, nor very large which allows the researcher to transcend the usual 'levels of analysis' distinction made by most process researchers. This meant that the processes of organising and innovating could be tracked by 'shadowing the object' (Czarniawska, 2007) being created, by cutting through the artificially restrictive micro-meso-macro 'levels-of analysis'. Since the administrative headquarters and the production factory were co-located, it was possible to gather data on the *practice of innovating* across functional departments and vertical hierarchies by shadowing the innovation as it evolved.

Third, conducting process research of such an immersed nature would not have been possible without intensive and at times even intrusive levels of access which was granted to me at Peak. Since innovating in most organisations is jealously guarded (and justifiably so) with rules to protect copyright and intellectual property, it might not always be possible to negotiate such favourable access terms when researchers set out to *re-search* such studies on innovation. Fourth, this was *not action research*. My task as a resident innovation academic was to *'observe'* the practice of innovating as a participant observer. I was not asked for my opinion nor did I volunteer my opinion (at least to the best of my knowledge) as I tracked the unfolding of events for the entire duration of my study. At the time of embarking on this study I had made it explicitly clear that this would be a study *with* people rather than a study *of* people (Ingold, 2011, p. 238).

Fifth, tracking two NPD projects in real time within the same organisation allows for a genuinely open-ended and comparative yet critical understanding of organising while innovating. The endeavour, though essentially comparative, does not compare bounded objects, structures, people, entities or outcomes but rather *the ways of becoming*. And finally, the permission to access all internal documents, emails (I was given an internal Peak email id) and audio record all the meetings, discussion and conversations simplified the execution of the research.

In sum, collaborating with Peak afforded the opportunity to meaningfully address the research question in an organisation, and not from the armchair! What makes studies in this genre truly processual, as Ingold (2011) so perceptively observes, is "that this world is not just what we think about but what we think with" (p. 238) and, therefore by the same token, radically different from positivist or neo-positivist process research in management. Process theorising here is being allowed to carry on outside academic corridors.

4.3 Ethics

Prior to the commencement of my field work, I had filled out the Research Ethics Form (REF) which outlined my research strategy. I had also simultaneously filled out a Participant Information Form (PIF) and prepared a Consent Form (CF). These were attached to the REF and all three documents were granted ethical approval by the Research Ethics Committee of the Department of Strategy and Organisation at the University of Strathclyde. The PIF and CF were circulated among the staff at Peak. All the participants signed the consent form which was also signed and approved by the Engineering Director.

The data gathered was treated confidentially and was accessible only to my supervisors and myself. It was stored away in a password protected folder. I was given permission to retain Peak's name and use certain visual images included within this thesis. The names of all participants, except the Managing Director, have been anonymised to protect their privacy. Also, Peak's clients who were involved in this study have been given pseudonyms of Alpha, Theta, Delta, T Compressors and G compressors respectively. All the empirical material presented here has been read and cleared by Peak's Engineering Director.

4.4 Data Sources

Doing 'processual' field research, although always exciting, can be messy and inefficient, fraught with logistical hurdles and unexpected incidents. Researchers will have to manage and navigate the complex 'site' (Schatzki, 2005) relationships, and cope with emerging constraints impacting data collection. These can often result in mid-project changes to planned research designs. For instance, when I joined Peak, for the first three weeks, I was tracking five ongoing innovation projects. However, two such projects being tracked concluded within a month into my fieldwork. To track them then would have meant resorting to retrospective reconstruction.

Hence these projects were dropped from fieldwork and the projects being tracked were reduced to the two projects reported here. The decision to track the two projects, Alpha Panda 2 and Theta Corona, presented here was based on the grounds of empirical richness, theorising potential and project time scale. The flip side of intensive access in the field is the increased likelihood of 'data asphyxiation' (Pettigrew, 1990).

Research methods used must have the twin capacity to sufficiently respect both theory and evidence (Van Maanen, et al., 2007).The predominant source of data was through participant observation. In order to scale the practical and useful heights in process theorising, one has to use the ladder of participant observation. But observation, here, refers neither to the removed, detached and disinterested contemplation of a world of objects (c.f Jarzabkowski, et al., 2012), nor to the translation of these objects into mental images or representations (Garud, et al., 2014). Rather, it refers to “the intimate coupling of movement of the observer’s attention with the currents of activity in the environment” (Ingold, 2011, p. 223). To observe then, as Ingold (2011) reminds us, is not so much to “see what is ‘out there’” but rather to “*watch what is going on.*” (p. 223 emphasis in original).

I started field work in August 2013, just after both the projects reported here had started. I used to reach Peak, which was a 90 minute bus ride from where I lived in Glasgow, by 8 am and catch the bus back home by 5 pm, spending my entire working day, all five days of the week, at Peak. I did so until the 10th of December 2013. From January 2014 until March 2014, I spent first three days of the week (Mondays, Tuesdays and Wednesdays) at Peak and the remaining two days organising the data gathered. I did so because most of the regularly recurring meetings discussing the project I was tracking were scheduled for these days. Such prolonged first hand exposure to the phenomena allows the researcher to gather data with an accuracy and empirical sensitivity honed by detailed observation.

Such access into the empirical is methodologically and qualitatively very different from the empirical access gained either through the reduction of events by treating them as abstract entities arranged into unified patterns (Poole & Van de Ven, 2010) or by treating “a sequence of “events” as “conceptual entities” (Langley, 1999, p. 692). But prolonged exposure also means that the fieldworker inevitably must come to terms with the situational dictates and pressures put on, expressed, and presumably felt by those involved in the study. Van Maanen puts it well when he writes “There are no short cuts, no ways to ‘learn the ropes’ without being there and banking on the kindness of strangers. Relations based out of a certain kind of rapport form only with time, patience and luck" (Van Maanen, 2011, p. 220). In sum, doing intensive fieldwork requires the researcher to develop social relationships and maintain credibility with a wide range of respondents from different levels and functions inside the organisation.

4.4.1 Research Diary

So how was the data gathered? I did so using a combination of methods. A research diary is a powerful data organising tool as it allows the researcher to make notes and inscribe empirical observations from the field (Van Maanen, 1988). In my case I also used the diary to make notes on and maintain a chronological record of the meetings I was attending. Typical diary entries recorded the circumstances leading to the meeting and notes on who were attending. A note of the audio file name of the recording too would be maintained. This is very important in this type of engaged research because later on, as one sits down to transcribe and analyse the recorded material, one may not be able to identify the cacophony of voices speaking. The diary also acts as a catalogue for the recorded audio file labels which contained data from meetings, discussion and interviews.

4.4.2 Meetings

Shadowing innovating also meant that I had to sit through multiple project, functional and departmental meetings in order to gather data. I was able to audio record most of the meetings I sat through. Although, there were some departmental meetings that were organised in very large rooms comprising of 30 or more engineers, which couldn't be recorded for logistical reasons. The size of the room and the cacophony of voices would result in an indecipherable audio recording. In such instances, note taking was pursued. Since this collaboration had the endorsement of the Board of Directors at Peak, it was (in theory at least) possible for me to follow any innovation project within Peak.

While I was a part of all regular meetings related to the innovations I was shadowing, in case there were urgent meetings which were convened, all I had to do was request the relevant Manager that I be allowed to sit through that meeting. This also included meetings with the Original Equipment Manufacturers (OEMs) for whom Peak design innovative gas generator solutions. Most of the regularly scheduled weekly meetings lasted between sixty and ninety minutes. The unscheduled meetings could last anywhere between twenty minutes to three hours. All meetings which were audio recorded were later transcribed and used as the empirical material for data analysis. A list of all the meetings can be seen in Table 2 below. On two or three occasions, when sensitive issues were being discussed, a couple of managers pointed to the presence of the recorder within the room and pursued the discussions of the issues only after I turned off the recorder or after the meeting concluded. During these instances, I had to make notes about the issues with diary entries or had to have a follow up private conversation with the concerned managers to learn about the issues.

Table 2: Summary of meetings attended at Peak

Serial Number	**Meetings**	**Number of Recorded Meetings**
1	Inter Departmental Meetings	19
2	Project Meetings with Alpha	11
3	Project Meeting with Theta	7
4	Project Meetings on Peak Industrial	6
5	Engineering Departmental Meetings	15
6	Design Engineering Departmental Meetings	4
7	Manufacturing Engineering Departmental Meetings	10
8	Product Manager's Meetings	12
	Total	**84**

"Meetings", as Krause-Jensen (2010) writes, "should be given independent attention as the *locus* where the process of organizing takes place, where the organization is ipso facto created. Their raison d'être is establishing and maintaining relations between people" (p. 30). However, there are two primary limitations of methodologies which rely on sitting through managerial meetings alone as the predominant mode of data collection. The first limitation is the risk of exaggerating the accessibility of what goes on inside it by mistaking the clarity of the 'frame'

(Goffman, 1981; Goffman, 1986). The dangers of taking the meeting as the starting point is that one can overlook the circumstances outside the interactional context that affect it (Krause-Jensen, 2010, p. 31). The second limitation is that the researcher would have very little means of continually evaluating the believability of the talk-based information harvested over the course of the study, an evaluation dependent upon the skill and good fortune in uncovering areas of ignorance, and various taken for granted features of the studied organisation (Van Maanen, 1979, p. 548).

4.4.3 Conversations with informants

Rather than relying on interviews used by researchers like Langley (1999), Eisenhardt (1989; Eisenhardt & Graebner, 2007), Burgelman (2011), Pettigrew (2012) and Poole and Van de Ven (2010), I relied on ongoing conversations with a variety of informants as organising and innovating unfolded. The processual sensitivity of the data gathered is always limited when one resorts to interviewing, irrespective of which interviewing technique (Alvesson, 2003) one deploys. Since the objective of the study was to explore rather than validate organising while innovating, my conversations with practitioners were grounded in a practical rationality framework (Sandberg & Tsoukas, 2011). The assumption here was that there is something going on and there may be better or worse ways of understanding these issues. The conversations attempted to gather "the meaningful totalities into which practitioners are immersed" (Sandberg & Tsoukas, 2011, p. 341) and capture the situational uniqueness in which the observed activities were taking place. My focus, therefore, was less on "data" and more on how 'data' is being constructed to aid theoretical reasoning in real time (Alvesson & Karreman, 2007). By the end of the field study, I had a total of 64 recorded conversations with organisational members from various levels within Peak. Table 3 below provides a summary of the various recorded conversations over time. Initially, as I entered the field, I spoke with managers and employees from various levels and functions within Peak. These were done to anchor the investigation and chart a roadmap for which projects to track. Typical conversations began with the following questions:

1. So could you please tell me a little bit about your Department?
2. What are you working on and what are the challenges you face?
3. How do you co-ordinate your activities with X and Y departments?
4. What do you think is working well / or not working well and why?

Table 3: Summary of conversations with informants at Peak

Serial Number	Participants	Number of recorded conversations
	Top Management	
1	Managing Director Peak (CEO)	1
2	Director Engineering	7
3	Director Marketing and Sales	1
	Middle Management	
4	Design Engineering Manager	4
5	Manufacturing Engineering Manager	4
6	Product Managers	2
7	Operations Managers	8
8	Sales Manager	3
9	Training Manager	2
	Employees / Staff	
10	Innovation Design Engineers	10
11	Design Engineers	12
12	Manufacturing Engineers	3
13	CAD Engineer	1
14	Product Specialist	2
15	Production Technicians	4
	Total	**64**

The informant would answer these questions and if I felt I needed more explanation on any of these points, I would pursue those points further. As the fieldwork progressed and the level of comfort between my informants and me grew, the conversations were on issues specific to the projects being tracked. Again, I would begin such a conversation at the canteen or meeting room with an opening question and would then allow the informant to lead the conversation. If I required further clarity on any of the observations made, I would pursue the issue after the informant has finished his or her point. Such conversations took place several times during seven months of fieldwork at Peak. The willingness of the participants to speak candidly, during my observation stint increased significantly with time and also my evolving understanding of the contexts and issues. Vital therefore is time, patience and a knowledge of details, and this depends on a "vast accumulation of source material." (Flyvbjerg, 2001, p. 133).

4.4.4 Internal Documents and Emails

One of the attractions of choosing to do fieldwork at Peak was the unfettered access to conduct a thorough exploration of the organising and innovating processes. I was entrusted with a secure Peak ID card which allowed me entry into all the departments and the R&D lab. I also had an internal Peak email id and was kept in the loop on matters pertaining to organisational change, project developments and co-ordination meetings. Further, I also had access to internal corporate documents hosted on the corporate server which included product design files, internal process documents, product photographs, production support related documents, customer requirement forms, powerpoint presentations, brochures and various product literatures.

I spend a good part of my initial month of field work at Peak gathering and reading whatever historical documents I could find. This exercise complements the data gathered in real time through the various other methods described and helps follow the organising and innovating trails leading to the innovation projects which I studied. Data gathering in this sense involved an iterative process of analysing data, writing up my understanding of the situations and events in the form of diary entries and then developing new questions to shape subsequent data collection.

4.4.5 Summary

To summarise, the combination of methods used was configured to complement one another thus enhancing the richness of the data gathered. Fieldwork does involve, rather mindfully, selecting, defending, blending, and combining various methods. The data gathering was guided as much from drift as design and trails that go dead when probing could perhaps be far more than the ones that do not. This therefore calls for a combination of 'disciplined imagination' (Weick, 1989) and the kind of detective work (Mintzberg, 1979b), that requires the researcher to probe for illuminating speculation, peripheral occurrences, capture the present in all its possibilities and incoherence, note and pursue nebulous insights and might-have-beens, all of which requires a healthy measure of creativity. This sort of 'wayfinding' (Ingold, 2000, p. 168; Chia, 2004, p. 31) is inevitable as one tries to grasp the 'logic of practice'. It means painstaking accumulating data, following pathways and abandoning certain less promising trails. All of this requires patience and an exercise of judgement when in the field and cannot be planned in advance.

4.5 Data Analysis

Doing processual research on innovating involves *not the study of* practice but rather *a study with* practice (Ingold, 2011). As the volume of data gathered swelled, so did the challenge of analysing it. The social texture of the data captured through the methods described above is grainy and knotted with practicality and detail. Therefore, any analysis must begin with an attempt to untangle these knots so that the data can then illuminate, what Chia and MacKay (2007) call, "the patterned consistency of actions" (p. 224). Since the focus of the research is on the process of innovating and organising, it becomes important to concentrate on *how these processes are constituted by the intertwining of activities as they correspond* rather than on the activities of individual agents per say.

Data analysis proceeded in two stages. I began the data sorting process in January 2014. The notes and audio recordings were transcribed and organised into chronologically labelled data folders. These folders contained internal documents, audio recordings, typed up diary notes, photographs and scanned copies of project related scribbling. Once this chronological sorting was completed, all the audio recordings were played out and most of the conversations relevant to the research question were transcribed. This was time intensive but in my opinion a relevant exercise because it allows the researcher to re-immerse with the experience in the field. There was over two hundred hours of recorded audio material. The tricky aspect of data analysis here is that quite often, a single recording can contain information related to multiple incidents which may or may not have a direct impact on the projects being shadowed. This meant that it was not possible to prepare project chronologies until the entire data was transcribed and sorted.

4.5.1 Stage One

The first stage involved data consolidation. By the end of the empirical material consolidation process, I had over 700 A4 size pages of data which now had to be sifted through to create the chronological sequence of activities which constituted incidents leading to the various events within the two projects. NVivo, a data organising software was used to sift through the empirical material and translate this material into data. NVivo is an extremely useful tool when it comes to organising empirical material into data for analysis. It provides a ready repository to hold data in multiple formats which can then be organised into distinct project categories by assigning project codes. However, the software is not adequtely endowed with features relevant for gererating a process theory. This is primarily because while it allows the researcher to sort segments of the empirical materials on the various files into distinct project categories, it does not have any timeline feature which allow the researcher to explore the temporal complexities within the data. Therefore, one must painstakingly reorganise the contents of the individually sorted project files manually into a chronology.

However, chronology is not the same thing as temporality. Doing process research, as described in the literature review, requires confronting the temporal complexity of the material. Giving salience to the temporal complexity inherent in the processes requires a unified analysis of “objective events and subjective experiences of continuity as intricately interwoven and synthesized through human conduct” (Simpson, 2009, p. 1337). In order to do this, one must turn to narratives. Narratives provide the means of conveying the often ambiguous and equivocal emergence from the process dynamics with the situated actions executed to cope with that dynamic (Bartel & Garud, 2009). So, detailed narratives representing the practice of innovating were prepared for the two new product development projects. The variety and richness of the incidents described along with the linkages between them conveys a high degree of authenticity that cannot be achieved economically with large data samples.

Narratives which contain 'thick descriptions' (Geertz, 1973), are not merely detailed observations but act as analytically informed and culturally contextualized reconstructions of the empirical (Alexander, 2008). The narratives directly reveal to us the complexities and difficulties of innovating within organisations. This marked the first milestone in the data analysis phase of the research. At this stage, these field narratives were shared with the managers at Peak and they were asked to comment on the factual accuracy of the narrative. The minor inconsistencies which they pointed out were reflected upon, compared with the data and either modified or further refined. Presenting the field narratives at Peak served as a valuable check in the theorising process and helps ensure internal consistency and validity (Van de Ven, 1992; Van de Ven, 2007).

4.5.2 Stage Two

In Stage Two, I undertook a systematic *within case comparison* and a *cross case comparison* of *ways of becoming* to create the first and second order analysis (Van Maanen, 1979). This required me to identify the processes which emerged from the practice of organising while innovating along with their regulating mechanisms. The processes of which these acts of organising and innovating are parts, which Schatzki (2005) refers to as "practice-arrangement bundle(s)" (p. 476), are to process theory, what metaphors are to poetry – the very heart of the matter. I was inspired by two complementary theory building frameworks, the first advocated by Alvesson and Karreman (2007) and the second by Sandberg and Tsoukas (2011).

Alvesson and Karreman (2007) expanding on the ideas of Asplund (1970) liken the process of theorising from the empirical to "the creation or discovery of a breakdown in understanding of theoretical interest (creation of a mystery) and the recovery of understanding (the resolution of the mystery)" (p. 1266). Their methodology allows theorists to extract insights by paying "particular attention to the interplay between theory and empirical material" (p. 1266). The inconsistencies and breakdowns in theoretical understanding which emerge from empirical observation, rather than just pure theoretical speculation, can then be woven into the theory development process.

Similarly, the 'practical rationality' framework by Sandberg and Tsoukas (2011) allows the theorists to explore the relationship between theory and practice, by making "theory a derivate of practice and, thus, more reflective of the "richness" of practice" (p. 339). This allows theorists to undertake “involved thematic deliberation” by which they mean “a mode of engagement that involves both immersions in practice and deliberation on how it is carried out” (p. 344). Just as generating theory from ‘mystery’ involves a careful threading of the empirical data to breakdowns in understanding and their subsequent restoration; theory generation with ‘practical rationality’ involves “the search for entwinement and the search for temporary breakdowns” (p. 339).

Exploring the links between the innovating and organising processes involves investigating how the innovating processes and organising processes entwine as they unfold. In order to proceed with the analysis, the empirical material for both the field studies was broken down into events constituted by several streams of incidents. There were a total of 70 events in the Alpha Panda 2 project and 92 events in the Theta Corona project (refer Appendix I and II). Following the chronological ordering of these events, I began the first round of coding. The objective here was to identify and abstract various process threads from the events and bundle them into process complexes. A process thread refers to a stream of activities which constitute incidents leading to events. A process complex results from weaving together several process threads. Since *complexus* in Latin refers to ‘what is woven together’ (Tsoukas & Dooley, 2011, p. 730), a process complex denotes an entwining of lines represented by the various process threads. The process is illustrated in Figure 10 below.

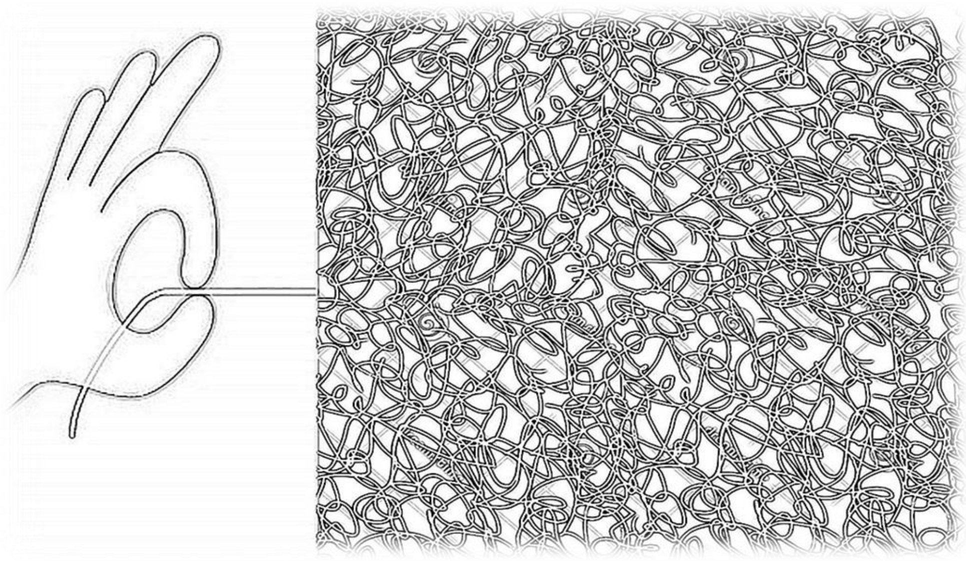


Figure 10: Delineating process threads

In Figure 10, the empirical material from which the coding proceeds is represented as entangled processes. The focus initially was on empirically observed modes of activities and their specific manifestation within the organising and innovating process. These formed the first order themes emerging from the unfolding of the organising and innovating processes. A second round of coding was then undertaken to delineate process threads from these activities by linking and contextualising rather than splitting and isolating. Generating process threads was an iterative process in which the coding started with broad definition. The interplay between the process thread code and the empirical material allowed me to narrow the coding definition and bring further precision to the process threads.

In the third round of coding I searched for relationships between and among the various process threads. By bundling similar process threads into the appropriate overarching process complex which it constitutes, I was able to weave process complexes. Finally, I undertook a fourth round of coding where I searched for entwinement among the various emergent process complexes. The links between the process complexes made the basis for the emergent analytical framework. The progressive structuring of the data which emerged from the coding process is summarised in Figure 44 in Chapter 6.

Then in order to explicate the mechanism which explains how organising and innovating entwine; I apply the emergent analytical framework to analyse the breakdowns that occurred while innovating, within and across the two field studies. Breakdowns while innovating, which refer to events where things did not go according to plan, help to unravel the entwined nature of the innovating and organising processes. This is because a breakdown could be interpreted as a disruption of the mechanism which keeps organising and innovating entwined. Guiding this analysis were three questions:

1. In what way did the incident constitute a breakdown, and what were its (potential) organisational implications?
2. What were the individual and collective responses to the breakdowns, and how was the breakdown subsequently resolved?
3. How might one explain these responses in terms of the processes that proceeded each breakdown?

Exploring these questions, required a careful examination of the process histories and 'descriptive integration' of the process complexes. This allowed me to identify the mechanism governing organising while innovating. In this way, I was able to investigate organising and innovating as processes which embody movement, duration, creativity and purpose. The data analysis process is summarised in Figure 11 below.

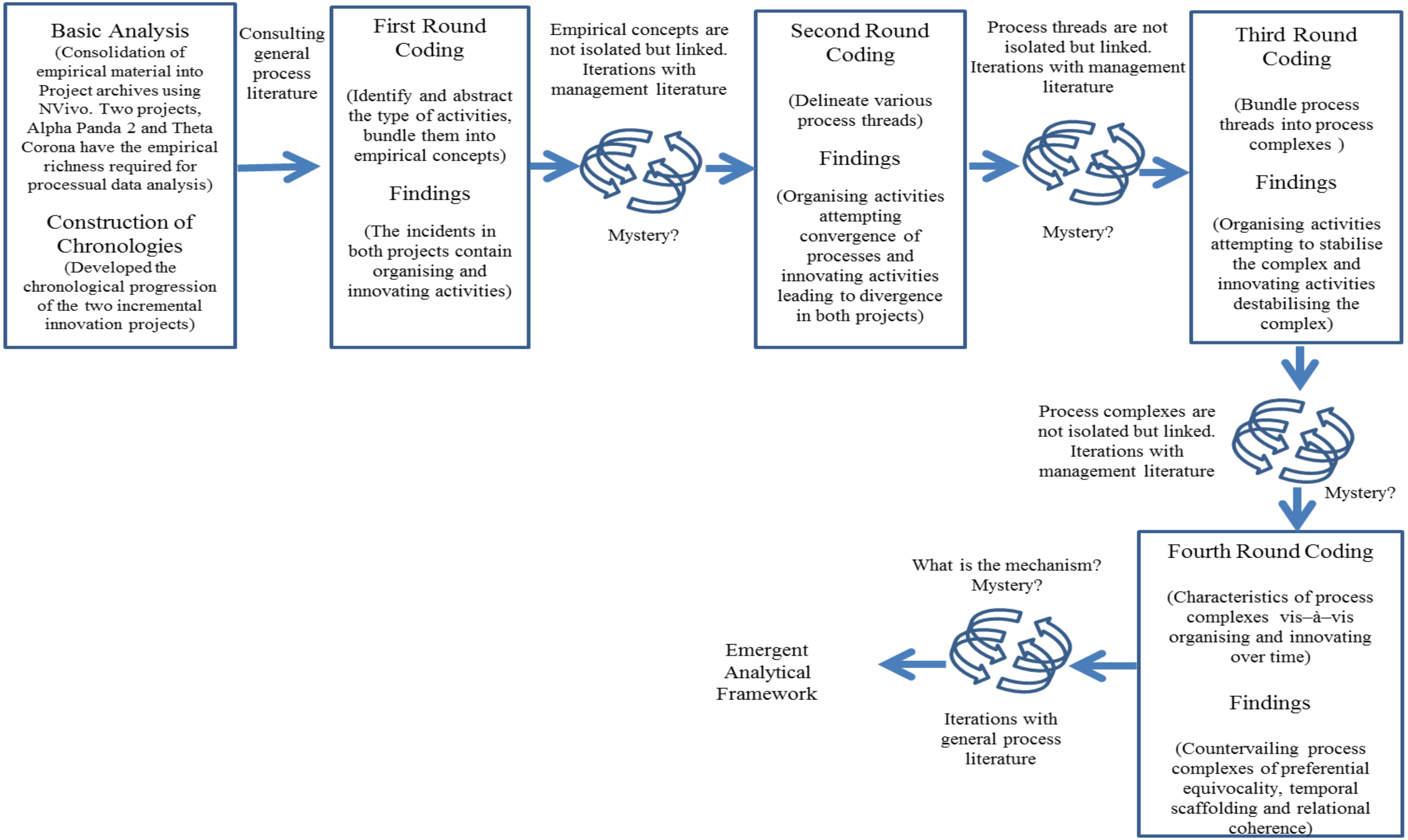


Figure 11: Data Analysis from Empirical Observations to Theory Construction

4.6 Fending off criticism

A reason this sort of immersed research investigating the organisational phenomena is lacking within management scholarship has been the researchers' inability to place themselves into the practitioner's frame of reference while they conduct their studies (Van de Ven, 1992, p. 181). This study seeks to address this issue by embracing a practical rationality framework which collects and analyses the applied knowledge of what practitioners do. This orientation could facilitate the interplay of knowledge required to simultaneously enrich both management theory and practice.

As with all research methodologies, trade-offs are inevitable. Building on Thorngate's (1976) postulate of commensurate complexity, Karl Weick (1979, pp. 35-42) highlights the challenges of developing a theory which is simultaneously general, accurate and simple. However, the goal of the methodology articulated here, unlike mainstream single case study research (Corley & Gioia, 2004) or multiple case study research (Eisenhardt & Graebner, 2007) is not to "*generalise from the particular"* but rather to "see *the general in the particular"* (Ingold, 2011, p. 233). By grasping continuity through change, this methodology allows us to probe a singular phenomenon deeper as it alongly opens up. It therefore provides far better access for management intervention than the present "social science of variables" (Flyvbjerg, 2001, p. 86).

Now scholars trained in the positivist or neo-positivist tradition (Eisenhardt, 1989) and who are enthusiastically committed to their method and to their principles, may question and criticise the element of subjectivity involved in doing such research. However, while investigating an organisational practice, a researcher does not explore, like in the positivistic tradition, stand-alone entities but rather, ways of becoming that show up in terms of familiar practices. Therefore, in the nature of the enterprise, a degree of subjectivity was inevitable. "Intellectual safety", as Trilling (1976) once wrote, when following such an approach "would then seem to lie, not only in increasing the number of mechanical checks or in more rigorously examining those assumptions which had been brought to conscious formulation, but also in straight-forwardly admitting that subjectivity was bound to appear and inviting the reader to be on the watch for it" (p. 230).

As for certain constuctivist arguments that veer towards extreme relativism and “anything goes” research (Flyvbjerg, 2001, p. 128; Gergen, 1985), such process research must be constantly confronted with praxis, including the praxis of the individual scholar. This requires a rejection of both foundationalism and relativism. Here, my thoughts echo Geertz’s (1973) assertion when he wrote,

> “I have never been impressed by the argument that, as complete objectivity is impossible in these matters (as, of course, it is), one might as well let one’s sentiments run loose. As Robert Solow has remarked, that is like saying that as a perfectly aseptic environment is impossible, one might as well conduct surgery in a sewer” (p. 30).

As regards validity, such research “is based on interpretation and is open for testing in relation to other interpretations and other research. But one interpretation is not just as good as another, which would be the case for relativism. Every interpretation must be built of claims of validity” (Flyvbjerg, 2001, p. 130), and the procedures ensuring validity are as demanding for processual research as for any other social science research.

Undertaking research of this nature means that theorists would inevitably be restricted to a single site of study. Critics may question insights from a ‘mere case”. Van Maanen puts it well when he writes "The smart-ass but wise answer to this hackneyed but commonplace question is ‘all we can’" (Van Maanen, 2011, p. 227). By this, what he means is that the insights from such a detailed exercise must be seen as what Sandberg and Tsoukas (2011, p. 353) call “heuristic generalizations”, built on concepts abstracted from concrete data, which allow practitioners and theorists to think analogically and see the extent to which current conceptual formulations help them understand their situated issues.

4.7 Conclusion

In this chapter, I have outlined my ‘theory of method’ and why I believe this is the most appropriate means of investigating my research question. I have also expanded on the research settings, data sources and the process deployed for analysing the data. The fundamental premise to explicate processes along Ingoldian lines can be summarised as follows:

1. Understanding the processes of innovating and organising requires researchers to engage in a direct observation of the activities or practices constituting these two processes in real time.
2. Researchers therefore are both involved in, and partially produced by, the processes which they study. Hence, researchers cannot stand completely outside of that which they study or ‘detached’ observation is not possible.
3. Practices – what “is done” – are more fundamental to developing a theory- practices are here understood as a “way of acting and thinking at once” (Flyvbjerg, 2001, p. 115).
4. The additional data gathered through meetings, interviews and internal documents must be scrupulously disciplined by the analysis of practices along with their corresponding processes over time.
5. Data analysis proceeds in two stages from “thick description” to “analytical” explanations.

Foundations for theory building are dependent on a systematic data collection strategy. However, as Mintzberg (1979b) correctly observes, “While systematic data create the foundations for our theories, it is the anecdotal data that enable us to do the building” (p. 587). It is this that enables us to better understand the unfolding of organising and innovating processes, not in closed social worlds but open ones. In the chapter that follows, I present the two field studies. This would familiarise the reader with the field data which I then analyse in Chapter 6.

5 *Weaving the Tales*

“When you are a small company, sometimes you have to keep your fingers in a lot of pots to keep things going because it is about building a business which stands on its own. It is not about doing something completely the right way every time because it doesn’t work like that in real life. You have got limited resource, limited skill set but you have got to make it work. So it is ‘Fly by the seat of your pants!’”

Peak’s Engineering Director on innovating

5.0 Introduction

In this chapter, I report the findings from my seven month long longitudinal field studies. These accounts are a ‘descriptive integration’ of data on two new product development (NPD) projects which I gathered in real time, within Peak Scientific Limited (henceforth referred to as Peak). The chapter is organised as follows. It opens by providing a brief overview of Peak. The goal is to acquaint the reader with the organisation and business context within which this study was carried out. Having established the contextual details, I then provide narrative accounts of two NPD projects which I tracked in real time. Narratives accommodate multiple contextual, temporal and relational complexities of innovating and provide a distinctive integrative approach to innovation research (Garud & Giuliani, 2013).

First, I shall describe the unfolding of the Alpha Panda 2 project. This project was a collaboration between Peak and Alpha Corp based in Canada. It began in December 2012 and concluded in November 2013. The second account describes the unfolding of the Theta Corona project which was a collaboration between Peak and Theta Corporation based in USA. This project began in March 2013 and was brought to a close in March 2014. The aim is to ensure that the reader is sufficiently familiarised with the details from the two studies, prior to data analysis which is undertaken in the next chapter. I’ve also included visual images from both innovation projects to convey a sense of becoming and transformation which results from acts of organising.

5.1 Peak Scientific: An Overview

Peak was founded in 1992, as a family business, to manufacture nitrogen gas generators for the analytical instruments industry. The business is owned by the MacGeachy family and is now run by Robin MacGeachy who is the Managing Director (MD). From 2006 until 2014, Peak grew at an annual rate of over 20 percent, year on year. They employ about 275 employees worldwide and have a turnover of a little over £ 31 million. Peak won the Queen's award for Enterprise in years 2005, 2007, 2011 and 2014. Being privately owned and without the pressure to pay out big dividends to external shareholders, Peak's internal corporate philosophy has been on "*doing what was right for the business*". In Robin's words,

> *"Let us look after the business, and if we look after the business, the business will look after us."* (MacGeachy, 2013)

Figure 12: Headquarters of Peak Scientific (image courtesy Peak Scientific)

5.1.1 Products

When you walk into a local supermarket, say your neighbourhood Walmart, Tesco or Carrefour, and pick up a food product or a bar of soap, how would you know what's in it? The simple answer is by reading the product label. Ever wondered how the label is able to accurately provide this detailed information on the ingredients? The answer lies in a combination of techniques called Chromatography and Mass Spectroscopy. Every consumer good that you purchase, be it soap, food, cosmetics or perfumes have their quality tested using chromatography and mass spectroscopy, which reveal the product's chemical composition. Product labels are a summary of these lab tests.

There are two distinct analytical techniques within the Mass Spectroscopy industry: Liquid Chromatography Mass Spectroscopy (LCMS) and Gas Chromatography Mass Spectroscopy (GCMS). The Mass Spectroscopes are complex technological devices manufactured by multi-billion dollar American and Japanese corporations. These corporations are referred to within the industry as Original Equipment Manufacturers (OEMs). However, labs which use these instruments require a constant supply of carrier gases, mostly Nitrogen or Hydrogen. Peak designs and develops gas generator solutions for Mass Spectroscopes manufactured by these OEMs.

Prior to the design and development of gas generators, Mass Spectroscopes would use gas cylinders (see Figure 13 below) to supply the device with the required gas.

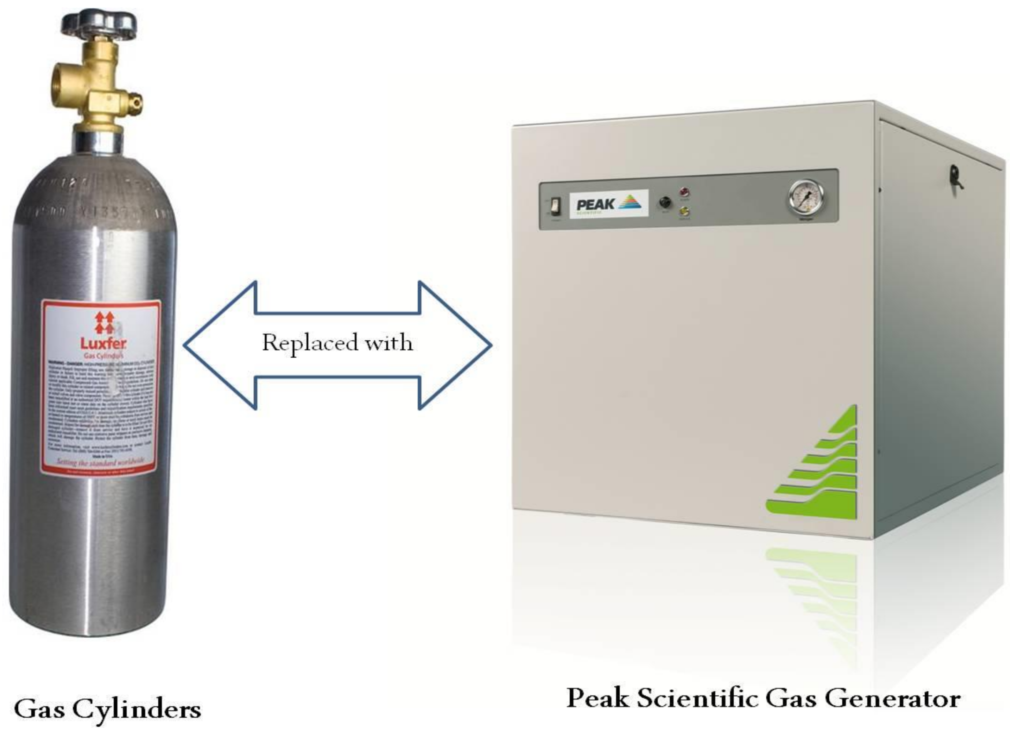


Figure 13: Gas cylinders replaced with gas generators

The use of gas cylinders has five major limitations, summarised below, which are overcome by using gas generators:

i. **Convenience:** Unlike gas cylinders, gas generators do not run out of gas and therefore do not require replacing.

ii. **Consistency in quality:** The industry supplying gas cylinders is largely unregulated and so the quality of gas in cylinders can vary greatly depending on the country you are in. Variations in gas quality also occur from cylinder to cylinder depending on how well they have been cleaned before refill. Since scientific applications like drug discoveries and forensic testing require gas of a very high quality, they cannot afford to be reliant on the vagaries of the cylinder suppliers.

iii. **Safety:** Some of the gases such as hydrogen are explosive and storing such gases in cylinders within laboratories can pose significant health and safety risks. Also, cylinders which contain highly pressurised gases are susceptible to blasts if their nozzles are defective and this poses an additional safety concern. The use of gas generators however ensure that atmospheric pressure can be maintained within the laboratory environments and therefore are a safer option.

iv. **Reliability:** Since the gas generators generate gas instantly, on demand, when required, at a standard quality, the application is reliable and eliminates the hazards which come with storing gases in cylinders.

v. **Cost:** Certain applications require a high flow rate of gas and this can make the replacement of drained cylinders very expensive in the long run. The gas generators on the other hand eliminate this running cost with a onetime fixed cost for installing the generators.

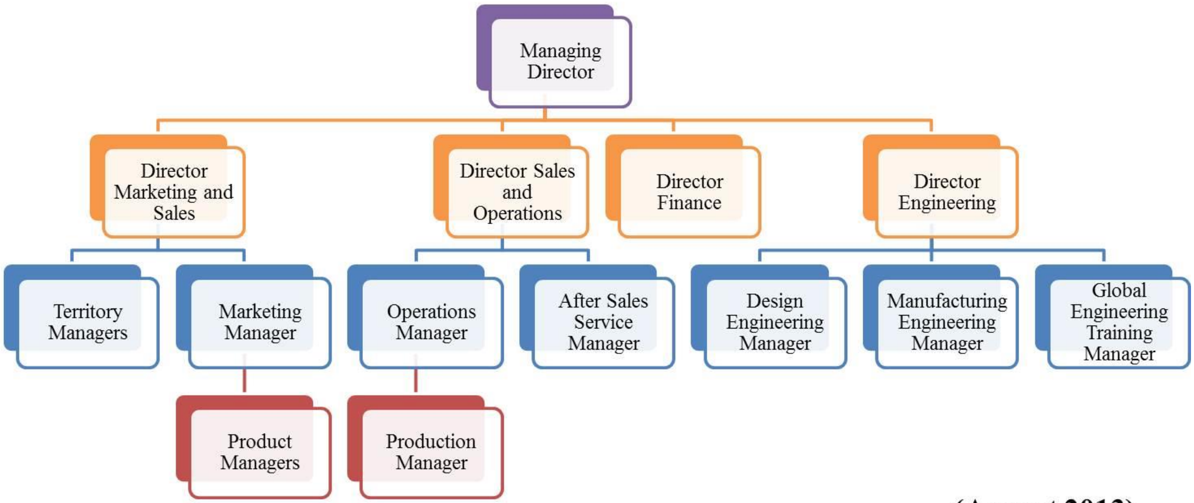
Figure 14: Impact of Peak's innovation

The ability to design and develop solutions for gas requirements of mass spectroscopes manufactured by OEMs is the bedrock of Peak's business. Developing gas generators to supply the mass spectroscopes with gas at a specified flow rate and purity is Peak's 'core-competency'.

5.1.2 Organisational Context

I began fieldwork in August 2013, following an invitation from Peak's Director of Engineering. Figure 15 below reveals how Peak was structured when I began the study.

Organisational Chart Peak



(August 2013)

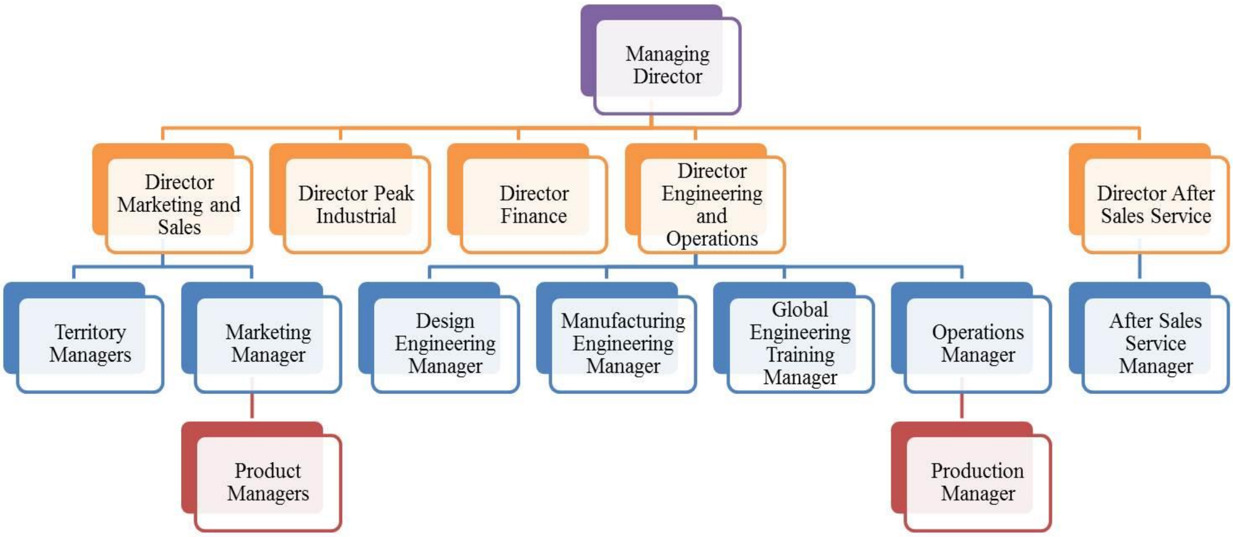
Figure 15: Management Roles and Responsibilities at Peak (August 2013)

Peak was headed by the Managing Director (MD). Reporting to him are the Directors of Marketing and Sales, Sales and Operations, Finance and Engineering. Together, the MD along with the other Directors constitutes the Strategic Management Team (SMT) at Peak. They are also referred to internally as Senior Management. Next in command are the middle managers (represented in blue) who report directly to their respective Directors. When I began my fieldwork, the role of Product Management was a newly created role. Although the individuals appointed as Product Managers had significant experience working at Peak, the role was new within Peak. It was created in June 2013 to ensure better co-ordination within the new product development process.

New product development at Peak primarily involved the Product Managers, Design Engineering Manager and a Senior Manufacturing Engineer representing the Manufacturing Engineering Manager. NPD was guided by two templates; the design development process (DDP) managed by Design Engineering and the new product introduction process (NPI) which was managed by Manufacturing Engineering. The Operations Manager (assisted by the Production Manager) was responsible for ensuring that the production volume keeps pace with sales orders. Reducing lead time on product delivery after the sales orders have been logged not just ensures an increase in sales and by implication revenue; it also ensures customer satisfaction which translates into future orders. This was the operating logic for combining Sales and Operations under the same Director.

The Manufacturing Engineering Manager during the period of this study was heavily involved with an internal corporate diversification project called Peak Industrial. Details on the internal corporate diversification project, though tracked, are beyond the scope of this thesis. It is mentioned here because of the minor impact it had on the Theta project reported here. By the end of my field study in March 2014, however, there were significant changes to the managerial roles and responsibilities at Peak. These changes are summarised in the organisational chart in the Figure 16 below.

Organisational Chart Peak



(February 2014)

Figure 16: Management Roles and Responsibilities at Peak (February 2014)

As Figure 16 indicates, a new role was created within the SMT and a Director for After Sales Service was appointed. Also, the Director Sales and Operations was made in charge of Peak Industrial. The Engineering Director assumed charge of Operations. With this brief overview, we can now proceed to explore the unfolding of the two NPD projects at Peak.

5.2 Field Study I: The Alpha Panda 2 Generator

Alpha is a global leader in the mass spectrometry industry. They are a trusted partner to thousands of the scientists and lab analysts worldwide who are focused on basic research, drug discovery & development, food & environmental testing, forensics and clinical research. The Alpha portfolio of scientific analytical tools includes innovative instrument systems, intuitive software, pre-packaged methods and chemistry reagents. These tools apply mass spectrometry technologies to enable scientists to conduct quantitative and qualitative analysis across a wide range of applications. Peak are solution providers for Alpha who are an OEM.

5.2.1 Origins

In December 2012, Peak received an inquiry from Alpha requesting an upgrade kit for their Standard Alpha 3G generator. The Alpha 3G generators are exclusively designed and manufactured for Alpha by Peak. Alpha is developing a new product codenamed Panda 2. Panda 2 is a LCMS application for the medical market. The Panda 2 has got some very specific gas requirements which the current Standard Alpha 3G generator system does not meet. Therefore, Alpha request Peak for an updated solution. The Standard Alpha 3G generator system delivers three gas outputs: one Nitrogen gas output and two air outputs. For the new Panda 2 application which is under development at Alpha, they require the Alpha 3G generator system to deliver Nitrogen gas through all three outputs.

A Standard Alpha 3G generator system (see Figure 17) comprises of three individual components. They are an Alpha 3G generator, an Alpha Table and an Infinity 1031 Nitrogen generator. An Alpha Table refers to a box containing cooling fans and a vacuum pump in which both, the Alpha 3G Generator and the Infinity 1031 Nitrogen generator, are traditionally housed.

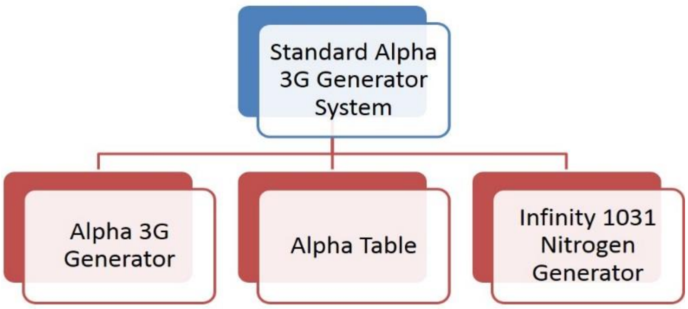


Figure 17: Standard Alpha 3G Generator System

Peak assigned a Design Engineer to assemble a kit which was then dispatched to Alpha. Some research work was undertaken on the design for a three Nitrogen gas output generator system. The Design Engineer was asked to carry out extensive and time consuming testing to ascertain the proof of concept for the new generator system. However, no orders come through for either the kits or the modified generator system. Since there were no orders, the research and development is set aside.

5.2.2 Restarting New Product Development

In June 2013, after a gap of four months since the initial inquiry, Alpha contact Peak. They place an inquiry for developing a new Alpha 3G generator system for their Panda 2 instrument but not with three Nitrogen gas outputs as previously requested. They now want the original one nitrogen gas output and two air outputs but at a different gas flow rate from the existing Standard Alpha 3G generator system. They would also like the system to be less noisy as the Panda 2 is meant for the medical market. The launch date for the Panda 2, Alpha informed Peak, has been set for the end of August 2013 or mid-September 2013. Alpha need the generator system urgently but cannot confirm the number of units or the final product specifications for this generator system. They however would like Peak to proceed with the project as there is not enough time for their Panda 2 target launch date.

All Alpha 3G generators and Alpha Tables for the Standard Alpha 3G systems require certification from the Canadian Standards Association (CSA certification). A CSA certification is mandatory for all products which contain electro-mechanical components and are to be exported to North America. It is impossible to export gas generators to North America without this certification. However, the Infinity 1031 Nitrogen generator that is part of the Standard Alpha 3G system is not bound by the CSA certification. The product certification process requires a four week lead time. Since the timelines for the Panda 2 product launch is tight, it would not be possible to get a new product CSA certified.

The management team at Peak sat together to resolve this problem. Since the only difference between the new gas generator system requirements and the current Standard Alpha 3G system are noise reduction and a higher gas flow rate, Engineering Management suggested that if Alpha agrees to use the new gas generation system being designed for Panda 2, in all Alpha applications including current ones, then Peak can upgrade the current Standard Alpha 3G system and circumvent the CSA certification. This circumvention is possible because the CSA certification is tied to the product name and not to the internal parts of the product. Since the modified gas generator system would have a higher gas flow rate, it can still be used by the previous Alpha applications. So in sum, if both Peak and Alpha could agree on just one upgraded product, the same component names can be retained and the CSA certification for the upgraded Alpha 3G generator and the Alpha Table can be avoided.

Table 4: Action Plan A, for upgrading the Standard Alpha 3G System

Current Component	Action	New Component
Alpha 3G generator	Upgrade internal parts to increase flow and lessen noise but retain component name to maintain CSA certification	Alpha 3G generator
Alpha Table	Upgrade internal parts for increased flow and to lessen noise but retain component name. to maintain CSA certification	Alpha Table
Infinity 1031	No changes required here.	Infinity 1031
Standard Alpha 3G System upgraded to Panda 2 Alpha 3G System		

The proposed action plan (Plan A) is summarised in Table 4. This quick fix would prove advantageous to all. Peak would not have to increase its product portfolio with yet another Alpha 3G generator system and Alpha would have a generator in time for their Panda 2 product launch that is also compatible with all their current applications. There is also the cost saving on the CSA certification which can be shared by both the organisations. This suggestion is internally approved within Peak and then sent across to Alpha for approval. Simultaneously, three Manufacturing Engineers (ME) are assigned to each of the components of the new Alpha 3G Generator system being developed for Panda 2. Manufacturing Engineer 1 (ME-1) is assigned to develop the new Alpha 3G generator, Manufacturing Engineer 2 (ME-2) the new Alpha table and Manufacturing Engineer 3 (ME-3) for integrating the current Infinity 1031 Nitrogen generator with these modified components.

5.2.3 Speed Bump in New Product Development

In early August 2013, Alpha again put their product requirement on hold. They are deciding on which of the two, three gas output gas generator systems (one nitrogen gas output and two air output or three nitrogen gas output) is more appropriate for their Panda 2 product, which is under development. Since Peak is developing a product for an instrument which itself is under development, there is a recursive level of uncertainty in this NPD project. Any drastic changes in customer requirements at this stage would not just undermine the previous project decisions internally approved within Peak, but could also adversely impact the gas generator system delivery date. According to the Design Engineer:

> "Yes, so we started work on it and a week later they told us, they have a massive problem and that we need to change everything. So for us it was back to the drawing board, new generators altogether"

Fifty percent of the design and development work, based on prior information, had been completed. The Design Engineer is now concerned that the product specifications are yet to be finalised. All further development work is halted and a meeting with Alpha is scheduled. The Design Engineering Manager sends Alpha an updated customer requirements document for confirmation. The scheduled meeting between Peak and Alpha takes place on 13th August 2013.

Representing Peak were the Director Sales and Operations, Operations Manager, Design Engineer, Design Engineering Manager, Product Manager and Senior Manufacturing Engineer. Representing Alpha was their Product Service and Support Manager and his team. The organisational hierarchy within the Peak team along with the departments they represent are illustrated in Figure 18.

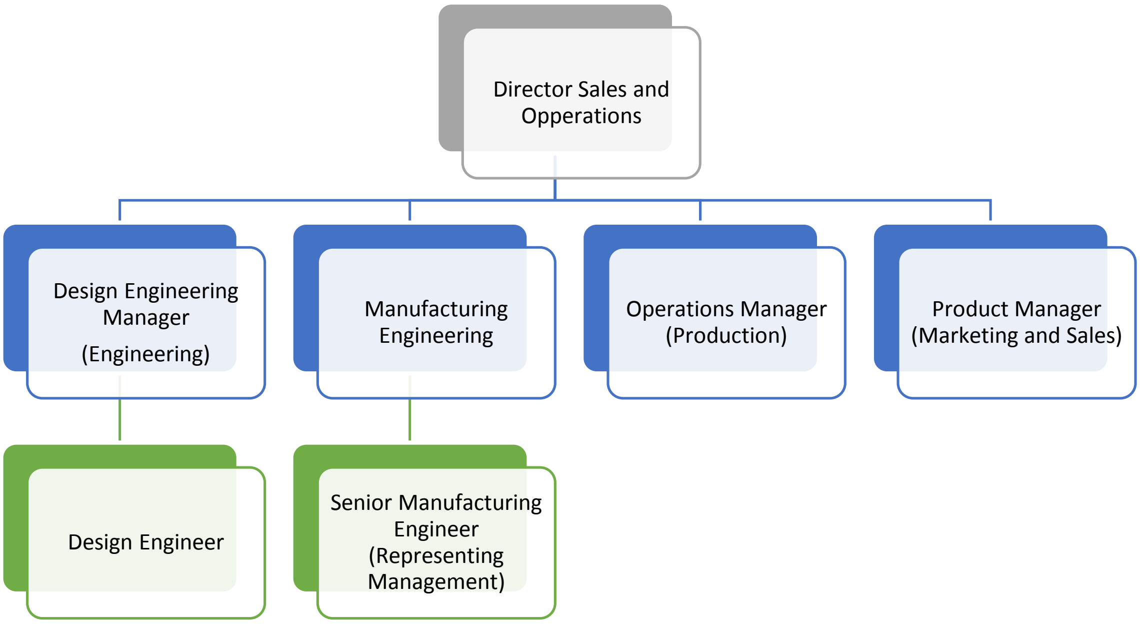


Figure 18: Project Management Team and the Organisational hierarchy

Prior to this meeting, the Design Engineer informs the team that new additional components would be required to upgrade the existing machines. This increases the bill of materials (BOM) cost for the new product. While the Product Manager is concerned about the additional cost, the Design Engineering Manager suggests that since the product is an Alpha specific, bespoke solution, Peak could command a higher price for this new and upgraded solution.

During the call, the Alpha Manager informs the Peak team that their Panda 2 product prototype is now fully working and that Alpha's engineering team have switched from product development mode to production mode. They are still working on the gas requirements for this new Panda 2. Hence, the Peak generator system specifications are yet to be finalised. Alpha also informs Peak that no definite product launch date has been set for the Panda 2. They estimate the launch to take place by the end of September or early October 2013. When asked for information on the number of generator units Alpha would require from Peak, Alpha do not have a specific number. However, they confirm a six week lead time between the order date and the delivery date. Therefore, they would like to place a rolling purchasing order with Peak to avoid raising a new purchasing order every time they require a new gas generator system. Peak would therefore have to maintain an inventory for the new generator system.

The Design Engineer informs Alpha that he has put together a 'bench test' (an experimental setup) to previous specifications and that he is getting the right results in ongoing bench tests.

He has ordered materials for a prototype build which are due to arrive on 23rd August 2013. Since the gas generator system is for the medical market, Alpha have demanded a lot of test data from Peak which the Design Engineer is now putting together. The call concludes with Alpha informing Peak that they would get back with the final customer requirement documents. After the call, an internal discussion ensues within the Peak team. The Product Manager wants to halt the project until they get a confirmation from Alpha. The Director of Sales and Operation is not too keen on halting the development work. He recommends that the team continue the research and development work and plan for twenty units.

During the rest of that week, the Design Engineer looks into the possibility for the three nitrogen gas output generator system design. He has halted tests for the system he was previously building. In any case, the changes would only impact the Alpha 3G generators and not the Alpha Table or the Infinity 1031 Nitrogen generator. So he works on updating the Computer Aided Design (CAD) models of these two components. Finishing that would allow him to starting co-ordinating with the Manufacturing Engineers (ME-2 and ME-3 respectively). Meanwhile, ME-1 has finished the work instruction manuals for the revised Alpha 3G generator. All the Manufacturing Engineers investigate the updated CAD models to plan the NPI process. ME-3 has begun work on the sub-assemblies for the Infinity 1031 Nitrogen generator.

5.2.4 Change of Plans

The following week, Alpha confirm that their Panda 2 would require a two air and one nitrogen gas output solution. However, they would like the nitrogen output flow on the Infinity 1031, increased by two litres per minute. The confirmation vindicates Peak’s decision to continue working on NPD. But this would require upgrading the current Infinity 1031 generator. This is not a problem because the Infinity 1031 does not require a CSA certification. Therefore, Peak upgraded the project plan to reflect changes in customer requirements. The updated Infinity 1031 generator with its output flow rate increased by two litres per minute would now be called Infinity 1035. The updated plan, Plan B is summarised in Table 5 below.

Table 5: Action plan B, for upgrading the Standard Alpha 3G System

Current Component	Action	New Component
Alpha 3G generator	Upgrade internal parts to increase flow and lessen noise but retain component name to maintain CSA certification	Alpha 3G generator
Alpha Table	Upgrade internal parts for increased flow and to lessen noise but retain component name. to maintain CSA certification	Alpha Table
Infinity 1031	Upgrade the internal design for the increased gas flow requirements. Since the component is not CSA certified, change the component name to Infinity 1035 and maintain two separate models, Infinity 1031 (lower flow) and Infinity 1035 (higher flow).	Infinity 1035
Standard Alpha 3G System upgraded to Panda 2 Alpha 3G System		

Alpha request Peak to provide them with experimental test results for product feasibility by 23rd August 2013. The Design Engineer has to now make changes to the Infinity 1031 Nitrogen generator. He then has to perform tests, record the results and generate a test report to prove the capability of the new solution. He therefore generates test reports for the upgraded Alpha 3G generator, upgraded Alpha Table and the Infinity 1035 Nitrogen generator. Figure 19 below shows the schematic diagram used for setting up the bench tests which were used to generate the technical reports.

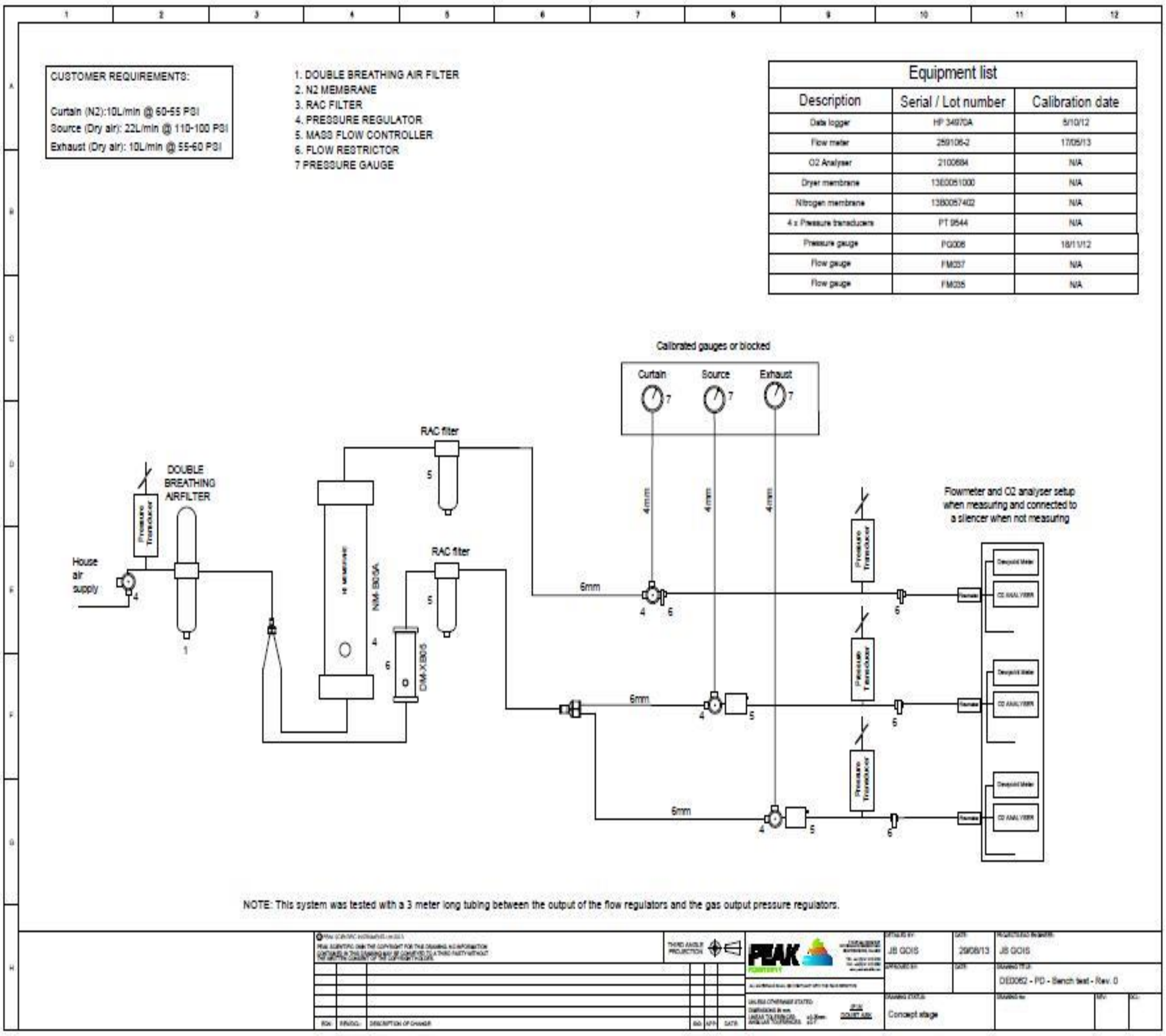


Figure 19: Bench Test diagram, Upgraded Standard Alpha 3G gas generator system

The final version of the customer requirement document is approved by Alpha and the NPD process for upgrading the Standard Alpha 3G gas generator systems can now begin. The customer requirements document is the starting point of the DDP which is an official NPD routine at Peak. Figure 20 below, shows the customer requirement document which emerged from the ongoing acts of organising.

Customer Requirements

Design Inputs > Design Proposal > Concept > Detail Design > Validation

Background information

AB Sciex has requested a new range of generators to suit their new medical device, known as Panda 2. This version will be based on the current AB-3G

Gas requirements (per generator)

System 1	Gas 1	Gas 2	Gas 3	Gas 4
Gas	Nitrogen	Air	Air	Choose an item.
Pressure	80-57psi	110-100psi	60-55psi	
Flow	10lpm	22lpm	10lpm	
Purity	>= 95%	<-11°C Dew point	<-11°C Dew point	
Name	Curtain	Source	Exhaust	
Comments				

Air supply

Air source	Internal compressor/ cell ☒	External ☐
Comments		

Electrical requirements

Input voltage	100V ± 10% ☐	110V ± 10% ☐	230V ± 10% ☒	Universal ☐
Frequency	50 Hz ☐	60 Hz ☐	50/60 Hz ☒	
Input connection	C13 (10A) ☐	C19 (16A) ☒	Other ☐	
Comments	Ferrites need to be added to the mains inlet wires to reduce electrical noise to medical standards. Otherwise the same requirements as the current AB-3G			

Environmental requirements

Operating temp.	5°C – 25°C ☐	5°C – 30°C ☒	5°C – 35°C ☐
Storage temp.	Minimum: -20°C	Maximum: 60°C	To be defined ☐
Maximum RH	70% ☒	80% ☐	Other:
Comments			

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Figure 20: Customer Requirements Alpha Panda 2 Gas System

A joint meeting of the Engineering Department was convened by the Design Engineering Manager. He announced that Alpha have approved the idea for an ungraded Standard Alpha 3G system. However, they would like to retain the original name of the Nitrogen gas generator as well. So the Infinity 1035 which was an upgraded Infinity 1031 would now have to be called an Infinity 1031. The Design Engineering Manager wants the Design Engineering team and the Manufacturing Engineering team to work closely on this tricky upgrade. The Manufacturing Engineering Manager raises concerns about this quick fix solution as these changes would be very challenging and impacts the NPI process controlled by the Manufacturing Engineers. However, his concerns are over ruled because the new system must be developed, tested and shipped in time to support Alpha Panda 2 product launch scheduled for mid-September 2013. Table 6 below summarises the new action plan

Table 6: Action plan C, revised for upgrading the Standard Alpha 3G System

Current Component	Action	New Component
Alpha 3G generator	Upgrade internal parts but retain component name to maintain CSA certification	Alpha 3G generator
Alpha Table	Upgrade internal parts but retain component name. to maintain CSA certification	Alpha Table
Infinity 1031	Upgrade internal parts to increase the Nitrogen flow and retain component name even though this component is not CSA certified.	Infinity 1031
Standard Alpha 3G System upgraded but remains Standard Alpha 3G System. Old Alpha 3G System is discontinued.		

The next day a Project Engineering team meeting is scheduled between Peak's Engineering Department and Technical Team from Alpha. Alpha want to discuss the test reports which were sent over by the Design Engineer the previous day. The customer requirements document is signed off by both parties. The Technical team from Alpha who are also responsible to ensure that the Alpha Panda 2 complies with the regulatory requirements of the medical devices market want Peak to perform some additional testing. The Design Engineering Manager, mindful of the time scale required to keep up with the first week of September 2013 deadline, feels that the additional tests can be done after the upgraded Alpha 3G system prototypes have been built. This was when Alpha reveal that their Panda 2 launch date has been postponed from their intended mid-September 2013 timeline. Panda 2 still requires some additional regulatory documentation work that needs more time to be completed. This takes Peak by surprise and the Design Engineering Manager is not pleased to learn about this postponement.

The new date, though yet to be finalised, is indicated as mid October 2013. Both parties agree that the current test report fulfil the technical requirement of Alpha Panda 2. Therefore, the project can progress to the next stage. However, in order for Alpha to sign off the Design Proposal document, they require Peak to change the test report of the Nitrogen generator from Infinity 1035 to Infinity 1031. Peak agree to make the changes and the design proposal was signed off. The Peak Design Engineering Manager’s closing words were:

> "I think from a technical point of view, we are all in agreement. Obviously we are now going to be adding components to the standard generators so there needs to be a discussion between the Alpha Manager and Director Sales and Operation here (Peak) to agree on how we are going to move forward on pricing. The on-going discussion is that Alpha Manager is seeking a price reduction on a current generator so I think they will reach a middle ground on the pricing."

The Figure 21 below displays the design proposal document. This design proposal document is the outcome of a co-ordinated series of actions on the customer requirement document displayed in Figure 20.

Design Proposal

Project: Click here to enter text. Project code: DE0062

PEAK

Design Inputs > Design Proposal > Concept > Detail Design > Validation

Attendees

YQ, CS, CP, RS, RR, PM, SR, ST, SK, DMcK, SB, JB	19/07/2013

Related documents

Document	Document Number	Revision
Customer requirements	REQ???	

Proposal

AB-SCIEX has requested a new range of generators to suit their medical device, known as the Panda 2.

As they are trying to clear regulatory issues, their gas requirement has not yet been confirmed, however, they believed that a solution is more likely to be selected over the other. With the short deadline, the development is going ahead with the Infinity 1031 with an increased exhaust pressure using a mass flow controller instead of the usual flow restrictor.

Lead Engineers

Design Engineer	Jean-Baptiste GOIS
Manufacturing Engineer	Safder KHAN

Design Proposal Inputs

Input	Accept/ Reject	Comments
Customer requirements	Choose an item.	To be confirmed

If the Design Inputs are rejected please give full details and propose an alternative where applicable.

Rejected Item	Details	Owner	Date

Consideration of existing designs

This product will be based on Infinity 1031 with the addition of a mass flow controller on the exhaust line.

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Figure 21: Design Proposal for Panda 2 Gas generator system

5.2.5 Talking Pennies and Pounds

Since the technical specifications have been agreed upon, the discussion switched to the commercial side of the upgraded gas generator system. Since the upgrades mean adding new parts to existing components, Peak seek a product price increase. The price negotiation involved Peak's Director Sales and Operation and the Manager at Alpha who was seeking a price reduction. Confidant that a middle ground would be reached on pricing, both the technical teams continued NPD. In order to revise the project plan, Peak request Alpha to confirm their new launch date.

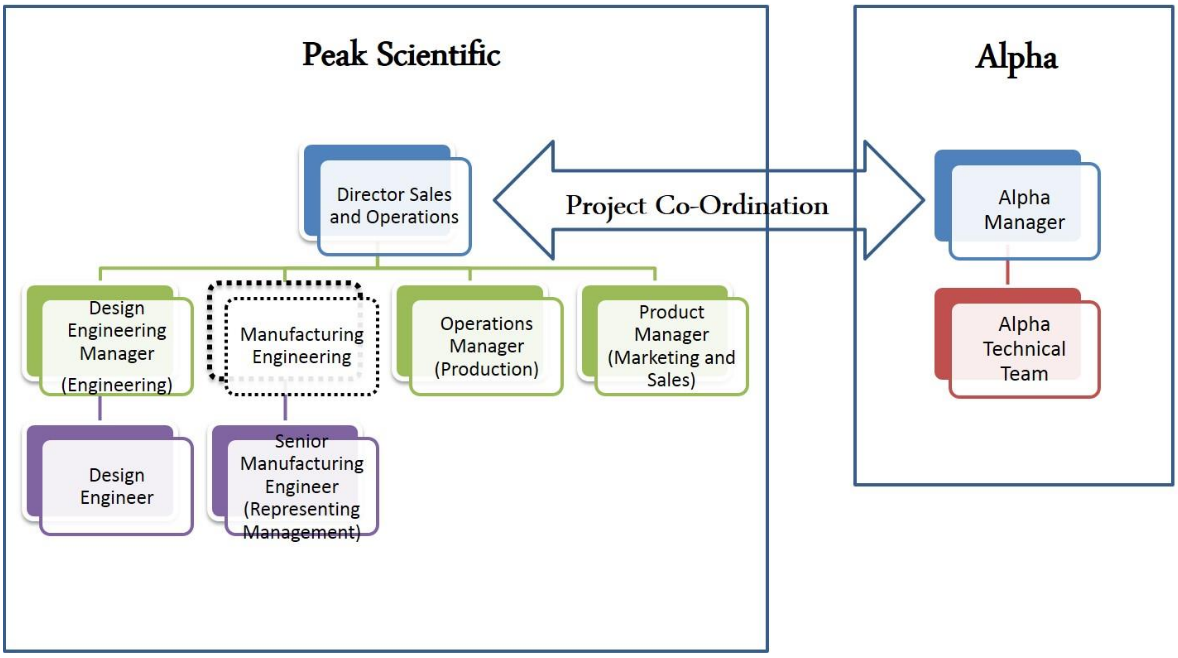

Figure 22: Project co-ordinating Structure at the start of the Alpha Project

It is important to note the changes in the project structure and co-ordinating mechanisms at this stage. The project tasks have now been divided into technical requirements and commercial requirements respectively. The technical tasks are to be driven by the Design Engineering Manager at Peak by co-ordinating with the Technical Team at Alpha. Commercial negotiations are taking place at the Senior Management level between the Alpha Manager and Peak's

Director Sales and Operations. Figure 22 and Figure 23 represent the evolution of management structure that was originally put in place to deal with the execution challenges of the project.

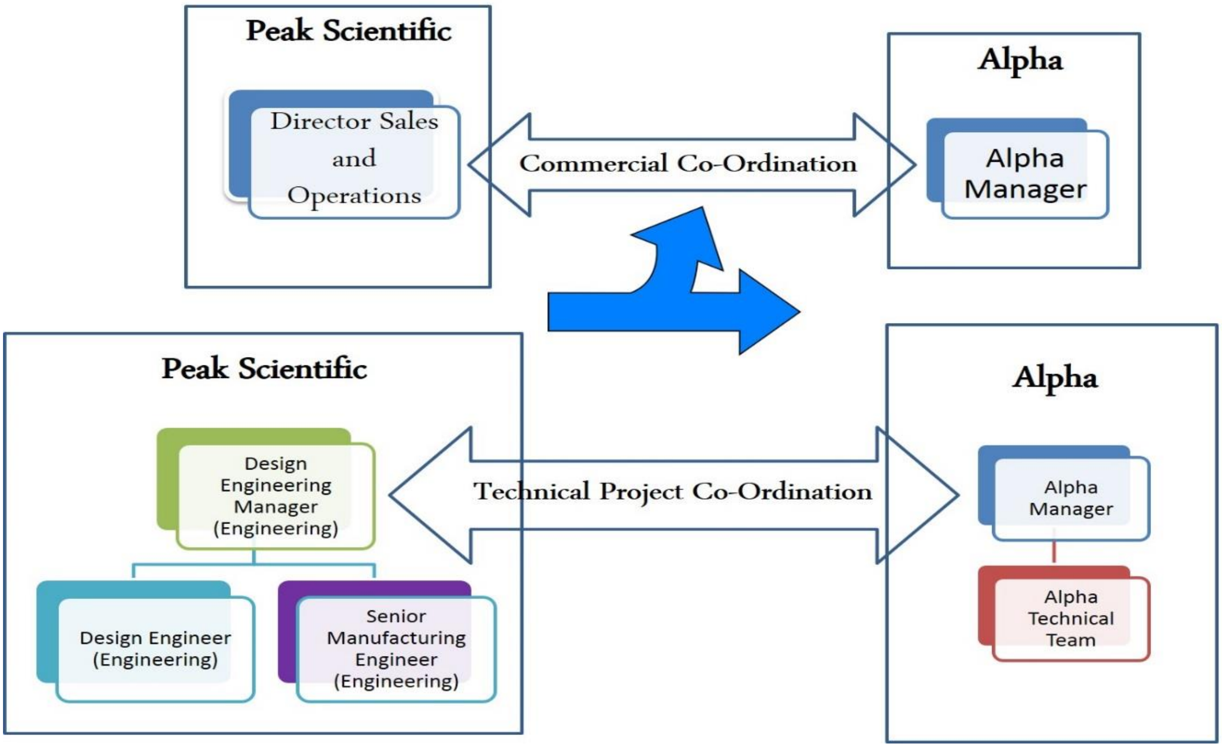

Figure 23: Evolving Project structure of the Alpha project

The Design Engineering Manager asks the Design Engineer to start working on the project. It is not a comfortable situation for the Design Engineer who does not have a fixed project deadline nor an assurance on the target cost of the product. The Design Engineer is now working very closely with the Manufacturing Engineers on each of the three new component builds. He is co-ordinating the development of the Alpha 3G generator with ME-1, the Alpha Table with ME-2 and the Infinity 1031 generator with ME-3. Figure 24, below was the first prototyped product to emerge from the ongoing acts of organising and innovating.

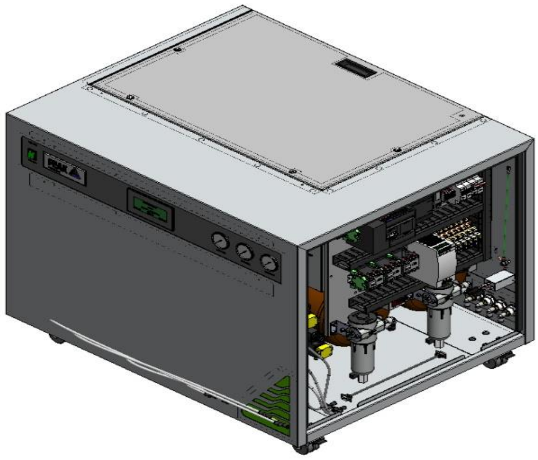

Figure 24: New Alpha 3G Prototype System

The following week, the product prototype is ready and a telephone conference is organised between Peak and Alpha. Representing Peak are the Director Sales and Operation, the Design Engineering Manager, the Senior Manufacturing Engineer and the Design Engineer. Alpha acknowledge the product test verification records sent by Peak. They approve the development from a technical point of view. The technical performance of the new Alpha 3G prototype system is compatible with the Panda 2 instrument which Alpha now plans to launch in mid-October 2013. In order to obtain the regulatory clearance for a mid-October launch, Alpha places an order for this prototype system which now has to be tested along with the Panda 2, as a combined unit. Peak confirm that they will ship the unit out on the 6th of September 2013.

When the Director Sales and Operations revealed that the upgraded Standard Alpha 3G gas generator system would cost $300 more than the previous model, the Alpha Manager enquires about the possibility of having two separate Models, the Standard Alpha 3G which is a lower priced product and a Panda 2 Alpha 3G which would be the new product. According to him, the Purchasing Department of Alpha would not allow for a price increase on model names which are currently being purchased from Peak. He would not be able to justify a price increase on a product with the same model name even though the internal components have been upgraded. The technical teams from Peak and Alpha object to this suggestion. In the words of the Alpha Technical Lead,

> "Everything we are doing is under the assumption that the name of the gas generator will not change. As of last week, I understand that this is under discussion at the business level. So if these changes can be incorporated into the main production so that we do not have to change the name of the gas generator, then we are good."

For Alpha, since all their regulatory filing documents state the components of the units as an Alpha 3G generator, an Alpha Table and an Infinity 1031 Nitrogen Generator, they cannot change the component names of the system. For Peak, the CSA certification for the Alpha 3G generator and the Alpha Table are tied to the Standard Alpha 3G unit. Any changes to the component names would invalidate the CSA certification thereby also violating the regulatory requirements of Alpha's Panda 2 instrument. Since a price increase is only possible on a new product model, both teams would now have to go back and relook at the work which needs to be done to make the required changes.

The technical teams from both the organisations are annoyed by these developments. The meeting ends inconclusively. Alpha are going to look into the paperwork required to change the model name of the product. Peak investigate the possibility of introducing a new product with CSA certification and maintain two separate product lines. In other words, the Standard Alpha 3G would have to be retained and the possibility of a new Panda 2 Alpha 3G system would have to be looked into. All of these need to be done prior to the Panda 2 launch scheduled for mid-October 2013.

5.2.6 Improvising and Wayfinding

Plan A (refer Table 4) which was the original plan was upgraded to Plan B (refer Table 5). Plan B was then discarded in favour of Plan C (refer Table 6). Now since Plan C is not acceptable, given all the time constraints on the launch date for the Panda 2, Plan B is revisited. The Design Engineering Manager calls for a meeting of the Engineering Department. It is decided that since changing the names for the Alpha 3G generator and the Alpha table require updating CSA certification, the names would be retained even though the products must be upgraded. However, since the Infinity 1031 is not tied in by the CSA certification, changing the name to Infinity 1035 would allow Peak to maintain two separate models which can be internally differentiated. This would also circumvent updating the CSA certification files as the model name remains unchanged. A substantial re-organisation must now be undertaken at Peak especially by Manufacturing Engineering in order to create and support a new product line. The new Panda 2 Alpha 3G Model would comprise of an updated Alpha 3G generator, an updated Alpha Table and an Infinity 1035 Nitrogen generator.

ME-3 who was assigned to build the Infinity 1031 will now have to change several production documents like Work Instruction manuals and Product Testing manuals to incorporate the new Infinity 1035. These manuals are for technicians on the production line who manufacture these new generators. Since the Infinity series of nitrogen generators is not tied to the CSA certification, changing it would allow Peak to not just maintain a separate generator but to also charge Alpha a higher price. The Design Engineer makes the required changes to the CAD model and sends it across to the Manufacturing Engineers who would now have to redo their manufacturing and production support documents for the new Panda 2 Alpha 3G System. Figures 9, 10 show the three new components of the Panda 2 Alpha 3G System.

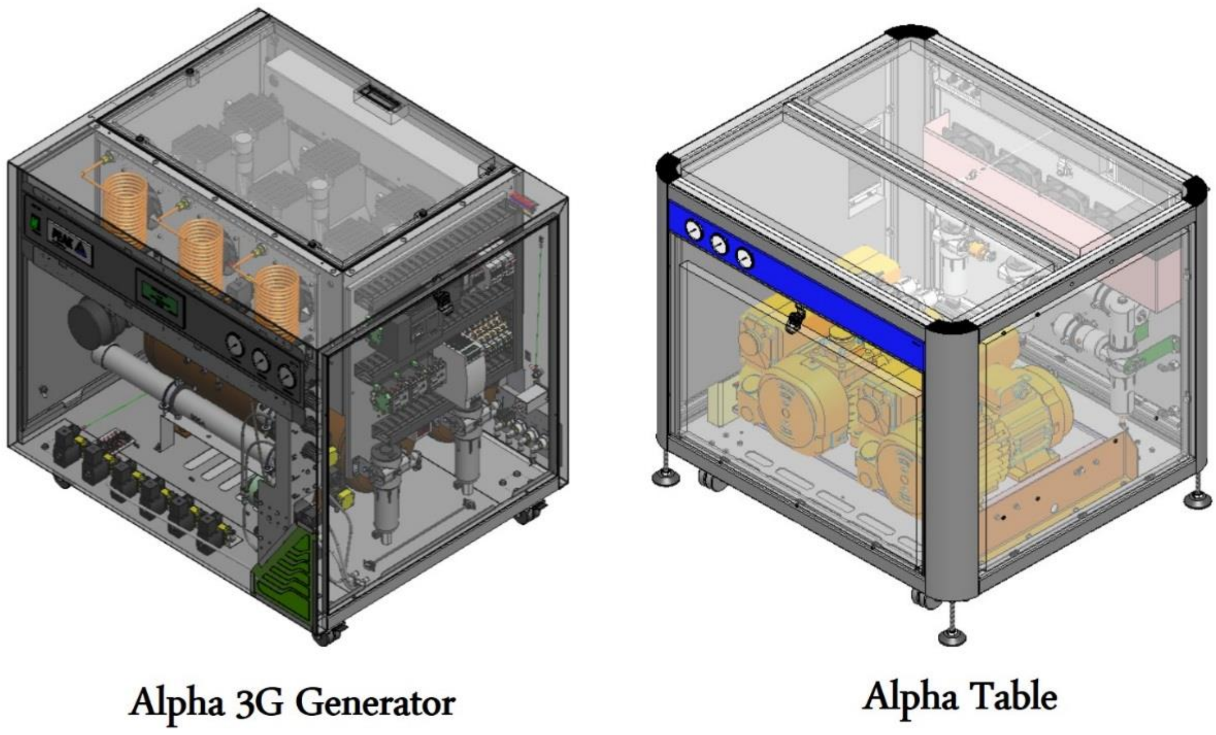

Figure 25: Panda 2 Alpha 3G generator and Panda 2 Alpha Table

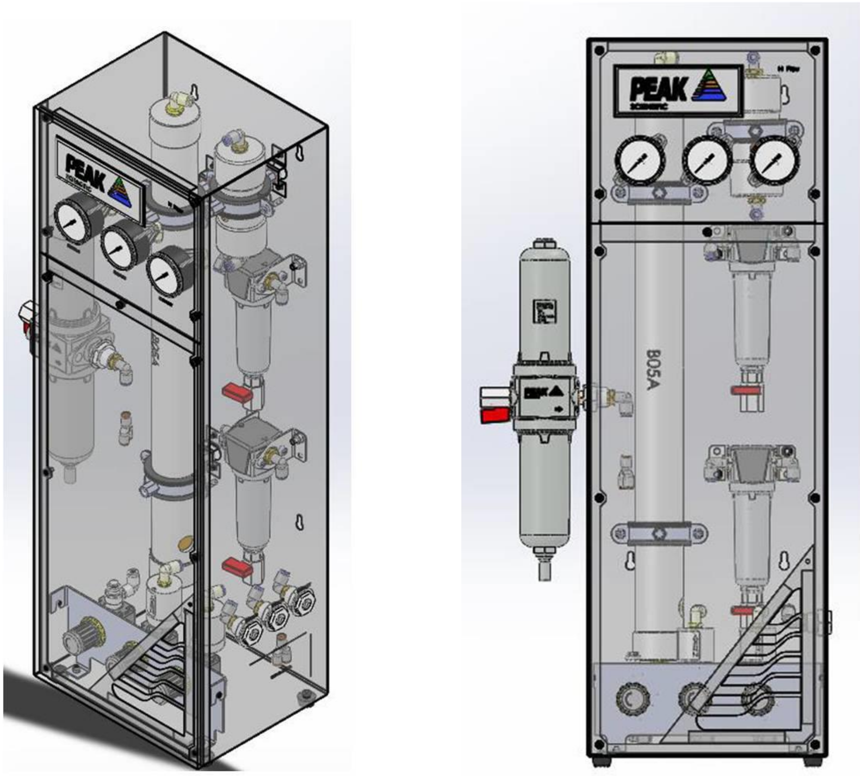

Figure 26: Infinity 1035 for Panda 2

However, in late September 2013, the Alpha technical team came back and informed Peak that since the regulatory documents of the Panda 2 already state Infinity 1031 as the Nitrogen gas generator model in the certification, Peak would either have to revert back to Infinity 1031 as the name for the generator or issue a letter of similarity stating that the Infinity 1031 and Infinity 1035 are the same generators.

The letter of similarity cannot be issued because the Infinity 1031 and Infinity 1035 are now different generators. Infinity 1035 contains additional components and has a higher flow rate. Reverting back to Infinity 1031 is also not possible since that was the main reason why the rework was ordered. Additionally, with the creation of two separate product lines, having the same name for two components which are different is hugely disruptive within the Production environment. There, the risk of building a wrong product has increased. All development work grinds to a halt. The Design Engineering Manager and the Product Manager are frustrated and disappointed with Alpha. In the words of Peak's Product Manager:

"If it were me, I'd take a harder line with them but since the Peak Director of Sales and Operation is in charge....Peak Director of Sales and Operation knew what he was doing and he gave them (Alpha) all the stuff and the Alpha Manager forgot even the conversation he had privately held with the Director Sales and Operations. So they (Alpha) have got a lot going on but if they cannot remember the conversations they have had privately, then .... I've never worked in a business like that! It's that bad but then that is the reality."

After a week's stalemate, Plan D was negotiated by the management at Alpha and Peak. It was agreed that the nitrogen generator name would now be changed back to Infinity 1031 but the design would be modified with the words *Hi-Flow* in front for all the three components. This would mean redesigning the product chassis. Redesigning the chassis would mean that ME-1, ME-2 and ME-3 would all have to revise and update their respective manufacturing and production documents and processes to reflect these changes. It would also mean ordering new metal work for the new product build. The new plan which got executed is summarised in Table 7 below.

Table 7: Action Plan D, Panda 2 Alpha 3G System

<table>
<tr><th>Current Component</th><th>Action</th><th>New Component</th></tr>
<tr><td>Alpha 3G generator</td><td>Upgrade internal parts but retain component name to maintain CSA certification</td><td>Alpha 3G generator (Hi Flow)</td></tr>
<tr><td>Alpha Table</td><td>Upgrade internal parts but retain component name. to maintain CSA certification</td><td>Alpha Table
(Hi Flow)</td></tr>
<tr><td>Infinity 1031</td><td>Upgrade internal parts to increase the Nitrogen flow and change design but retain component name even though this component is not CSA certified.</td><td>Infinity 1031-(Hi-Flow)</td></tr>
<tr><td colspan="3">Two models will be maintained the Standard Alpha 3G System and Panda 2 Alpha 3G System (with upgraded Alpha 3G generator, upgraded Alpha Table and Infinity 1031 Hi-Flow).</td></tr>
</table>

This new plan is cleared by Alpha. For Alpha, the regulatory documents tie the Panda 2 System only to a model number (here the Infinity 1031). Having Hi-Flow designed on the product front panel would allow both organisations to internally distinguish the Standard Alpha 3G generator from the Panda 2 Alpha 3G. Both teams have muddled through towards a workable solution. The redesigned Infinity 1031 Hi-Flow generator is shown in Figure 27.

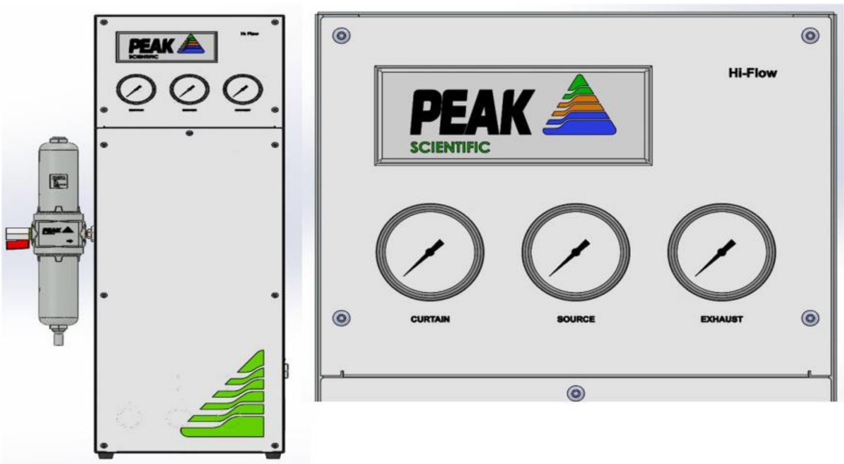

Figure 27: Infinity 1031 Hi-Flow Nitrogen Gas Generator

The changes made to the front panel of the Panda 2 Alpha 3G generator and the Panda 2 Alpha Table can be seen in Figure 28 below. Hi-Flow is inscribed on both the front panels to distinguish the build from the Standard Alpha 3G system.

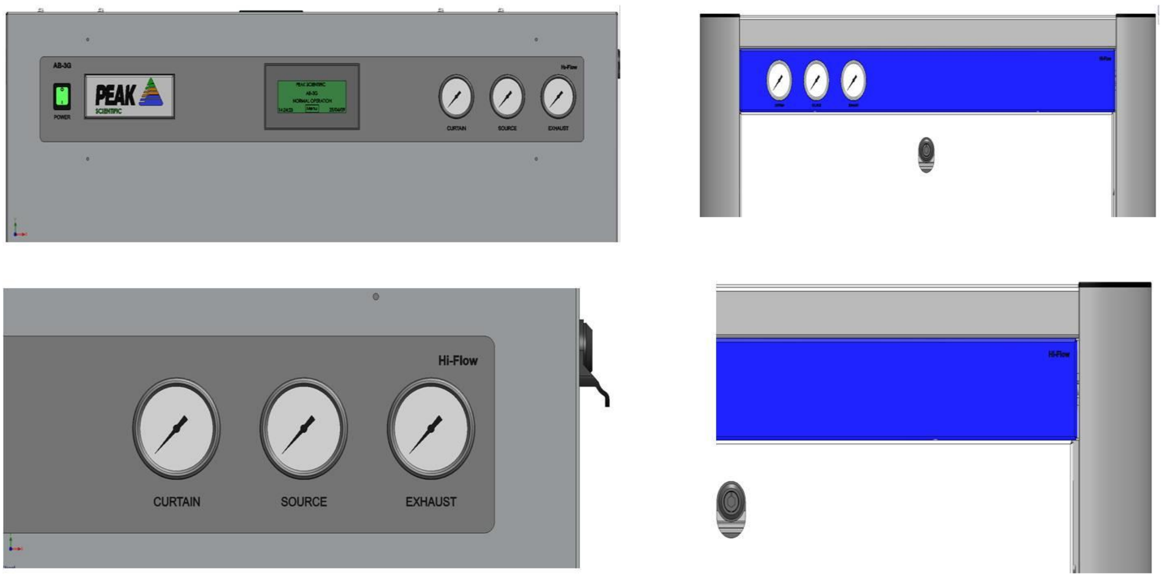

Figure 28: Modified Hi-Flow front panels for the Alpha 3G generator and Alpha Table

The developments force Alpha to push back their Panda 2 product launch from 12th October 2013 to 12th November 2013. An Engineering review is held at Peak and the designs are jointly agreed by Design and Manufacturing Engineering. The project has increased the Manufacturing Engineering workload. They now have to work with a compressed product introduction timeline to ready the new Panda 2 Alpha 3G system for production. Manufacturing Engineers would also have to repeat a lot of training procedures with Production Technicians responsible for building these hard to distinguish products. The new product is ready for launch in early November. Figure 29 shows the Panda 2 Infinity 1031 Hi-Flow being built for sale.

Figure 29: Infinity 1031 Hi-Flow

A joint Detailed Design Review and a NPI meeting was organised within Peak to launch the new system. All gathered (Product Management, Design Engineering, Manufacturing

Engineering and Production) sign off on the project. When discussing the project, the Peak Global Engineering Training Manager is not surprised. As he puts it,

> "I've got this before; every time we talk to Alpha it is the same. They go around in circles. We go round and round in circles and address the same points again and again. It keeps coming around and the individuals change. There is no consistency of people around there."

Peak's Director of Sales and Operations has a lot of questions to answer pertaining to the entire project. This account highlights the challenges of organising while innovating. Appendix I offers a chronological guide to the unfolding of the Alpha Panda 2 project.

5.3 Field Study 2: The Theta Corona Generator

Theta Corporation (henceforth referred to as Theta), is a $17 billion enterprise headquartered in the USA. They are leaders in developing analytical equipment and in enterprise laboratory design. In 2011, in a bid to expand their product portfolio, Theta acquires Delta (pseudonym). Delta, now a part of Theta, are leading makers of chromatography systems and advanced chemistry technologies for chemical analysis, sample preparation, and laboratory automation.

5.3.1 Origins

In March 2013, at the PittConn conference and exposition organised jointly by the Spectroscopy Society of Pittsburgh (SSP) and the Society for Analytical Chemists of Pittsburgh (SACP), Peak's Director of Engineering is approached by representatives from Theta. The Theta delegates liked the design of the new Precision range of scientific generators designed by Peak, on display at this exposition. They are looking to replace their current gas generator supplier and seek a new partner who can supply them with a solution for their new Corona application which is currently under development. After discussions, Theta realise that the product on display does not meet their requirement. It did not have the desired Nitrogen output flow and purity. They inquired about the possibility of Peak developing a new customised generator for their new Theta Corona instrument. The Engineering Director forwards the request to the Design Engineering Manager at Peak.

The Design Engineering Manager discussed the requirements with the Design Engineer. The Design Engineer is asked if the generator can be modified to provide 95% pure Nitrogen gas at an output flow rate of 4 litres per minute. The Designer Engineer picks up the machine displayed at the exhibition, makes a few tweaks, adjusts it to the customer requirements and responds,

> “Yeah we can get that out of this CMS (Carbon Molecular Sieve) system.”

Peak’s Engineering Director speaks to Theta and informs them that Peak will provide them with a functioning generator. In his words,

> "It won’t look like what you want but if you could try it, validate it and see what happens?"

This feedback will allow Peak to develop a customised solution for Theta. The prototype generator unit was shipped to Theta to find out if it met their requirements. The engineers at Theta test this modified generator prototype with their instrument and confirm that Peak’s solution is working and meet Theta’s instrument requirements.

Sensing a potential sales deal, the Engineering Director assigns a Product Manager to oversee the project. The NPD process is initiated. The Product Manager provides the Engineering team with a first draft of the customer requirement document. The goal is to complete product development work and make the product available by the end of July 2013. Figure 30 displays the customer requirements document for the generator. Theta require a solution that can supply Nitrogen gas which is at least 95% pure at a flow rate of 4 litres per minute.

Customer Requirements

Project: Corona Nitrogen   Project code: DE0060

PEAK

Design Inputs → Design Proposal → Concept → Detail Design → Validation

Gas requirements

System 1	Gas 1	Gas 2	Gas 3	Gas 4
Gas	Nitrogen	Choose an item.	Choose an item.	Choose an item.
Pressure	0-80psi			
Flow	4L/min			
Purity	≥ 95%			
Name	Nitrogen			
Comments	Product Development in cooperation with Thermo/ Dionex for their range of CAD systems, replacing current OEM generator from European manufacturer			

Air supply

Air source	Internal compressor/ cell ☐	External ☒
Comments	n/a	

Electrical requirements

Input voltage	100V ± 10% ☐	110V ± 10% ☐	230V ± 10% ☐	Universal ☒
Frequency	50 Hz ☐	60 Hz ☐	50/60 Hz ☒	
Input connection	C13 (10A) ☒	C19 (16A) ☐	Other ☐	
Comments				

Environmental requirements

Operating temp.	5°C – 25°C ☐	5°C – 30°C ☐	5°C – 35°C ☒
Storage temp.	Minimum: -20°C	Maximum: 60°C	To be defined ☐
Maximum RH	70% ☐	80% ☒	Other:
Comments			

Indicators/ Legend

Indicators	Service ☐	High Duty ☐	Alarm ☐	Other ☒
Other	Green, amber lights, service indicator light to be added to facia? Is that possible as product based on Precision Nitrogen not sure if control is sufficient. If not, this is not a critical feature and we can do as per Precision Nitrogen re: alarms and service…			

Critical dimensions

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Figure 30: Customer Requirements Theta Corona Nitrogen

5.3.2 A Tale of Two Technologies

There are two commonly used technologies for producing Nitrogen gas. These are the Carbon Molecular Sieve (CMS) Pressure Swing Adsorption (PSA) technology and the Membrane Technology respectively. Of the two technology platforms, internally within Peak, Membrane is the dominant technology platform. Most Peak Nitrogen generators are designed using the Membrane technology platform. But the membranes used in this platform are based on complex technologies which are patented, manufactured and distributed globally by a single large multinational organisation. The upfront capital expenditure required to manufacture the membranes imposes a high entry barrier for other manufacturers. Being aware of the technological and commercial risk of sourcing from a single supplier, the Engineering Director decided to develop Nitrogen generators based on the CMS-PSA Technology platform. Since there are several manufacturers of CMS, he reasoned, diversifying the technology platform would reduce long term technological and commercial risks for Peak.

The Precision Series Nitrogen generators on display at the PittConn exposition were based on the CMS-PSA technology platform which was new within Peak. One such modified Precision Series Nitrogen generator was sent to Theta as a prototype. Following the introduction of the CMS-PSA systems, Peak offered customers a technology choice between Membrane and CMS-PSA based systems. However, in this case Theta did not state a preference. So the technical team lead by the Design Engineering Manager proposed designing the new generator with the CMS-PSA technology platform. From an Engineering resource efficiency point of view, since the existing modified generator prototype was already based on the CMS-PSA technology platform, the Design Engineer could quickly make the required modifications to cover the new requirements. The Design Engineer began modifying the existing Precision generator. He organised a meeting to confirm the Design Proposal. The model presented at the Design Proposal meeting is shown in Figure 31.

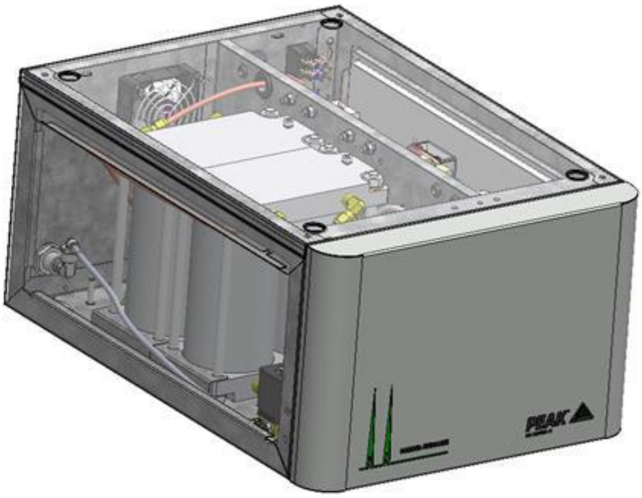

Figure 31: The Carbon Molecular Sieve PSA Nitrogen Gas Generator Prototype

In attendance were the Product Manager, Director Sales and Operations, Design Engineering Manager, Design Engineer and Senior Manufacturing Engineer. The Senior Management team at Peak responsible for authorising NPD is represented below in Figure 32.

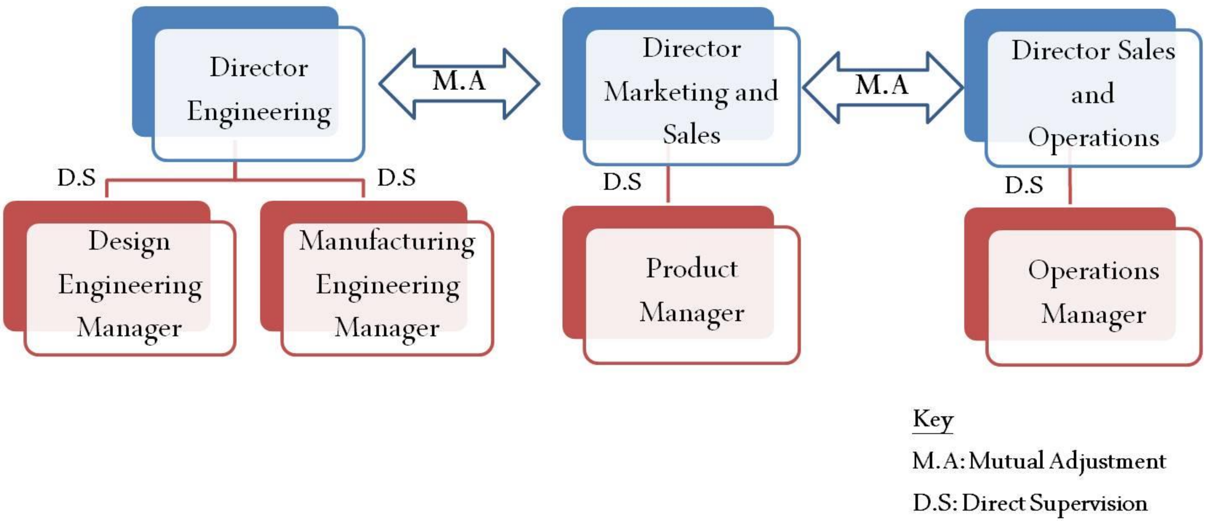

Figure 32: Peak Senior Management Team New Product Development

After the proposal was presented, the Director of Sales and Operation aired his concerns about the design. In his opinion, the BOM cost for this new generator was four times more than

Peak’s internal target BOM cost. Going ahead would impact Peak's profit margin on each generator. He inquired if the team had considered designing with the Membrane Technology?

Compared to the CMS-PSA technology underpinning the current design, a generator based on Membrane technology would be cheaper and less complex. It would have fewer control devices and simpler electronics thereby reducing the chances for component failure. Fewer components would also mean less time to manufacture. The switch to the membrane platform would also allow Peak to develop a sleeker system. Most organisations, because of their limited lab space, prefer small and compact Nitrogen generators which plug into their analytical instruments. It was agreed that the new customised generator for Theta would be redesigned based on the membrane technology. This decision delayed the concept stage of the new product design. This new design proposal was eventually approved by Peak’s Engineering Director.

5.3.3 Off your mark, re-set, go….

These outcomes forced the Design Engineer back to the drawing board. He now had to develop a new product design based on the Membrane Technology platform. These updates were shared with Theta who requested a conference call with Peak to reconfirm the design inputs for the new product design. On learning that a new product was being designed from scratch, Theta confirm that they would now require two variations of this new solution. The first variant, to be called Theta Corona Air, would have an internal compressor. The second variant would be without the internal compressor and will be called Theta Corona Nitrogen. Theta Corona Nitrogen is to have a higher priority over Theta Corona Air. A new product development process would now have to be undertaken at Peak. The product launch date is now pushed to January 2014. It is back to square one for the Design Engineer. Figure 33 below summarises the two variants to be developed.

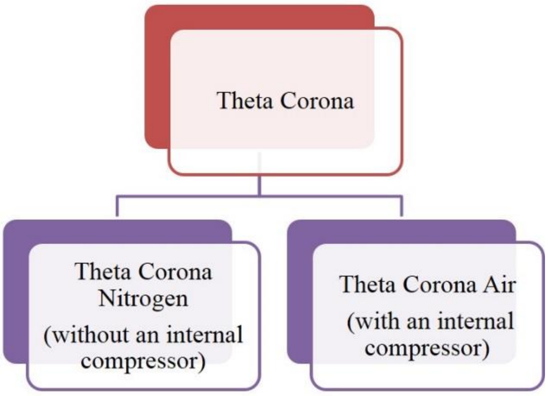

Figure 33: Variants of Theta Corona

On the project management front, the Design Engineering Manager divided the main project into two separate projects. The same Design Engineer was in charge of designing both the product variants. However, two different Manufacturing Engineers are assigned to these variants. Theta Corona Nitrogen (without the internal compressor) was assigned to ME-1 and Theta Corona Air (with the internal compressor), to ME-2. The internal launch dates for the Theta Corona Nitrogen and Theta Corona Air are set to January 2014 and February 2014 respectively. A project management mechanism is put in place to oversee and co-ordinate the product development. Figure 34 below shows the project management structures which is put in place for this project.

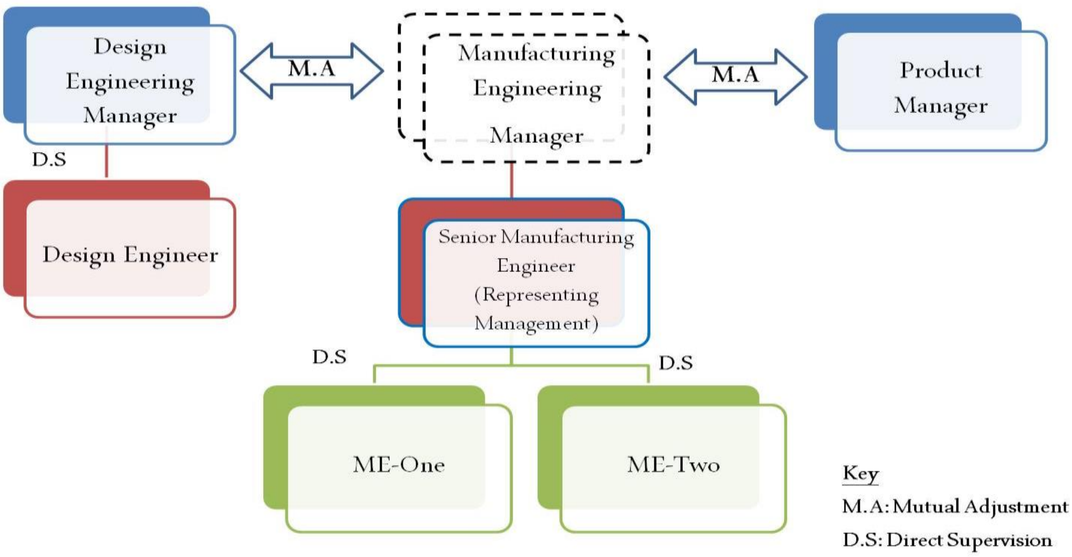

Figure 34: Peak Project Team for Theta Corona

Since Theta Corona Nitrogen has top priority, the Design Engineer designed and developed four potential product concepts. These were presented to the Senior Management team (refer Figure 32) at a meeting convened by the Product Manager. These new product concepts are displayed in Figure 35.

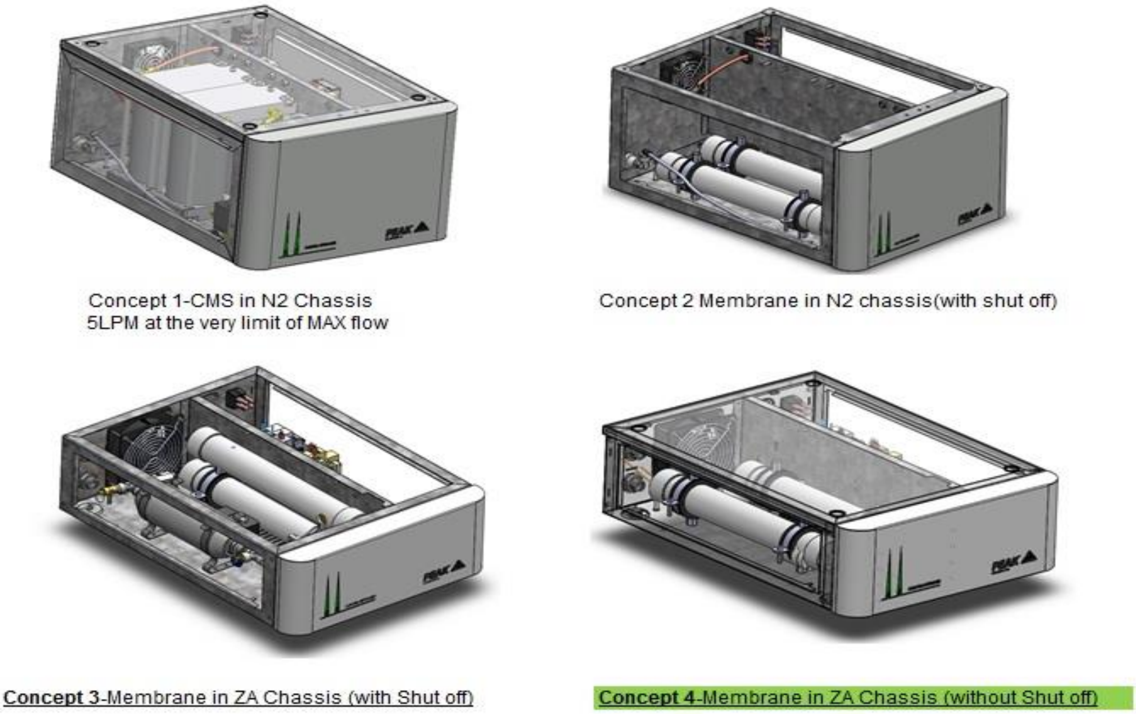

Figure 35: New Product Design Concepts for Theta Corona Nitrogen

Since Concept 4 was slimmer and had a sleeker design when compared with the rest of the concepts, it was unanimously chosen for further development. Its Spartan features also had a lower estimated BOM cost. When the Product Manager updated Theta on this NPD, they requested Peak to share the design model with them. The design was sent over to Theta and Theta got back saying,

> "We loved the new design but want the width of the chassis increased to match the footprint of Corona, our analytical instrument under development." (Theta Product Manager)

Switching to the new membrane technology platform had allowed Peak to make a substantial reduction in the size of the gas generator. But the new dimensions did not match the dimensions of Theta's new analytical instrument which this new Peak generator was supposed to complement. This change stalled the progress which the Design Engineer was making. The Design Engineering Manager assigned a CAD Engineer to assist the Design Engineer with the required changes. The modified drawings are sent to suppliers who had been requested to quote prices for the new Theta Corona Nitrogen generator chassis.

Changing goal posts during the design development process often presented design engineers at Peak with grave challenges. Changes to product dimensions might not appear to be a major change. After all, how much time does it take to re-model your designs? However, the impact of these changes is much more than what meets the eye. Since these gas generators are electro-magnetic devices meant to be operated in laboratory settings, they require product safety certifications approved by the relevant agencies before they can be exported to their target markets. Changes to the chassis size impacts the EMC (electromagnetic compatibility) directive issued by the European regulators. The Design Engineer explains the knock on impact of these seemingly trivial changes on his design and development process.

> "You are going to start affecting the characteristics for the EMC in the low voltage. So the external auditor might say that they need to test that generator again. In the smaller chassis, the power socket was 20 millimetres away from the air outlet. Now you have increased it so they might say, now we need to look at that. So even though it feels like hardly any change, we have just made it a wee bit wider, the same components, it has a knock on effect on the regulations and work instructions and manufacturability. The induced delays. Every change has an implication. Sometimes you just don't realise this."

From a project management perspective, frequent changes also increase the work load on Manufacturing Engineers. They have been tasked to create and maintain the manufacturing processes required to take this product into Production. Manufacturing Engineers have to rework the work instructions manual for this new product since the layout of the components might now be impacted. They would also have to repeat certain test procedures, such as thermal testing, to ensure product safety. Therefore even seemingly small changes present lots of challenges to existing organisational arrangements. Remedying the situation could induce delays that push the project back. Given the flurry of changes to the original plan the development work on the Theta Corona Nitrogen has already gone past the original deadline. The detailed design is yet to be finalised.

Simultaneously, planning for the Theta Corona Air was being jointly undertaken by the Design Engineer and ME-2. The Design Engineering Manager, because of the proposed changes to Theta Corona Nitrogen, has an increasing pipeline of development projects requiring engineering resources. Sensing a need for urgency within the product development the Design Engineering Manager along with his counterpart in Manufacturing Engineering decide to fast track the Theta Corona Air project (with the internal compressor). Since the target launch date for Theta Corona Air is end of February 2014, the Design Engineering Manager feels that there will be a need to ‘short cut’ the DDP after the product validation phase. Theta Corona Air is seen as a low risk product within Design Engineering. Since the compressor based architecture which will be used within Theta Corona Air is already a proven design within Peak, the Design Engineering Manager sees merit in fast tracking the development process. The elaborate DDP, for him, is only required while designing completely new products. This decision is conveyed to the entire Engineering Department within Peak. Manufacturing Engineers are concerned about introducing a yet to be validated product on to the Production shop floor but reluctantly agree with the decision.

5.3.4 The Compressor Road Block

In September 2013, information began trickling in from the Service Division which cautioned Engineering that Peak is facing a rising number of product failures in the field with their popular 30 series generators. Now all the 30 series generators are based on a proven and reliable compressor based architecture. Breakdown of the internal compressor, was reported by the field service engineers, as the main reason for product failure. Increasing number of compressor failures was also being seen in Peak’s bestselling product which is an internal compressor based system. A meeting was convened by Peak’s Engineering Director to discuss this problem. The architecture of Peak's compressor based systems is designed around the T brand of compressors. T-compressors are manufactured by a leading worldwide manufacturer of compressors and vacuum pumps. The compressor is a critical component in the design of Peak’s gas generators. As the Engineering Director puts it:

> "The problem is the compressor pump is the heart of our system. It is the beating heart of our system. When that pump runs, it pumps air through our system and we make the gas. That heart stops, our system stops and the application fails. So we have a heavy reliance on the reliability on this pump."

Historically, when Peak was designing the compressor based architecture for their product range, the T compressor pump was the only pump, in a then small market, with the highest flow rate and pressure. Since Peak's internal compressor generators required a flow rate of 50 litres a minute at a pressure of 145 PSI (per square inch); there were no other competitors who could deliver to that specification then. The closest alternative, manufactured by G compressor pumps could only do about 30 or 32 litres a minute. So the decision to use a T compressor for the compressor based architecture was a 'no brainer'. Now however, a high percentage of the T Compressors were failing after a thousand hours or a thousand five hundred hours instead of lasting their promised four thousand hours product life. This was forcing Peak to service these machines within the warranty period. In the words of the Engineering Director:

> "So between the two, we (Peak) are bleeding money through our Service Group and at the same time, having a whole bunch of unhappy customers. Once we have unhappy customers, we are going out and redressing it quickly and getting them up and running. Our usual good customer service kicks in and they are happy with that, but I'd rather we didn't have to do that."

The solution to failing compressors was to replace the T Compressor with a new G compressor which is being beta tested at Peak. Over the last three years, Peak has been collaborating with another compressor manufacturer who are close competitors to the T-compressor manufacturers. However, it was only recently, in the last year that the G-compressors have really come on board. The Director of Engineering at Peak explains:

> "Last year and a half. I think they (G compressors) had a change of management over there as well and realised that we were a big potential for them. They recognised that and their new CEO came to see us and hooked us up with their Engineering team. What they have now done is developed their systems to give us the flow we need and the pressure we need so we have got pretty much a direct comparison. And they have also been working on the compressor life. They have been engaging with our systems. So I have a much better feeling with G compressor manufacturers now."

The beta test results were promising and the manufacturers of the G compressor were able to guarantee a higher product life time of 7000 hours. This would allow Peak to switch from a six month to an annual service and maintenance contract thereby bringing in a lot of savings to the After Sales Service Group and the business. A decision was taken to switch from the T compressor to the G compressor and a separate project was set up to roll out these changes. The Engineering Director explains his decision,

> "We could wait another 12 months and get a bigger beta test going and more data but the point we have got to is it is no more worse than what we have got. But what we have got now is customers who were upset and units that are failing in the field."

However, the G compressor is not Conformité Européenne (CE) certified. A CE certification is a requirement for all product components which are to be exported into the European Union (EU) market. So a Manufacturing Engineer is assigned to co-ordinate the CE certification process with the G compressor manufacturer. The first week of March 2014 is fixed as the date for rolling out these changes within all Peak Compressor based Systems. The Design Engineering Manager was made responsible to manage this transition project. Since Theta Corona Air is a compressor based system, these recent developments would have a significant impact on the Theta Corona Air Project which is yet to begin. The changes could also impact the workloads of Manufacturing Engineering who are responsible for updating all the production related documentation and rolling out these changes on to the Production shop floor. The 'low risk' product is not so 'low-risk' now.

A project management meeting was convened at Peak by the Product Manager. Attendees included the Design Engineer, Design Engineering Manager, Senior Manufacturing Engineer, Director Sales and Operations, Director Sales and Marketing, Operations Manager and Peak's Territory Manager for USA. The Product Manager has received information from Theta that they intend to order a total of 90 units of the new Theta Corona gas generators each year. Of these 25% might be Theta Corona Air which is the compressor based solution. This meeting was called to plan the production of the Theta Corona units. The Product Manager had received information that Theta normally tend to order forty five units every six months. She wants to learn about the potential engineering and production challenges of producing a new product in such volume. Peak normally produces a new product in small batches before ramping up production to meet the increase in sales volumes. Setting up production arrangements for forty-five new units would be unprecedented within Peak.

At this meeting, the Design Engineer seeks clarity on what the Product Manager means when she says the project deadline is January 2014. As it stands, the Theta Corona Nitrogen is awaiting its detailed design review which needs to be completed before the metal works for the prototype build can be ordered. All of these have a knock on impact on the tasks of the Manufacturing Engineering. Handling these tasks are ME-1 and ME-2. The Engineering Department is operating under the assumption that the new product would be introduced at the end of January 2014. The Design Engineer is yet to receive approval from Theta regarding the new wider chassis that he has designed. The concept diagram for the new generator which emerges from the ongoing acts of organising and innovating is depicted in Figure 36 below.

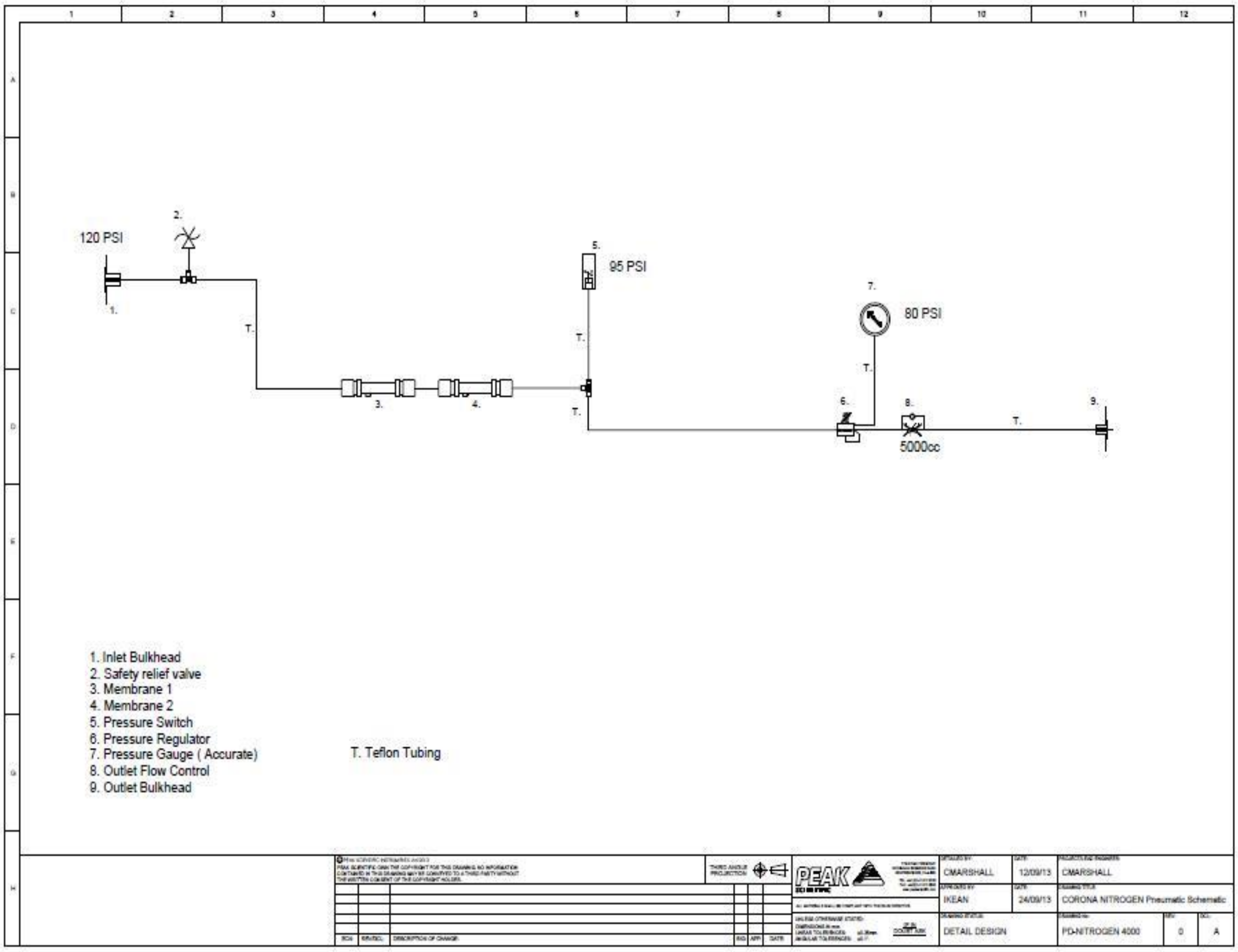

Figure 36: The pneumatic diagram for the Theta Corona Nitrogen Generator

The Product Manager is unclear about the ambiguity around the product launch and would need to speak to Theta about it. In fact one of the reasons she wanted this meeting was to inquire if Senior Management had any particular preferences on how they would like to meet the customer's order. Would they prefer shipping the products in multiple smaller batches or would they be able to ship forty five units all at once? She wanted to learn if anybody had a preference because in her opinion, management at Theta had quite an open mind on this matter. The Director of Sales and Operations conveyed that Peak would be able to fulfil whatever decision the customer takes. So all Theta has to do is to confirm this as soon as they can. Also, since Theta are headquartered in USA, Peak's USA Territory Manager who is scheduled to visit

Theta in a week's time is entrusted with the responsibility of discussing pricing and production planning details. Figure 37 represents the internal Structure of the Marketing and Sales Department within Peak and resulting changes which were outcomes of this meeting.

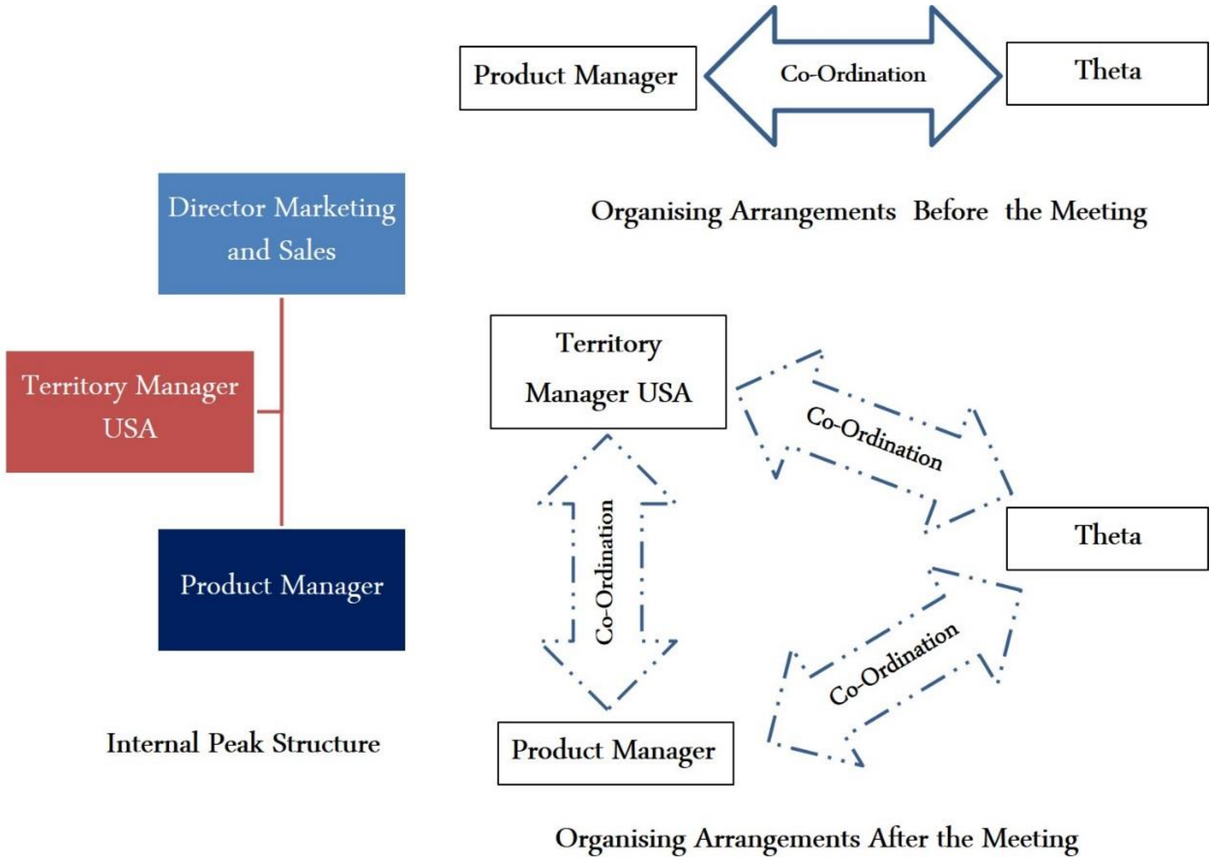

Figure 37: Changing tasks within Marketing and Sales

In the following week, Theta confirm that they will place orders for the new Theta Corona Nitrogen generators in the beginning of January 2014. There would be a four week lead time for Peak to fulfil the orders. However, they are still to confirm on the order quantity. Pricing discussions are currently on between Theta and the Peak's USA Territory Manager.

5.3.5 A Split Wide Open

Meanwhile the Design Engineer schedules a Detailed Design Review for the new Theta Corona Nitrogen which he has designed. The Detailed Design Review is a multi-functional team review within Peak. Representatives from various functions including Engineering, Product Management/Marketing & Sales and Service gather together and discuss the new product. The prototype model discussed is shown in Figure 38 below. During this review, it is found that the design was not 'Service Friendly'. Every couple of years, Peak's Field Service Engineers would have to service these generators and replace certain components which are past their product life. According to the Service Training Manager, the current machine design restricts access to components which require servicing.

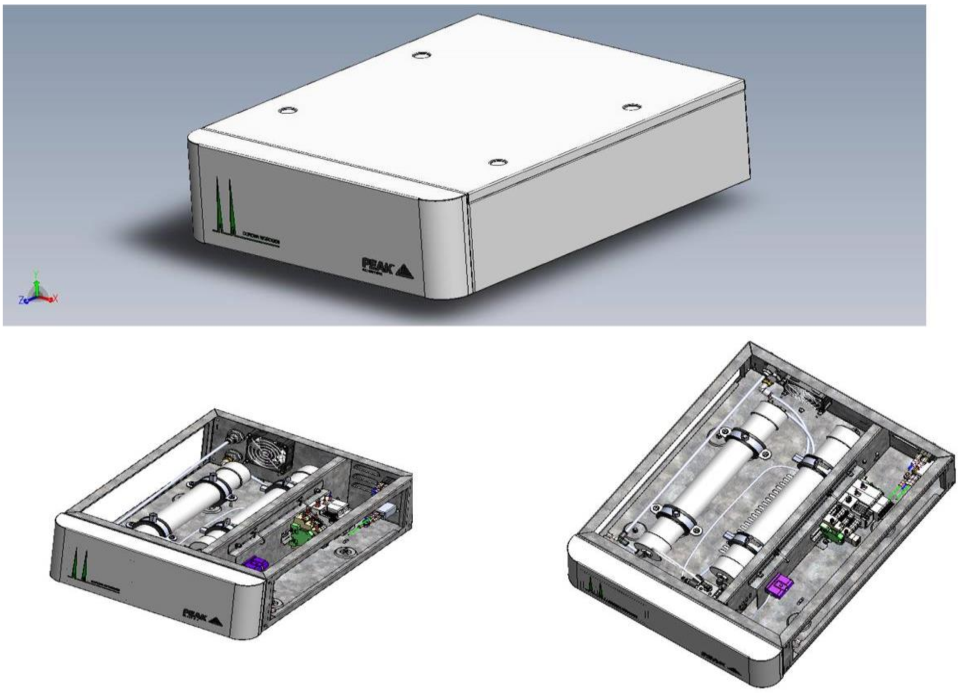

Figure 38: Detailed Design Review Theta Corona Nitrogen (16th September 2013)

Manufacturing Engineer, ME-1 concurs:

> "If we design to move the membranes, then it makes it easier for Service and virtually everybody. Also, if the boys (Production Technicians) have got a leak on that they would have to strip up the entire box with this design."

The design therefore might increase the product servicing time for Field Service Engineers. They are responsible for servicing the generators and repairing any on field faults. It also has an impact on the manufacturing time required to assemble this product. On these grounds, the design is rejected. The Design Engineer is left dejected and frustrated as he would have to repeat the entire exercise of redesigning the component layout for this generator. Arguments over disagreements which were lingering between Design Engineering and Manufacturing Engineering surface. The Design Engineer and the Manufacturing Engineer began quibbling over who was responsible for the rejection of this design. Each side blames the other for the failure to get the product design approved.

According to the Design Engineer, the issue of 'serviceability' should have been picked up by ME-1, earlier on in the Engineering Review which was held prior to this Detailed Design Review. Design Engineering is concerned that Manufacturing Engineering is stone walling the project and not allowing it to proceed on flimsy pretexts like 'service friendliness'. Manufacturing Engineers on the other hand are genuinely concerned about faulty or incomplete product design which could create chaos amongst the assembly line technicians. Product failure on the assembly line would then be attributed to them. Besides, the failing compressors have increased Manufacturing Engineering workload and changed their priorities. It was left to both the Design and Manufacturing Engineering Managers, to step in and restore calm. Their mediation resolved the breakdown.

It is back to the drawing board once again for the Design Engineer who now has to act on the inputs from the failed detail design review. The delay in the detail design review also means that the metal works required for the prototype build and test would have to wait until the design is approved. This has a knock on impact on the NPI process which is managed by the Manufacturing Engineering department. Conscious of the delay and the product development timelines, the Design Engineer enquires about the possibility of adding additional resources from Manufacturing Engineering to keep up with the project schedule. He wants a doubling of resources if possible.

The Design Engineer modifies the design and the new design is cleared by both the design Engineer and ME-1 for the Detailed Design Review. In the interim the BOM for this new model is set up. ME-1 verifies the BOM with the model, and begins work on the work instructions required to build this unit. A Detailed Design Review is arranged. Figure 39 below, shows the modified product design which cleared the Detailed Design Review. Delays in the DDP has pushed the NPI process into February 2014. The Product Manager communicates these changes with Theta.

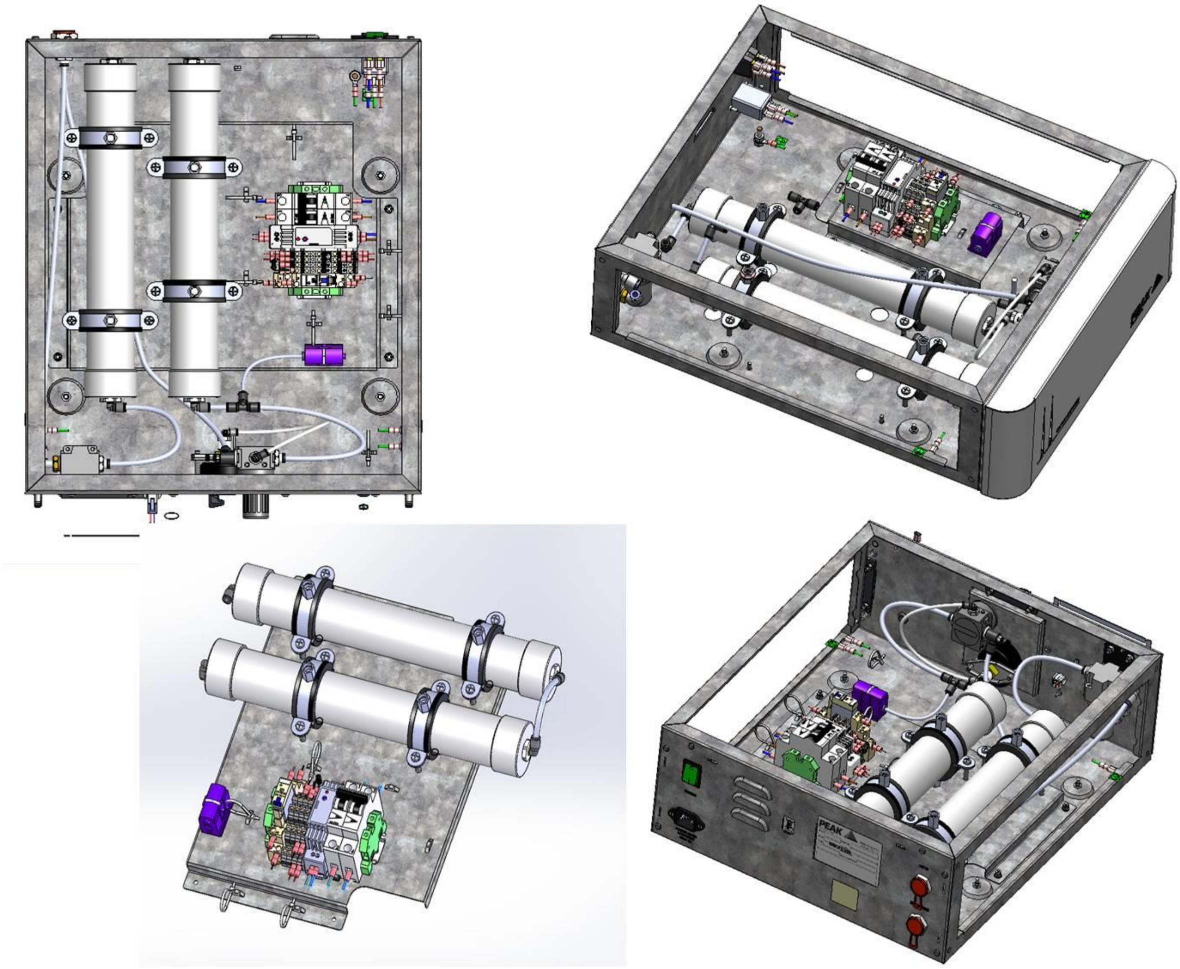

Figure 39: Detailed Design Review Theta Corona Nitrogen (21st October 2013)

After the Detailed Design Review, the Design Engineer began investigating requirements for Theta Corona Air. The Theta Corona Air project was put on the back burner while the Design Engineer was busy developing Theta Corona Nitrogen. ME-2 who was assigned to collaborate with the Design Engineer on Theta Corona Air was investigating the schematic and pneumatic diagrams but he still did not have any design inputs to begin work on the manufacturing work instructions.

The Design Engineer now discovers the evolving dependencies between the Theta Corona Air project and the compressor change over project. The transition from the T compressor to the G compressor was being managed by a different Design Engineer who reports directly to the Design Engineering Manager. The Design Engineering Manager is the common link between the two projects which now has to be run and managed in parallel. Since both projects now involve the G compressor, it would not be possible to proceed with the Theta Corona Air design until the required technical designs and documents for the new compressor architecture have been approved. This would only happen after the new G-compressor architecture is validated. The validation design testing is being overseen by the Design Testing Team Lead who, once again, reports to the Design Engineering Manager.

The compressor change also requires Manufacturing Engineering to raise and manage an Engineering Change Notification (ECN). The ECN is the trigger which allows Design Engineering to modify the current product compressor architecture. The Manufacturing Engineer responsible for co-ordinating the CE certification of the G compressor has successfully completed the process. Peak's Product Manager is still waiting for Theta to sign off the final customer requirements. Theta have confirmed that they would place orders by the end of January 2014 but are yet to confirm the quantity.

The Design Engineering Manager sets the Theta Corona Nitrogen build and design validation date for mid-November and early December 2013 respectively. The ECNs come through which allows the Design Engineer to work on the detailed design of Theta Corona Air. Since the design modules of the Theta Corona Nitrogen which was recently completed can be reused around the compressor based new design, a quick Engineering Review is scheduled for the end of October 2013. This is where the Design Engineer and ME-2, together, go through the product design prototype and make the necessary changes. This design can then be presented to the wider team in the Detailed Design Review which follows.

While the detailed design review for the Theta Corona Air is being planned, the management within the Engineering department is concerned by the slippages in the project plan. In order to bring the product availability date back on track, the Design Engineering Manager, after consultations with the Manufacturing Engineering Manager, decides that the NPI process for the Theta Corona Nitrogen is going to start once the first prototype is built. The Design Engineer and ME-1 can work together on this prototype build. Then the validation testing for this product can run in parallel with the NPI process. Reducing the time lag between the two processes can save a few weeks and put the project back on schedule. The risk of doing so, however, is that if the validation tests for the Theta Corona Nitrogen fail, then that would render the NPI process null and void. The Design Engineer would then have to redesign the prototype. ME-1 would then have to repeat all the manufacturing processes with the modified product design.

The decision to bring forward the NPI process is conveyed to Product Management during the weekly briefing. The Product Manager informs Engineering that she has been in touch with Peak representatives in Brazil. They tell her that Theta Brazil are extremely interested in this new solution which Peak is developing. While Theta Brazil wants the solution as soon as possible, they favour the compressor based Theta Corona Air over Theta Corona Nitrogen. Theta Brazil would like to position their offering with a compressor based solution. She also acknowledges that this new bit of information contradicts the product priorities issued from the Theta headquarters in USA. Officially, Theta have prioritised the non-compressor based systems (Theta Corona Nitrogen) over the compressor based systems (Theta Corona Air).

The Design Engineering Manager informs the Product Manager that both Design and Manufacturing Engineers are working on the product design. The ongoing validation testing on the G-compressor architecture has held back progress on Theta Corona Air. This testing is required to confirm the switch from the T compressor to the G compressor. Since the change impacts the compressor based architecture in Peak's entire portfolio of compressor based solutions, extensive testing is required before approval can be granted. A knock on impact of these changes would also affect the Service Department. Switching compressors would extend the compressor life of Peak’s generators from six months to one year. This would make it technically feasible for After Sales Service at Peak to replace current half yearly product service contracts with annual product service contracts. Once completed, this transition would boost savings by reducing Peak’s product maintenance cost.

Meanwhile, the compressor changes announced would mean that Manufacturing Engineering would have to update the Production work instructions for all of Peak’s compressor based products. This puts enormous pressure on their time for new product introduction. They would have to balance NPI with an even greater priority; keep Production running. There are further updates from Product Management where Engineering is informed that information from the Chinese market like the Brazilian market is favouring the compressor based Theta Corona Air solution over the non-compressor based Theta Corona Nitrogen solution. The caveat on this information is that there is still no official confirmed from Theta’s headquarters. Given the contradictory signals from two different sources, which NPD must now be prioritised?

Meanwhile, the Theta Corona Air project is still stalled. Given Peak's current design expertise, the Design Engineering Manager feels that a compressor based solution (Theta Corona Air) designed using the existing T compressor architecture would require compressor servicing every seven months. Is Product Management ok with that? The alternative choice, he informs, is the G compressor architecture which Design Engineering is currently testing. This, he believes would extend the life of the product from six to twelve months. His concern is that since the Theta machines are relatively low cost machines, the frequent cost of servicing T compressors might increase costs to Theta over the long run. Theta might thus find this product unattractive. The Product Manager, even though she prefers the twelve month product life as a solution, informs him that Theta have signed off on the six month servicing agreement. So from her perspective, having longer service time on a half yearly service agreement would increase Peak's revenue stream for a low margin product.

So should the stalled Theta Corona Air project continue with the T-compressor based architecture? This architecture is tried and tested, can be instantly deployed and when reliable, it would last six months. Or should they use the new G-compressor architecture which is yet to be proven but promises a product life of twelve months? The decision is left hanging. While the benefits of longer product life is unanimously desired by all, the Design Engineering Manager still needs data from the ongoing test results to approve the switch in service plans. The indecisiveness further delays the development of the Theta Corona Air for which a Detailed Design Review has been set for mid-November 2013.

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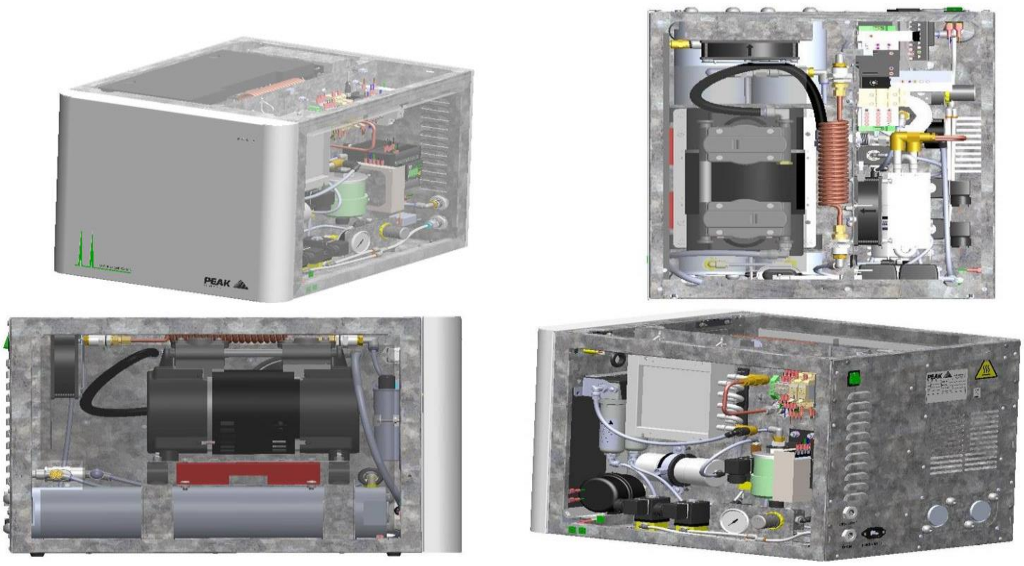

Figure 40: Detailed Design Review Theta Corona Air (13th November 2013)

Figure 40 above shows the design of the Theta Corona Air generator. The design was shared with all the stakeholders within Peak and was unanimously approved. The joint efforts of the Design Engineer and ME-2 during the Engineering Review on the product has clearly worked this time.

5.3.6 Going with the flow

Before the end of the detailed design review for Theta Corona Air, the Product Manager breaks news confirming that she has had a request from Theta who now want to increase the Nitrogen output of both generators to 7 litres per minute from the original 4 litres per minute. The 95% gas purity target remains unchanged. These updates unsettle the Design Engineer. He wants clarity as he has a target deadline to meet. However, given the strict timelines, he is given a go ahead to order the metal works for the prototype build. The BOM for this product would now have to be reconfigured. In his words:

> "Product Manager, when they want seven, does that mean that they want me to do eight (litres/min) because they initially wanted me to do four. What I can tell you is at 7l/min, the impurity is less than 2% and the target is 5% so we are ok. The Design Engineering Testing Lead is still doing that test this morning."

The test results please the Product Manager who is more concerned about the impact of the compressor life. Due to rising reports of compressor failures, she is not confident about going ahead with the current T compressor which is supposed to last six months. Since the alternative solution is yet to be proven from the ongoing testing, she has no choice but to watch the product timelines slip. However, she cannot afford for it to slip too much because Peak's USA Territory Manager has been promoting this new solution within USA and wants a product launch at an upcoming exhibition scheduled in March 2014. Nevertheless, she is certain that if Peak went ahead with the current T compressor design, were it to fail within the six month guarantee period, then the project would no longer be financially viable.

The work on the product build required for finalising the manufacturing process cannot begin until the metal work arrives. The unanticipated changes have set back the ordering of the metal works which are yet to be made by the Design Engineer. Since the tasks of Manufacturing Engineers are directly linked to the progress being made by the Design Engineer, they are now concerned about the scarcity of time within which they have to accomplish their responsibilities. As ME-2 puts it:

> "I think the impact on the work instructions might be much larger than we thought."

The Product Manager is dismayed to learn that the flow rates have been changed from the original four litres to seven litres per minute, this late into the NPD process. As revealed in the earlier section, she had a direct communication line with the Product Management team at Theta. Following the division of responsibility (refer Figure 37), that arrangement was disturbed. This was impacting her ability to speed up the product development process by promptly gather information and pass it on to the Engineering team. To bring clarity back into the development process, both the Product Manager and the Design Engineering Manager want a telephone conference with the Product Manager at Theta. Given the developments, they also would like to explore the possibility of pushing back the dates on the Theta Corona Air (compressor based system) and do more testing and development work on it. Since Theta haven't confirmed a target date for Theta Corona Air, the Design Engineering Manager wants the launch date pushed to March 2014. That would allow him to implement the design changes which would extend the compressor life to twelve months. The Product Manager set up a meeting with Theta for the end of November 2013.

While the current focus has been on the Theta Corona Air, the metal works for the Theta Corona Nitrogen generators is due by the end of the third week of November 2013. Soon, both the Design Engineer and ME-1 would have to jointly build this product and accelerate its progress through the NPI process. The NPI process is largely controlled by Manufacturing Engineering. They hope to start with the prototype build in a week's time. Meanwhile, the Product Manager has been pushing her counterpart at Theta to confirm the output flow rates for the generators as soon as possible. She warns him that any further delay in confirmation could delay the product.

The Senior Manufacturing Engineer enquires about the orders and the quantities. If the order is going to be for forty-five units every six months, Peak have to plan the production ramp up accordingly. On this issue, the Product Manager clarifies by informing the Manufacturing Department that the delivery would most likely be on a "supply on demand" basis. The only reason why Theta previously ordered in bulk was because they wanted to get a better price for the generator. The ongoing discussions between Theta and Peak’s USA Territory Manager has yielded a low enough product price for Theta. Therefore, they would like to procure generators on a "supply on demand" basis.

The prototype for Theta Corona Nitrogen was completed by the Design Engineer and ME-1 and is displayed in Figure 41 below. Initial test results confirm that the new product requirement is being met. The Nitrogen output for the test results so far is 10 litres per minute at 3.8% impurity. The 3.8% impurity is still below the 5% target but the purity might degrade over time as the membranes work overtime. This has to be confirmed in validation testing. The impact of the extra flow and the reduction in the margins of impurity from about 2% when the output flow was 4 lit/min to 3.8% as it currently stands raises doubts for the Product Manager about the membranes lasting for the entire product life cycle.

> "If we want to add a membrane, we would want to make the unit more expensive to them which then gives us a case for having a system for a single Corona and a system for two Coronas. It doesn’t give me a warm fuzzy feeling, turning it up to ten litres a min. There is too many ifs and buts."

Figure 41: The prototype and final build of Theta Corona Nitrogen

Acknowledging her concerns, the Design Engineering tries to dispel her doubts by saying:

> “The Design Engineer is very careful and cautious. Possibly over cautious at times. So all these concerns are valid but I’m not overly concerned myself."

The scheduled meeting between Peak's Product Manager, Design Engineering Manager and Theta's Product Manager goes ahead as planned. Theta clarifies that their R&D Engineers are thinking about the future requirements for their instrument and so want a higher Nitrogen output flow rate. Theta, confirm that they would now like to increase the output flow for both generators from seven litres per minute to ten litres per minute. Peak share the prototype test results with Theta who are not concerned about the 3.8% impurity as it is still below their specified 5% limit. Theta gives the project a green light and puts the Peak Product Manager in touch with their Procurement division. They discuss about how the orders might be managed (45 units on a half yearly basis or otherwise). Both Theta and Peak agree to have both the products ready by the third week of February 2014. Theta are now interested in providing both variants of Theta Corona solutions at the same time.

While the added time is of some comfort to Engineering, the Senior Manufacturing Manager is concerned about the increase in manufacturing work load required to modify production work instructions to build the generator. Since these changes were confirmed while the prototype build and validation testing were running in parallel with the NPI process, design changes to increase the flow rate from four litres to ten litres per minute would have a knock on impact on ME-1 who would have to redo his tasks to reflect these changes. As ME-2 waits for the metal works of the Theta Corona Air to arrive, the Design Engineer uses the window of opportunity to get the Theta Corona Nitrogen, CE certified. The CE certification, issued by an EU certified testing body, is required to export these generators within the EU. The clearance comes through in mid-January 2014.

Between the Design Engineer and ME-2, the prototype build for the Theta Corona Air is scheduled for the second week of December 2013. However, this could be held up because the team of Design and Manufacturing Engineers working on the G compressor architecture are yet to update work instructions for its build. The electrical panel designs have changed and so has the BOM. These updates are yet to be made to the work instructions. Meanwhile, on the pricing front for both the products, the Product Manager informs that they have suggested a modified price and are waiting to hear back from Theta. The Engineering Director inquires if the price should be doubled as they have doubled the output flow rate of the gas. He feels that product pricing should factor the additional engineering hours it took to make these changes. He is disappointed to learn that that option is not on the table.

While the Theta Corona Nitrogen unit was away for CE certification, the Manufacturing Engineers swing into action. They complete the documents required to support its launch. A list of critical components is drawn up and passed on to the Design Engineer who is co-ordinating the certification process. On hearing about the project progress, the Product Manager from Theta confirms that he would be visiting Peak in mid-January 2014 to discuss and co-ordinate the generator launch. The metal work for Theta Corona Air has arrived and the Design Engineer and ME-2 begin work on the prototype build of this product. The test results from this working unit will be crucial as Theta Corona Air would be the first Peak product based on the G compressor architecture. The images from the prototype build are shown in Figure 42 below.

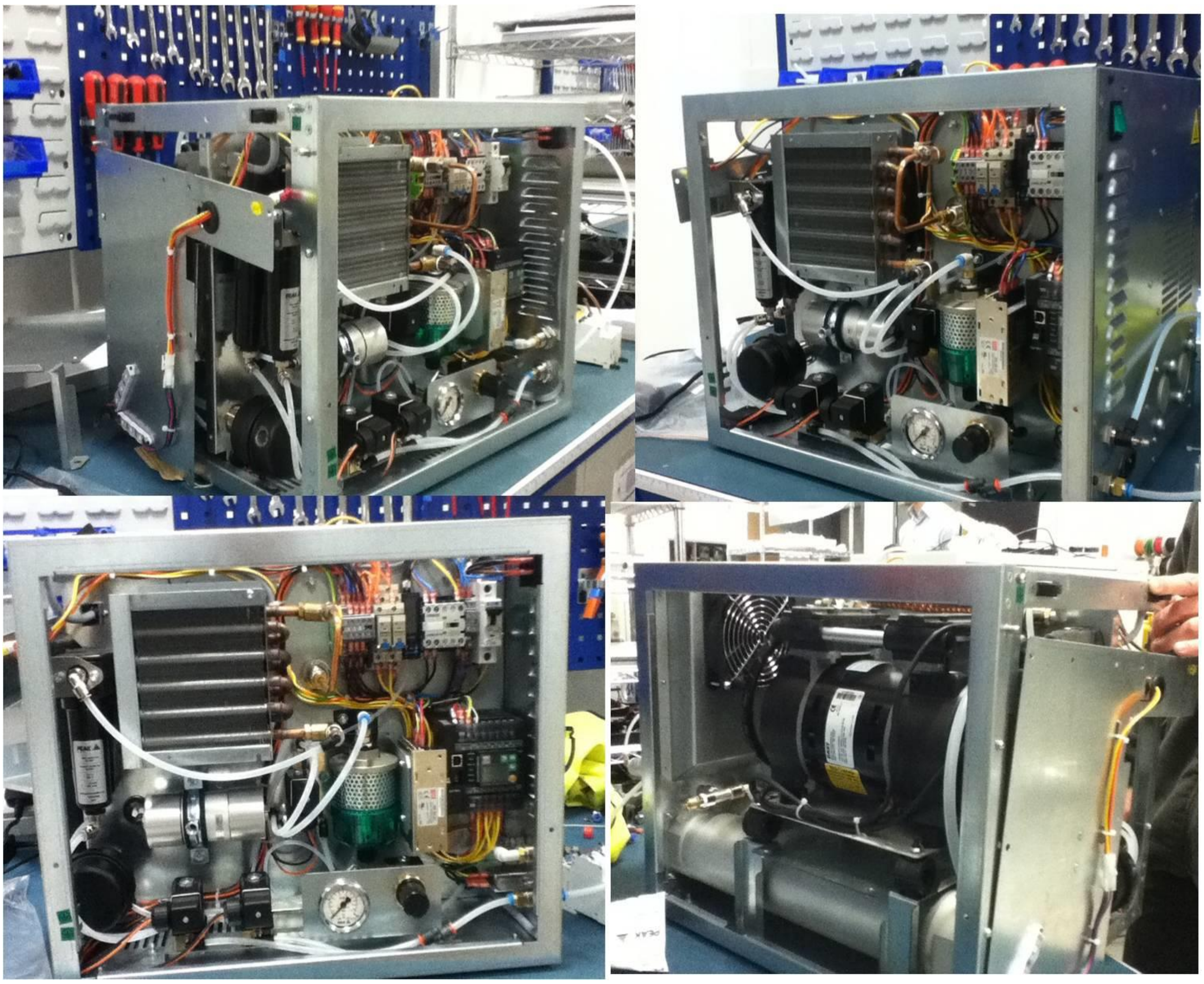

Figure 42: Prototype build Theta Corona Air

5.3.7 Getting the act together

In mid-January 2014, the transition plan to switch from T compressors to G compressors is approved by the Engineering Director. He consults with the Design Engineering Manager and Product Managers and confirms the last week of February 2014 as the date for design transition. The first week of March 2014 would see this new compressor architecture rolled out for all compressor based systems. Based on this confirmation, internal deadlines for the Theta Corona products are set to mid-February 2014. The Manufacturing Engineers have begun the formal NPI process for the Theta Corona Nitrogen since early January and are looking to complete the handover to Production by the end of January 2014.

The visit of Theta's Product Manager was successful. The after sales service contracts for Theta Corona were discussed and finalised. Plans were also laid out for a joint product launch at the exposition in the USA scheduled for March 2014. The Product Manager confirmed that the orders for the Production units of the Theta Corona Nitrogen will arrive in the last week of January 2014. The NPI work was underway on the Theta Corona Air as well with ME-2 in charge of sorting out the manufacturing issues.

In mid-January 2014, Peak undertook an audit conducted by the British Standards Institute (BSI) which they require for fulfilling future production needs. Since most of the manufacturing engineering responsibilities for this audit was organised by ME-1, he is pulled off temporarily to work on this audit. This derails the Theta Corona Nitrogen NPI process. Since the Design Engineering Manager has no direct control over ME-1's unplanned break from the Theta project, he is concerned about the likelihood of the project slipping. As he expresses:

> "Right updates…..Theta Corona Nitrogen, it is showing a slippage this week. It is still within the launch date. ME-1 is working on the NPI stage and he has been pulled off extensively to work on the Industrial systems. The effect on the project plan is only really, transpired when it was highlighted at last week's meeting. ME-1 highlighted it and he felt he wasn't getting on as much with the Corona as he wanted."

Meanwhile orders are in for 8 to 10 production units of the Theta Corona Nitrogen generators which Theta want delivered to their demo labs. These units need to go out as soon as Peak can set up production. ME-1 is back to work on the NPI but is surprised to find out that the Production Manager cannot release technicians for product build training as they are all busy trying to meet their monthly generator production targets. There has been an increase in the demand for the generators after the New Year holidays and Production is busy trying to keep pace with this surge. This has now pushed the project on to the critical path. The Manufacturing Engineer (ME-1) makes Management aware of these developments:

> “I’m just trying to get a technician from Production to do the Train the trainer build. But they say that at the end of the month, it is difficult to release a technician for a train the trainer build. So they told me Wednesday (5th Feb 2014). This happens quite often and timelines get extended."

ME-2 has completed 90% of the NPI work on the Theta Corona Air. However, the Design Engineer now has to reschedule the Validation Review for both Theta Corona Nitrogen and Theta Corona Air as all stakeholders need to be briefed on the changes that transpired due to the increase in the gas output flow rate since the previous review. As this validation review is being planned, issues with the change over to the new G compressor overlap and get tangled up. The test results with the G-compressor architecture have confirmed the Design Engineering Manager’s hunch on the compressor life. The compressor maintenance contracts can now be from six months to an annual service contract. This would require changes to the internal program which was being used to control the compressor. These changes would at first have to be approved within the Engineering Department before it can be incorporated into Theta Corona Air.

Validation testing and the review is not possible without completing these changes to the compressor control program. This has also created a dependency with Manufacturing Engineering who need to be made aware of the factory settings for the production units. ME-2 has completed the Manufacturing Engineering build and is trying to push the product through the test stage. He has got Production training set up for the first week of February although the availability of the Technicians is yet to be confirmed by Production. As the Design Engineer puts it

> "So 17th March 2014 is the date but it is always been a tight one. One of the things which is possibly out of my control on this one is the service program. The point to note here is that the validation process for this is really a critical path now. ME-2 has done a good job on the NPI but he still needs a wee bit of information on it. So the validation is the biggest danger to holding this project back."

The Design Engineering Manager is not all that concerned with the design engineering inputs which are required to complete the project. Since all the initial orders have been for the Theta Corona Nitrogen which is already on track for completion, he believes there is still more time to work on updating the control program of Theta Corona Air. At a project management meeting, the Design Engineering Manager informs the Product Manager about the delays and the lack of a confirmed launch date for the Theta Corona Air for which the orders are yet to come in. The delay annoys the Product Manager who points to the fact that the orders haven't come in because the ECNs on the compressor haven't been completed and signed off for the metal work to be ordered. The signing off process must be concluded before the orders can be placed on the system. She promises to confirm the launch date. Meanwhile the Theta Corona Nitrogen clears the Validation Review and the new requirements and design modifications are accepted by all stakeholders. The final production unit is shown in Figure 43 below.

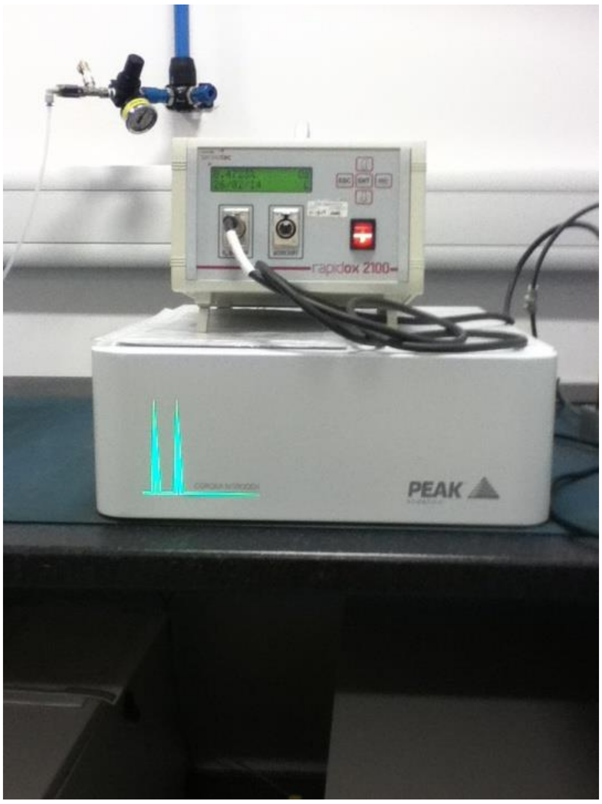

Figure 43: Production Unit Theta Corona Nitrogen

For the Theta Corona Air, it is slightly more complicated. Since both the DDP process and NPI process are running in parallel, rather than sequentially, it has created a lot of unforeseen dependencies. These dependencies are holding up the Validation Review and pushing back the launch date into late February 2014. The project is on a critical path. When the decision was taken to run both the processes in parallel, the Design Engineering Manager was yet to make a decision on whether the control program for the compressor had to be changed. This decision depended on whether Peak would switch to an annual product service contract. When it was decided that the contract would indeed be annual, based on the validation tests, the program changes became inevitable. This had a knock on impact on Theta Corona Air as well. So the Design Engineering Manager along with assistance from another colleague began working on the program, not just for this product but also for every G compressor based Peak generator.

As that project evolved, the Design Engineering Manager realised that having separate programs for different compressor based product ranges is going to be difficult to manage. This is because when service plans change, each of these programs would have to be modified. Instead, he could standardise the program across the entire range of Peak's compressor based systems. Standardising the program would make it more efficient to manage and implement future changes. This decision was taken when Theta Corona Air was nearing completion. ME-2 had completed "Train-the-Trainer" for the Production shop floor technicians and is waiting for the Design Engineer to finish programming the compressor control. However, as the Design Engineer explains, there are new complications which have arisen within the program upgrade which is delaying the project:

> "There is a little bug on the Precision generator which is still there so obviously I'll have it on the Corona Air. So ME-2 can't really do his testing until I can say to him I've fixed the bug. I do not fully understand what is happening and what I need is a Precision generator to work on and we don't have one. The target date was originally the 17th Feb 2014 and it moved along with the Corona ones at the same time and we have put another two days on it for us to sort the issues. We are working on the programs."

Until the program changes come through, Manufacturing Engineering are mere spectators in the new product development process. They cannot re-test the units and confirm the Test and Quality Control work instructions until the program has been completed. The project plan had already been moved into March 2014. The Theta Corona Air validation review has now moved as well. Design Engineering are working on the program and fixing the bugs which have crept in while making these changes. The Design Engineering Manager confirms the second week of March 2014 for the delivery of the program. He also says that Theta are planning to launch the product in the third week of March. So orders are only going to come in then and there is going to be a lead time of four weeks for product delivery.

This lead time is critical for Manufacturing Engineering. ME-2 had completed "train the trainer" build for the Production technicians with the current work instructions which are now obsolete because of the program changes. Train the trainer processes along with the NPI process would have to be redone. After ensuring that the build technicians are comfortable with the changes, he would have to retrain the test technicians after making amendments to the main work instruction and the test work instructions. The required changes are approved, the validation meeting is held and Theta Corona Air signed off by all the stakeholders making it ready for Production. A unit is shipped to the customer for a demo lab test. The ECN is raised by the Design Engineer to incorporate these changes into the compressor sub assembly build for which ME-2 has now updated the work instructions and re-trained the trainer. The project is concluded in mid-March 2014. Appendix II offers a chronological summary of how the Theta Corona project unfolded.

5.4 Conclusion

In this chapter I have provided a detailed account of the two innovation projects I shadowed during my seven month long field study at Peak. After providing a brief overview of the organisation and the business context, I have presented a granular description of the unfolding of the Alpha Panda 2 project and the Theta Corona project, which I tracked in real time. Consistent with the methodology, developing a processual understanding of innovating requires a rich and fine grained account of its unfolding in real time. These accounts describe and reconstruct the innovating process with all its messy complexities. The two narratives set the backdrop required to undertake a deeper analysis into how organising and innovating entwine as they become. The chapter which follows, attempts to develop an analytical framework to further our understanding of the innovating and organising processes.

6 Delineating Processes

"I think there are scientists in that (Engineering) department, each wired to their own little ways, I think the Design Engineering Manager has hellava big team and hellava lot on his plate. So sometimes it might well be difficult for the Design Engineering Manager to keep all of the balls in the air"

Peak's Sales and Marketing Director on Innovating

6.0 Introduction

Understanding organising while innovating requires a deeper interrogation into the innovating process. In the previous chapter, I presented narrative accounts of two real time field studies which vividly illustrate the complexities of innovating. The aim of this chapter is to develop an analytical framework that furthers understanding of the entwined relationship between organising and innovating. By juxtaposing the unfolding of organising and innovating, I present empirical evidence for how innovating actually unfolds within an organisational context. I also explore how the two processes entwine as they unfold, an issue which has only received limited attention within innovation research (Garud, et al., 2011).

So how exactly does, as the opening quote suggests, organising keep 'all the balls in the air' while innovating? My study has unearthed three process complexes of fundamental significance for the proper understanding of organising while innovating. These process complexes concern: (i) dynamics of preferential equivocality, (ii) the dynamics of temporal scaffolding, and (iii) the dynamics of relational coherence. The organising challenges that emerged while innovating depended on how these three process complexes entwined as they unfolded over time.

In the following sections I shall elaborate on each process complex in detail, using examples from the two field studies for purposes of illustration. In order to make the evidence as transparent as possible I have co-ordinated and integrated the descriptive analysis of the findings with the data structuring process (see Figure 44) and provide additional illustrative examples in the supporting tables (See Appendix III, IV and V).

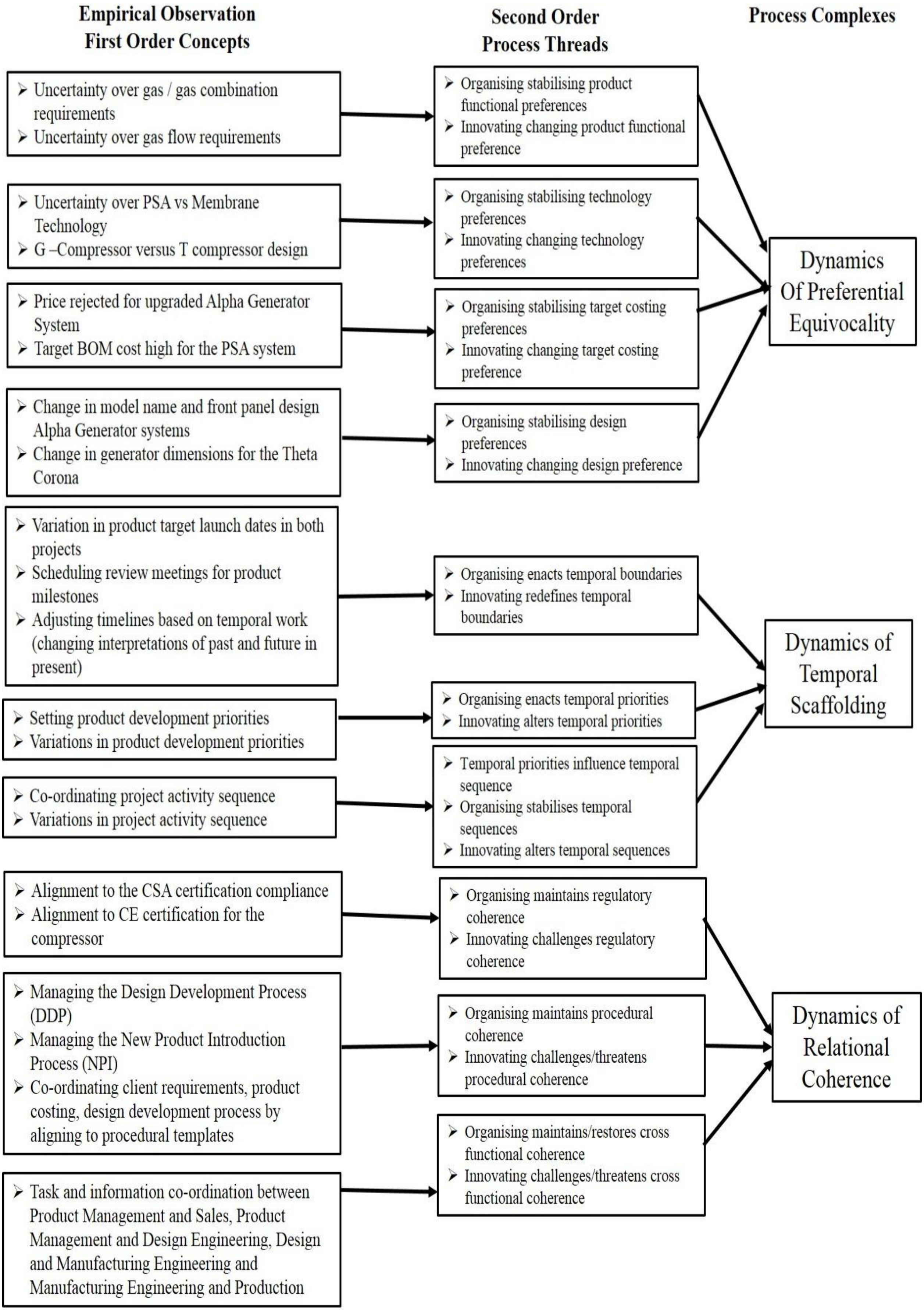

Figure 44: Data Structure for Emergent Process Complexes

This is meant to furnish the reader with the additional data required to evaluate and scrutinize the evidence. I conclude with the emergent analytical framework which summarises the links between the three process complexes.

6.1 Dynamics of Preferential Equivocality

One of the early dynamics to surface from my empirical material was the constant fluctuation in product specification as innovating unfolded. I was alerted to this early on during a middle management co-ordination meeting where the Manufacturing Engineering Manager remarked,

> "The other thing is that the customer really doesn't know what they want. So they can't put together a specification for design to work on!"

His observation suggests that organising efforts during the innovating process are directed towards reducing the level of uncertainty surrounding product specification. The product specification here, of course, is a reflection of 'preference'. If innovating is directed towards satisfying a need, then the role of the organising process is to align the innovating effort with those needs. But how then is it possible to organise for 'preferences' which are at best nebulous or worse still yet to be defined? Upon closer examination of the data, I was able to identify four distinct yet intertwined sub-processes which shaped the dynamics of preferential equivocality while innovating. These sub-processes related to product function, product technology, product cost and product design.

Here, I've made an analytical distinction between each of these sub processes, to untangle and explore them individually. However, in practice they normally unfold as an intertwined process. Taken together, these sub-processes constitute, what I call, the dynamics of preferential equivocality which I shall define in a later section. In the sections which follow, I shall explore the unfolding of each of these sub-processes, across the two projects in closer detail. I've organised the analysis, along thematic process threads to demonstrate how the same sub-processes unfold across the two innovation projects described earlier.

6.1.1 Process of Product Function Preference

The equivocal product function process involved ambiguity over the gas output requirements (which gas combination is required) and gas flow rate (and purity) requirements. Within the Alpha Panda 2 project, the initial preference was for an upgrade kit to support the existing Standard Alpha 3G Generator System. However, there was a lot of uncertainty surrounding the exact gas output the generator is supposed to deliver. While it was relatively certain that the system would have three gas flow outputs, whether that would mean three nitrogen gas outputs or single nitrogen gas combined with twin air outputs, was unclear. As the Design Engineer puts it,

> "They (Alpha) were not sure but they told us that they would prefer us to work on the first solution again. So that is what I've been doing. And last week, the Design Engineering Manager was very good at asserting to them to specify what they wanted exactly. They were actually not good at telling us what they need. The Design Engineering Manager actually knows their product better than them. As you could have gathered from yesterday, they hadn't made up their minds yet. Those guys...."

The remark underscores the organising challenge faced by those entrusted with innovating. Faced with the preferential equivocality involving product function, both solutions are simultaneously being pursued. However, there is pressure to narrow the range of possibilities. Since the customers are yet to make up their minds, the preferences which shape the product specification are still fluid. The Design Engineering Manager's 'assertion' is an attempt to stabilise this dynamic. However, the processual quality of the dynamic becomes evident from the following observation made by the Design Engineer during a meeting convened to discuss the change in customer requirements:

> "The communication with Alpha I think is the biggest challenge. It is odd because with each call, we know something new is going to come. Each time we communicate there is this 'Oh...we didn't know this!' element."

The remark points to the emergence and evolution of product function preference while innovating. The 'oh we didn't know this!' element suggests how innovating creates new information which then shapes the product function. Preferences shaping the product function specification, in other words, is revealed while innovating. Similarly in the Theta Corona project, the initial functional requirements specified a nitrogen gas flow rate of four litres per minute at 95% purity but by the end of November 2013, the specification changed to a nitrogen gas flow rate of ten litres per minute at 95% purity. This shaping of preference was expressed during a meeting scheduled between the Theta Product Manager and Peak. According to Theta Product Manager:

> "What do you (Peak) guys think? We want to increase the flow a little bit just to cover a little bit more excess. My R&D department would like to see a higher flow rate for some product improvements in the future. But really I need to make sure that it is ok with you guys? If there are concerns from your end I'm quite happy to discuss it with you."

It is clear that consideration about the future product improvements was not factored in by Theta during the initial product specification. This preference emerged and was revealed while innovating. However, changes to the product functional requirements pose significant challenges to the design engineers who have to constantly adapt their product features to changing preferences. Reflecting on the organising challenges, the Design Engineer for the Theta project explains,

> "In some way, we are sure behind in getting the customer requirements. If we had a gated process, we still might be sitting at the concept stage saying we cannot proceed till we get those answers. The reality of it is that the design engineers really have to try and get to push ahead and plan the design. Make sure its functional and within reason because you cannot go too far. That would be a waste of time. It's experiencing and balancing how far we can go forward."

Innovating, in order words, must constantly be aligned to the emerging and evolving product function preference. The engineer's observation also suggests that the task of design engineering is to arrest and stabilise the dynamics of product function preference within the 'functional design'. Additionally, in the Theta Corona project, we also see that the change in the compressor technology led to a change in the product function preference for the Theta Corona Air. While the initial preference was to have a product service life of six months, the switch in technology allowed the service life to be extended to a year. This meant modifying the compressor control program. The Design Engineering Manager explains:

> "What we are doing now, this is to form a standard set up for the compressor program. So going forward, it should make the programming bit a lot more standardised."

In sum, *the process of product function preference refers to the emergent purpose, which the innovation being designed is expected to fulfil.* Both field studies illustrate how product function preference rather than being completely specified at the beginning is actually emergent and evolving while innovating. Design Engineers realise this and attempt to stabilise, or 'balance' this dynamic while innovating. 'Balancing' is required because the purpose which the innovation is expected to fulfil was repeatedly being updated. Updates were necessary because the new insights that emerged while innovating resulted in changes to product function. Since product function is a reflection of ‘preferences’, the process of product function preference constitutes an important sub-process within the larger dynamics of the preferential equivocality process.

6.1.2 Process of Product Technology Preference

The second discernible sub-process involved uncertainty surrounding which technological platform to adopt while innovating. The previous chapter highlighted two technology platforms: the Membrane Technology and the CMS-PSA Technology platforms which are used to design gas generator solutions. The product technology preference was stabilised early on within the Alpha Panda 2 project where the decision was taken to upgrade an existing Standard Alpha 3G Generator system which was based on Membrane Technology. Alternatives were not considered. The impact of technology equivocality was more acute within the Theta Corona project. Here the initial product design was based on the CMS-PSA technology. The Design Engineer working on the Theta project explains the technology rationale for the choice as follows:

> “Initially we were experimenting with the Pressure Swing Adsorption (PSA) technology because the remit was to take the current Nitrogen Precision (series generator) and try and make it do, it so happened that Nitrogen generator from the Precision range, which is a pressure swing adsorption system. We did achieve it but it was a lot closer to the capacity of the generator. So we could do it, but we could only ‘just’ do it! We probably would have been comfortable selling it as it would have been close enough as there was still a little bit of room but maybe it was a wee bit overly complex, cutting it too fine."

The remark reveals how information on the ‘overly complex’ nature of the technology platform while innovating altered the technology preference. The CMS-PSA technology was subsequently discarded and the final product which was launched was based on Membrane Technology. Another instance of technological uncertainty involved the choice of compressor to be used for the design of the Theta Corona Air. Since the widely used T-compressor based design was experiencing a lot of problems in the field, Peak decided against its use for the design of Theta Corona Air. Here, the choice of technology was largely forced due to the circumstances rather than deliberate choice. The technology dilemma was between persisting with a technology with which Peak has had a long history, but was now unreliable and a promising but yet to be adopted technology. As the Design Engineer, reacting to the information explains:

> "The gas compressors used in the Theta Corona generators too would be impacted by this change (from the T-Compressors) as they use the same compressors."

Had information on the technology failure of the T-compressor based units not trickled in, it would have been the default choice of technology for the new product design. However, given the circumstances, the new G-compressor based technology platform was adopted.

To summarise, the process of product technology preference refers to the emergence and revelation of choice of technology platforms used while innovating. The technology preference is generally shaped early on at the start of each project. This was because the choice of the product technology platform constitutes a basic building block while innovating. As the narratives reveal, this sub-process was relatively stable in the Alpha Panda 2 project but was destabilised twice during the Theta Corona project. The extent of this impact, therefore, depended on when it is experienced within the innovation journey. The process of product technology preference, as these examples demonstrate, constitutes a key sub-process within the larger dynamics of preferential equivocality process.

6.1.3 Process of Product Target Costing Preference

The fluctuating preference around the target product cost was the third preferential equivocality dynamic which emerged from the data. While on the one hand, organising must enact a target Bill of Materials (BOM) cost to guide innovating, on the other hand, the target is always a guesstimate. In the words of the Operations Manager,

> "The bigger question is, at what time within the new product's process does the BOM become a 100% correct? And the question then becomes, does the BOM ever become a 100% correct, whilst in a new product process? Very often it's only after the products are into production do the BOMs become a 100% correct. But this should be way way before that."

The instability of the BOM, as the remark reveals, poses significant challenges to the Operations Manager whose department is responsible for the procurement of components and the production of the new product. Since the BOM is an outcome of the process which determines the target product cost, fixing the BOM cost implies stabilising the process of product target costing preference. The challenge here is to develop a new product without a clear idea of its design and functional requirements. Since the target cost depends on the components being used within the product design and the components being used depend on the product function to be realised, it is difficult to accurately estimate a target cost. Now in the Alpha Panda 2 project, the design engineer responsible for the product design had indicated to middle management that given the then product function requirements, the target BOM cost will go up. Upon hearing this information the following exchange ensued between the Product Manager and the Design Engineering Manager.

> **Product Manager:** I'm concerned with the additional cost for the components and brackets.
> **Design Engineering Manager:** Since the product is tailored, we could charge them (Alpha) an additional $300.

The Product Manager is clearly cognisant of the potential future impact of the price increase on innovating. However, his concerns are allayed by the Design Engineering Manager's interpretation of the target cost preference. Alpha too did not object to the news on the increase in cost as they were more concerned about having a solution in time for their Panda 2 application. However, because of the sequence of events which led to a retention of the original product name even though additional components were added, the additional cost could not be justified. The displeasure at how things turned out is captured in the following remark made by the Director Sales and Operations, at the internal product launch,

> "Just want to go away and look at the BOM cost and the pricing. Alpha are trying to screw us on pricing and the only chance we get to improve our margin is when a new product comes in or they change their product. So for example a 60 quid increase in BOM cost is 300 dollars so we can increase our margin. In the meantime they are trying to screw us down from the other side. So I've got a few things I can go back with as well."

The remark discloses the commercial implications of the process of product target costing preference while innovating. Inability to sufficiently stabilise the process early on in the Alpha project led to later innovating challenges. Likewise, the dynamic process of preference related to the target product cost also unfolded in the Theta Corona project. It was the reason why the PSA technology platform was discarded in favour of the Membrane technology. According to the Product Manager who sat through the design review meeting,

> "We've just wasted a month and a half shipping them (Theta) a product we already had with technology that is suitable but very expensive without even having considered anything else because we just have this tunnel vision. "The customer said they want that." But we don't know actually if that is the best we can do for them. We sort of got carried away. The Director of Engineering got carried away and then we all got carried away."

The Product Manager's remark further highlights the emergence of 'cost' as a preferential dynamic in the innovation journey. As the remark suggests, the technology, here, was suitable and was therefore a stabilised dynamic. However the product target cost which emerged was deemed too expensive. The statement provides two insights. One, it reveals a target cost preference since the design was deemed expensive with regards to this preference. Two, it also shows the dynamic quality of its emergence since clearly there was no such preference a month and a half ago. It emerged only during the product concept design meeting when the design was presented to Product Management.

In conclusion, *the process of product target costing preference refers to the ongoing emergence and revelation of preferences regarding product target cost while innovating.* The dynamic constitutes an important sub-process influencing preferences. The data also demonstrates how this leitmotif cut across both the Alpha Panda 2 and the Theta Corona projects, suggesting the key role it plays while innovating.

6.1.4 Process of Product Design Preference

The final sub-process to emerge was the dynamic shaping changes to the product design. These changes mainly impacted model name, component layout, product chassis dimensions and design. This dynamic which impacts the final form of the product design, unfolded within both projects. For example, in the Alpha Panda 2 project, there were multiple instances where the model name which impacts the front panel design of the generator, was changed. As the Design Engineering Manager explains during a meeting,

> "Initially when we agreed that we are going to update all Alpha 3Gs and all Infinities (generators), and all tables, we thought we'd update all the 1031s (Generators) as well so that we keep the product count lower. But when it was decided that we needed two separate part numbers, one for Panda which would have a slightly higher BOM cost or selling cost and a separate table, the discussion

> then was there is no point having confusion having two 1031s (generator models) when we could quite easily call it 1035 and have the distinction we couldn't get with the table and Alpha 3G."

The initial preference, as the remark suggests, was to lower the product count and that meant keeping the product design as standardised as possible. However, when this preference changed, so did the product model number and by implication, the product design. The emergence of the preference for two separate generator models meant that the initial design preference which was aimed at standardising the product design changed. The emergent preference required the product design to now be differentiated rather than standardised, based on different product model numbers. This would impact the final product chassis dimension and front panel design. Similarly in the Theta Corona project, the initial design requirement was assumed to be a smaller chassis design. According to the Product Manager,

> "Smaller, sleeker, better etc, that's the good point. I think that there is this kind of Engineering thought where they are kind of scared to make it smaller or there is a barrier with them as if to say 'You know what, this is as good as we can do!'. That is the impression I get"

The scientific laboratories around the world that buy Peak's solutions have limited lab space. So their general preference is for compact gas generators which occupy minimum lab space. This was the 'preference' guiding the product design. However, this preference evolved to a wider chassis when Theta wanted the generator dimensions to match the dimensions of their analytical instrument. The Design Engineer explains,

> "So the concept stage and then we move into the detail design but there are always problems of the customer changing the requirement in which case you have to get back to redress things. Which as I say, we were just about good to go on the standard chassis looking at that thinking we do not have to do too much work and work instructions and then the customer says we'd like it to be wider. It's a nuisance but it is not too much trouble for the customer. It is worth doing it if that is what they need."

The process of product design preference, as we can see here, has destabilised the innovating process. The Design Engineer, aware that the dynamic he has stabilised within his design has now been destabilised, finds it a 'nuisance'. Yet, he is aware of the need to re-stabilise this dynamic to realign the innovating and organising processes. Another example of changing design requirements was when the design for Theta Corona Nitrogen was rejected for not being manufacturing friendly or product service friendly. As the Manufacturing Engineer put it,

> "There is no point saying that everybody should obviously be checking things a lot more! But it is the same, I can look at that and you can look at that and say it is great until you've got to build it.

> Again you don't know. It's something, you look at stuff and you look at it and you look at it and you look at it and say 'Ok it is only somebody who is making a wee suggestion which I couldn't come up with myself'. That is what has happened here."

Despite the repeated checks and inspection, the product design preference changed during the detailed design review where cross functional team members sat and inspected the product design. As the Manufacturing Engineer's remark shows, until the product prototype is built, it is impossible for him to 'know' how the design must be. This suggests that the design preference is revealed along the innovating process rather than being stable and imposed at the start.

In sum, *the process of product design preference refers to the emergence and revelation of preferences shaping product form while innovating*. This sub-process was seen to unfold within both the Alpha Panda 2 and Theta Corona projects. The dynamic impacts the final form of the innovation by shaping the product chassis design, component layout and product dimensions.

6.1.5 Dynamics of Preferential Equivocality: The Process Complex

In the previous sections, I have untangled and expanded four distinct sub-processes which I've called the process of product function preference, process of product technology preference, process of product target costing preference and process of product design preference respectively. These sub-processes suggest that preference while innovating is multi-dimensional and is rarely stable. In this section, I explore the relationship between these various sub-processes while innovating.

Within the Alpha Panda 2 project, the initial specification was to develop a kit for realising a triple gas output Nitrogen generator system. This then changed to reflect the single Nitrogen and twin air output gas generator system. When clarity on the gas combination emerged, the output gas flow rate of the Infinity 1031 Nitrogen gas generator was increased by two litres per minute. The Design Engineering Manager, when asked about these changes at the product management meeting said the following,

> "The Alpha 3G System testing is throwing up a few spurious things and that is what is holding up the project. The Design Engineer is looking at the pressure switch settings because the flows are a bit higher. It is on the hairy edge so can take a couple of hours to get the pressure."

In short, the remark highlights the intertwining of the process of product function preference with the process of technology preference. A change in the gas flow rate which reflects a change of product function preference has now destabilised the technology pushing it onto the 'hairy edge'. Stabilising this technology related dynamic requires a change in design. The design change by introducing the Infinity 1035 model reflects the attempts to re-stabilise the previously stable dynamic of product design preference (the Infinity 1031 design). When the design was later stabilised as Infinity 1035, Alpha requested a single upgraded Standard Alpha 3G Generator System. This changing preference reflects the destabilisation of the previously stabilised dynamics of product function, technology and design preferences.

As innovating unfolded, it became clear that the upgraded system would cost more than the current Standard Alpha 3G model. This new information which emerged while innovating destabilised the dynamic of target cost preference. In fact, according to the Alpha Manager,

> "Yes, we did discuss pricing but the assumption was there are two models and we'd harmonize prices. Because our volumes are much higher than intended."

Since the sale of Alpha's analytical instruments had risen, it meant that a cost increase on an existing model would be reflected across all product lines at Alpha. Hence, the change in the manager's 'assumption' which shaped the original product target cost preference. Therefore the stable process of product target cost preference is now destabilised and since it is intertwined with the process of design preference, the design must now be changed to introduce two models.

Likewise, in the Theta Corona project, the initial preference was to upgrade an existing CMS-PSA technology based gas generator system to meet the gas flow and purity requirement of Theta. However, after the concept design stage, the technology was deemed too complex and expensive to manufacture. This episode highlights the entangling or 'knotting up' of the processes of product function, technology and target cost preferences. When one of the processes was destabilised, the others too had to be re-stabilised. Had these sub-processes, been distinct and not entwined, then destabilisation of one dynamic should not impact any other dynamic.

However, as the narrative demonstrates, the changes to the three processes also resulted in changes to the product design. Figure 35 is a reflection of this change. The link between product function and product cost is further evidenced in this project when the functional requirements for the Theta Corona Nitrogen changed. The following conversation played out between the Engineering Director and Product Manager responsible for the Theta project.

> **Engineering Director:** Have we already agreed a price with them (Theta)?
> **Product Manager:** No, we have suggested a price but we are still waiting to hear from them (Theta), their German team.
> **Engineering Director:** Shouldn't we be doubling the price now that they want double the flow?
> **Product Manager:** We were thinking about the possibility!

The exchange highlights the destabilisation of the process of product function preference. Since the requirements have changed from a gas flow rate of four litres to ten litres per minute, the design of the product must now be altered to meet this new preference. The increased engineering hours required to make these changes is what prompts the Engineering Director to raise the product cost. The episode illustrates how preferences linked to product function, target cost and design are all entangled and dynamic.

To conclude, these episodes reveal that each of the sub-process identified in the previous sections are in fact entwined while innovating. Further, we also see that these preferences are rarely stable and emerge while innovating. Taken together, these sub-processes constitute a process complex called the dynamics of preferential equivocality. *Dynamics of preferential equivocality refers to a gradual emergence and revealing over time of the various preferences that shape innovating.*

6.1.6 Dynamics of Preferential Equivocality: Summary Insights

In this section, I have explicated and analysed a process I've called dynamics of preferential equivocality. It is a key process complex with which innovators have to grapple. The dynamic of preferential equivocality, as both projects suggest, is an equivocal, and emergent process which needs to be stabilised while innovating. In the words of the Design Engineering Manager,

> "We are getting all these things, getting driven from the bottom. Let's go away and look at this, let us go away and look at that! But we are not being told, here is our goal and here is how we want to be able to achieve it. So to me you can make a proposal, but in my mind, it is what it is looking at, at the moment. We need to look at design and say, here is what we want to achieve and achieve it. The strategy might be we keep on doing what we are doing…."

His remark highlights how the ‘goal’ while innovating is rather equivocal and ill defined. This is because preferences rather than being static and pre-given are always emergent and require stabilising. There were four distinct yet entwined preferential sub-processes which surfaced from the study. There were the process of product function preference, process of product technology preference, process of product target cost preference and process of product design preference.

Though explored individually, the field studies suggest that these processes are entangled in practice. While these sub-processes were common across both the projects, the impact of each individual preferential dynamic while innovating was varied and contingent. For instance, the process of product technology preference was relatively stable in the Alpha Panda 2 project but required repeated stabilising in the Theta Corona project. Likewise, the process of product design preference was more prominently felt within the Alpha Panda 2 project when compared with the Theta Corona project.

Acts of organising are attempts directed towards the establishment of a workable level of preferential certainty required for innovating. Reflecting on the uncertainty, the Product Manager says,

> "In some respects, that is absolutely fine. When building a product, not having all the information and saying, ‘Yes we are going to build this!’ without knowing what volumes they (clients) want it in and we have had examples, you have seen Alpha. We don’t know what their product is, we don’t know what our relationship involvement is. While innovating, I think that there are certain things that we take on faith in this company rather than actual facts and proper business acumen."

It is interesting to pursue the Product Manager’s observation about innovating relying on ‘faith’ rather than ‘facts’ or ‘business acumen’. If preferences, as the data analysis suggests, is actually dynamic and emergent, then the ‘facts’, which by definition are fixed and unchanging, cannot always be a reliable guide while innovating. ‘Faith’, on the other hand, even if misplaced, reflects a belief in one’s ability to stabilise any emergent dynamic. It is therefore crucial while innovating. The following remark by the Director Sales and Operations, when Peak had to decide on whether to continue innovating on the Alpha project, highlights this point:

> "They (Alpha) work functionally. Their product is for Europe. The trick is to allow them to lead. We (Peak) know their demand from their ordering pattern, better than they do."

The Director is willing to 'follow' Alpha and respond to their changing specifications because of his faith in their previous collaborations. The task of organising, as the remark indicates, is to stabilise the preferential dynamics by translating faith into certainty. His faith in Peak's ability to understand Alpha's preferences, by allowing them to lead, allowed innovating to continue. Innovating, however, triggers organising by generating new knowledge which might alter preference. It does so by generating new information about functionality, technology, cost or design, which can then shape preferences. This in turn, widens the range of possibilities which organising must stabilise on an ongoing basis.

To summarise, organising attempts to stabilise preferential dynamics which emerge while innovating and innovating destabilises this dynamic to trigger organising. Additional support for the processes of product function, technology, target costing and design preferences from the two projects which constitute the dynamics of preferential equivocality can be found in the illustrative quotes displayed in Appendix III.

6.2 Dynamics of Temporal Scaffolding

The second key dynamic which I unearthed from the two field studies related to the role played by time and timing in the unfolding of innovating. I was alerted to this dynamic while sitting through a Design Engineering Meeting when the Design Engineer working on the Theta Corona project made the following remark:

> "From a design engineering point of view, the Design Engineering Manager schedules my work load. If the Product Manager then makes a request, through the design development process, it is then the Design Engineering Manager's call as he understands the work loads. If resource becomes a problem, we can go to Design Engineering Manager and say I cannot meet this deadline. In that case Design Engineering Manager could say, 'I'll get somebody to help you.' Maybe he'll tell the Product Manager, we cannot do that. I'm not sure how often that happens. My time is managed by Design Engineering Manager."

The statement illustrates the role of time and the significance of temporal dynamics while innovating. The 'workload' which the Design Engineer talks about here, is entirely shaped by the timeline set for the project. Further, the 'request' which he alludes to is the accommodation of a 'changing preference' within the temporal activity sequence. And finally, since his time is managed by the Design Engineering Manager, the priority accorded to each of the tasks he undertakes is shaped by the temporal dynamics of innovating.

I call this dynamic which I shall define later, the dynamics of temporal scaffolding. My study revealed three sub-processes which constitute the dynamics of temporal scaffolding. These processes relate to (1) temporal boundaries (2) temporal prioritising and (3) temporal sequencing. In the sections that follow, I shall unpack, explore and then integrate each of these sub-processes.

6.2.1 Process of Temporal Boundaries

The shifting temporal boundaries were a dominant dynamic within both the Alpha Panda 2 and the Theta Corona projects. Within the Alpha project, the innovation project plan was guided by the temporal horizons communicated by Alpha. Managers at Peak would constantly inquire about product timelines, deadlines and launch dates to reference their development tasks and activities. For instance, on inquiring about the Panda 2 launch date in early August 2013, this is what the Alpha Manager had to say:

> "No launch date has been set for the product yet. It is estimated by the end of September or early October (2013)."

The management at Peak took that as a cue to enact timelines which would allow the generator system to be ready by the first week of September 2013. So when it was revealed in late August 2013, that the Panda 2 launch date has been pushed back, Peak's managers were taken aback by the development. According to the Design Engineering Manager,

> "Ok this comes as a surprise to us. We are still working on the assumption that the launch of the Panda product was still going ahead in September or end of August and we had to have, generators available in the second week of September. So we are kind of moving the earth here to achieve that. So can you confirm that that date has now changed?"

The Design Engineering Manager is surprised because the temporal boundary he had enacted had been breached. The temporal boundary which determines innovating timelines was based on an assumption which was no longer valid. Information guiding the new timelines was proposed by Alpha:

"So the Panda 2 launch, all we know at this point is that it wouldn't be in September. We are working towards finalizing a date sometime in October. But it is not going to be in September." *(Alpha Technical Lead)*

What stands out in the above statement is the ambiguity surrounding the target launch date. On one hand, it adds to the certainty of the temporal work now required to be undertaken by clarifying that the temporal boundary has been shifted. On the other hand, a clear temporal boundary is yet to be set. As the Design Engineering Manager puts it,

"We will have to recheck our project plans to see how soon we can get these reports to you"

'Rechecking' here, refers to re-interpretation of the current timeline, based on the new information and the re-imagination of a new temporal boundary. Temporal work, therefore involves interpretation of the past as well as orientation towards the future within the present. The temporal boundaries are normally enacted based on customer product launch dates. When the Panda 2 launch date was shifted again in late September 2013, this is what Alpha had to say,

"The launch date for the project (Panda 2) is now confirmed in the second half of October. So we have another four weeks." *(Alpha Technical Lead).*

Peak would have to now co-ordinate the developmental activities by referencing this new temporal boundary. Similarly, the enactment and breach of temporal boundaries was also a feature within the Theta Corona project. Here, the initial timeline for making the product available was end of July 2013. So when that temporal boundary was overshot, a new temporal structure had to be enacted. The Product Manager explains the increase in temporal complexity like this,

"We've just wasted a month and a half shipping them (Theta) a product we already had with technology that is suitable but very expensive without even having considered anything else because we just have this tunnel vision."

She considers the time 'wasted' because the original timeline which was enacted for this project has to now be revised. Yet, the importance of enacting a temporal boundary while innovating can be gathered from the following remark made by the Design Engineer working on the Theta project,

"When you say January 2014, what do you want? Do you want us to be able to build them (Corona generators) or is that the point at which we just finish the design bit. We just need to clarify. I'd like to say it is all going well but it is impossible to say that without knowing the deadlines. What I'd say is that the drawings are all ready and some prototypes are already out there with the clients."

What is striking about the remark is the referencing of the developmental activities to a temporal boundary. Innovators derive cues about the priority of their tasks, scheduling their workloads and altering their activity sequence, all based on the enacted temporal boundary. In the absence of some guiding structure, they find it 'impossible' to organise their innovating. A temporal boundary is thus necessary to regulate innovating. The corollary to the temporal boundary is the notion of temporal 'slack'. This is well illustrated in the following conversation which ensued between the product managers at Theta and Peak.

Product Manager Peak: In terms of orders and shipments, are you still expecting your first shipments for Theta Corona Nitrogen at the end of January?

Theta Product Manager: The orders are due in Q1 [First Quarter of the year] so that seems reasonable to me.

Product Manager Peak: "Yeah that is fine. Also for the Compressor, would you expect it by the end of January 2014 or is there slack there?"

We can see here that the temporal boundary is being negotiated for the end of January 2014. But equally, there is an attempt to damp the temporal dynamic by injecting temporal slack. The temporal slack allows smoothing of the temporal dynamics by varying the temporal boundaries. However, once set, maintaining the boundary requires active temporal work. An example of such temporal work at Peak, between the Product Managers and the Design Engineering Manager, presented in the episode below is particularly revealing:

Product Manager: Can't afford to kick it (Project) back again.

Design Engineering Manager: Well, kick it back from where? Because we have not got a date because start date and when it is finalised is two different things.

Product Manager: You are being very brave because if the Engineering Director was in the room today, he would be saying the same thing as me.

Design Engineering Manager: And I'd be telling him exactly the same stuff. When do you need this product?

Product Manager: ASAP (As soon as possible) which is why I said that it is a priority product. I know that is a bit of a worry following the same design development process. What is slowing it up because if things keep getting kicked back, then if that is the right process, then naturally the end date is going to be longer.

The episode highlights the differing meanings that the Product Manager and the Design Engineering Manager have extracted from the enacted temporal boundaries. While the Product

Managers have a certain notion of the temporal boundary which they use as a reference to co-ordinate organising activities, the Design Engineering Manager doesn't share the same notion of the temporal boundary. Hence, his puzzlement when informed about the breach. For him there was no boundary and so he cannot see how the innovating has shifted the temporal boundary. This episode nicely encapsulated the active role played by temporal work in stabilising the process of temporal boundaries.

The final characteristic of temporal boundaries, which emerged from the data, on the organising and innovating process related to how project milestones were co-ordinated by referencing the temporal boundaries. Take for instance the following remark made by the Design Engineer working on the Panda 2 project at a project meeting,

> "Still need to review the plan together and still haven't decided on a time scale......On the Panda 2… I need to organize a meeting for the detailed design review. I'll be doing it this week."

The time scale here is a reference to the varying temporal boundaries. The reviews which constitute the emergent milestones during the innovating journey act as loci for the organising processes. Judging the effectiveness of organising while innovating always refers to some temporal boundary. In the above remark, the trigger to schedule a detailed design review is pegged to a temporal frame. The significance of the enacted temporal boundaries is further clarified in the following remark made by the Design Engineer working on the Theta project:

> "In terms of the project plan now, the project plan is slipping substantially. One thing we haven't managed to do, Manufacturing Engineer, is go through the NPI (New Product Introduction) section and go through the changes from there. Where we are is the detailed design review."

Here, the notion of 'slipping' is referenced to a temporal boundary. Invoking an enacted temporal boundary allows the Design Engineer to judge if his project is slipping. We can also see how organising processes are being triggered from the cues derived from the enacted temporal boundaries. Thus, co-ordination is sought with manufacturing engineering to set up the NPI process.

In sum, the enactment and co-ordination of temporal boundaries, constitute a key sub-process while innovating. *Temporal boundaries refer to barriers set in time while innovating.* In both projects, organising enacts and regulates temporal boundaries while innovating. Temporal boundaries are either enacted by setting project deadlines or imposed through project launch dates. Setting temporal boundaries involves temporal work. It was also observed that temporal slack regulates temporal boundaries while innovating. The process of temporal boundaries, therefore constitutes an important sub-process within the dynamics of temporal scaffolding.

6.2.2 Process of Temporal Prioritising

A second dicernable sub-process related to the variation in temporal priorities as innovating unfolded. The organising activities co-ordinating innovating were shaped by the temporal priorities accorded to various activties. The task of assigning priorities was influenced by the enacted temporal boundaries. However, the actual implementation of tasks from the emerging sequence (as opposed to the planned sequence) was guided by the variations in temporal priorities which emerged while innovating. A clear instance of this dynamic is evident within the Alpha Panda 2 project where Peak wanted to concentrate on product build whereas Alpha was more interested in the product technology test reports which validates the product's technical feasability. Consider the following observation made by the Design Engineering Manager:

> "Ok. The other option is to actually get the systems built and we can rerun the tests. And give you the serial number from those tests but we are now just conscious of the time scales you are putting on us at the moment. We are trying to get things done quickly so that we can have products available by the end of next week. Our backs are up against the wall at the moment as we try to speed things up but we will certainly look at that and see what is the best option for us at the moment."

Normally, product testing would be run after the product build. But since there is a need for a quicker time-to-market for the Panda 2 analytical equipment, Alpha want Peak to concentrate on extensive technology testing, referred to internally as bench testing, to ensure that the test results are available for obtaining regulatory compliance. Peak on the other hand are more concerned about having the product built and ready for sale. They would like to re-run the test for the reports demanded by Alpha after the sales orders are confirmed. Here, the temporal priority normally associated with testing and design are reversed.

Likewise, in the Theta Corona Project, after the timelines were re-enacted for the new product development project based on membrane technology, the Product Manager had to assign product development priorities between Theta Corona Nitrogen and Theta Corona Air. According to her,

> "I'd like to have it before June (2014). The Corona Nitrogen is now universal. So that really needs to be done."

The statement provides a clear guideline to innovators on where the attention needs to be focussed. However, as the project unfolded and information began to trickle in about the demand for the compressor based solution, she changed her priority and requested that the Theta Corona Air project be accelerated. As she puts it,

> "The only reason I mentioned that is because the compressor is moving further out and out and out. And we let that happen purposely because we got information from Theta that is not going to be such an urgent requirement but that might turn around a little bit more than we had thought."

It is interesting to note that the 'drifting' in product development is a reflection of the temporal priority accorded to each task while innovating. The processual quality of the dynamics of temporal prioritising is also revealed in this statement which reflects a shift in 'urgency' between the various developmental tasks outlined in the innovation plan.

To summarise, *by process of temporal prioritising, I mean the progressive ordering of attention accorded to tasks while innovating.* Numerous instances in the two field studies indicate that it is a common sub-process within the larger dynamic of temporal scaffolding. Acts of organising set the temporal priorities to guide innovating. Innovating, as the examples show, resets the temporal priorities by generating new information which triggers organising.

6.2.3 Process of Temporal Sequencing

A corollary to temporal prioritising is the emergent temporal sequence. In both projects, it was observed that the emergent temporal sequence played a key role in how innovating unfolded. An example of the impact of temporal sequencing can be found in the following observation made by the Design Engineer while explaining his project choices,

> "They were provided by Alpha as they did the test with centrifugation. Everything is the same as before. Because of the time frame which they gave us which changed afterwards, we had to keep the same name, Alpha 3G and we added a Hi-Flow to differentiate it from the previous one. If we had known the previous time frame, we might have changed the name to something different."

The Design Engineer is referring to the specific lack of control over the temporal sequence that shaped innovating. From his remark it is also clear that had the time frames been clearer, the 'same as before' temporal sequence could have been followed and the temporal dynamics brought under control. In yet another example within the Alpha Panda 2 project, the Design Engineering Manager remarks,

> "Rather than having a (Infinity) 1031 and a (Infinity) 1035 [referring to the different generator model numbers] which will be discontinued months after the launch. The new 1031, do you see where I'm coming from with that? What is the kind of timeline for looking at the commonisation? Are we looking at it this year or...?"

Here too we see an active role played by organising to regulate and stabilise the process of temporal sequencing while innovating. The fluctuation within the generator design priorities are shaping the sequence of the unfolding innovation. The Design Engineering Manager is seeking to order the developmental tasks by referencing the temporal sequence to a temporal boundary.

Similarly, when the design for the Theta Corona Nitrogen was rejected for not being 'service friendly', the temporal sequence of the activities to follow got altered. According to the Design Engineer on the Theta project,

> "But then what that does to the plan is that it really delays the concept stage because you think the first stage is concluded in June and then in August, it was final answers from the customer. Normally we would hope to tie that off pretty quickly the project."

The delays in the development milestones are a reflection of the alterations to the temporal sequence of project development activities. The importance of managing the temporal sequence while innovating is also evident when a software bug was discovered while upgrading the control program of Theta Corona Air. Since the switch in control functions to reflect an upgrade in service plans (six months to annual) was deemed straightforward, the activities were sequenced, keeping in mind a quick program change. However, once the bug was discovered, that derailed the temporal sequence of the development plan. Again, as the Design Engineer on the Theta project explains,

> "The fact is that we probably had enough time to do this bit of work. But it just wasn't priority enough then, now this work has taken longer to the point where it is now on the critical path."

The remark once again highlights the blurred lines between the processes of temporal sequencing and temporal prioritising. The lack of stability in the latter often destabilises the former, putting innovating on the 'citical path'. Organising, it can be seen, attempts to stabilise and regulate the temporal sequence. Innovating by altering the temporal sequence triggers organising.

In sum, *the process of temporal sequencing refers to the ordering of innovating activities unfolding over time.* Both the field studies highlight the impact of the process of temporal sequencing while innovating. Organising attempts to regulate the temporal sequence while innovating destabilises the sequence to trigger organising. The dynamics of temporal sequencing, therefore consitutes a key sub-process constituting the larger dynamics of temporal scaffolding.

6.2.4 Dynamics of Temporal Scaffolding: The Process Complex

In the previous sections, I have untangled and expanded three temporal sub-processes which I've called the process of temporal boundaries, the process of temporal prioritising and the process of temporal sequencing respectively. These sub-processes when taken together reveal the dynamic nature of the temporal complexities encountered while innovating. In this section, I explore the relationship between the various sub-processes in greater detail. I do so by illustrating entwinement between the sub-processes using episodes from both field studies.

In the Alpha Panda 2 project, after the kits were dispatched, a loose temporal boundary was enacted which allowed the Design Engineer to experiment with various solutions. However, as he explains,

> "So that request was done (the kits). They never really asked for it so the development work was done but the orders never came through. So we stopped R&D."

Stopping R&D indicates the enactment of a temporal boundary, a change in the temporal priority and by implication the temporal sequence. Therefore, we see how the temporal boundary, priority and sequence all come together to briefly constitute a temporal scaffold while innovating. In light of the orders not coming through, this scaffold is undone only to be re-enacted in early June. This was because the Panda 2 was scheduled to be launched by the end of August 2013. The setting of the product launch date enacts a temporal boundary within which all innovating tasks are referenced according to their temporal priority. The temporal sequence emerges once these priorities are set.

However, when the temporal boundaries were shifted by Alpha due to regulatory delays, we see temporal priorities being altered and a change in the innovating sequence from product development to product function testing. Since these test reports are now essential for the product launch, we see that the temporal boundary is entwined with the temporal sequence. It is only after the test reports have been generated can a new temporal boundary in the form of a product launch date be set. Until then, innovating unfolds within a fragile temporal structure. The delay in product launch from September 2013 to November 2013 is a reflection of the shift in temporal boundaries caused by variation in temporal priorities and alterations to the temporal sequence.

Similarly, in the Theta Corona project, the initial temporal boundary was set for the end of July 2013 and the priorities and task sequence were referenced keeping this boundary in mind. However, when it emerged that the solution would be based on the Membrane rather than the CMS-PSA technology platform, we see a breach of the temporal scaffold. A new temporal boundary was enacted when the target product launch date was set in January 2014. The change in temporal boundaries resulted in new priorities and a new temporal sequence. We see the prioritisation of the Theta Corona Nitrogen over the Theta Corona Air when this new boundary was enacted. The temporal sequence of activities altered when information on the failing compressors began to emerge. The compressor based Theta Corona Air began to gain priority. However, this altered the temporal sequence of the activities for the Manufacturing Engineers who now had to concentrate on supporting Production with the new G-Compressor based solutions. According to the Senior Manufacturing Engineer,

> "All the time we are getting squeezed to reduce time to market. A lot of time is consumed by design and so we are expected to work with the remainder. We are working with the Design Engineering Manager. We also work with the Purchasing team. A challenge is to get alternative components for parts from them. We need to get the processes in place, so much what we do is in people’s heads, and we need to ensure we don’t fail audits."

The observation succinctly encapsulates the impact of the temporal complexity caused by the combined processes of temporal boundaries, temporal prioritising and temporal sequencing. The squeeze he refers to is the impact of the temporal boundary. The temporal boundary, is used as a reference to decide the temporal priority. Here the choice between keeping innovation going by supporting Design Engineering or supporting Production by redesigning the production processes with an alternate component is a temporal priority confronting Manufacturing Engineering. The decision, in turn alters the temporal sequence and could lead to a variation in the temporal boundaries.

Temporal priority was also influenced by the temporal slack in the project. As the Product Manager for the Theta project remarks,

> "Really I don't think there is any slack for us to launch it any later because the USA Territory Manager keeps talking about launching it at PittConn [an exhibition]. So there is going to be an official launch in March [2014]."

The lack of slack suggests an approaching temporal boundary. Ensuring deadlines are met would require stabilising both the temporal priorities and the temporal sequence with a stabilised temporal boundary. The remark therefore, encapsulates the entwining of the dynamics of temporal boundaries, temporal prioritising and temporal sequencing. It is this entwined dynamic that I call the dynamics of temporal scaffolding.

To conclude, these episodes reveal that each of the identified temporal sub-process are in fact entangled while innovating. Further, these sub-processes require stabilising and shape innovating. Taken together, process of temporal boundaries, temporal prioritising and temporal sequencing constitute a process complex I've called the dynamics of temporal scaffolding. *The dynamics of temporal scaffolding refers to the ongoing enacting and maintaining of temporal boundaries by regulating of development priorities and activity sequence while innovating.*

6.2.5 Dynamics of Temporal Scaffolding: Summary Insights

This section explicates and examines the dynamics of temporal scaffolding, yet another key process complex that innovators have to contend with on an ongoing basis. Both studies reveal a wide variety of temporal activities such as enacting launch dates, scheduling workloads, inducing temporal slack, changing task priorities and altering project sequences. All of these constitute the dynamics of temporal scaffolding which unfolds while innovating. Organising, by enacting temporal scaffolds facilitate innovating. In the absence of temporal scaffolding, the clarity required to enact temporal boundaries, reference temporal priorities and co-ordinate temporal sequences while innovating vanishes. This is evident from the following remark by the Design Engineering Manager:

> "But the thing is we don't have a target end date. ASAP is fair enough but if you [Product Management] can turn around and say that this has to launch on the first of July, and if we slip a week or weeks and can't meet the first of July for some reason, then I see the issue. But if the goal is as soon as possible, then that is willy nilly!"

Here, the dynamics of temporal scaffolding are unstable and so the temporal boundary which provides innovators with cues to reference their task priorities and sequences cannot be enacted. Organising must therefore stabilise the dynamics of temporal scaffolding to guide innovating. Without a stabilised temporal scaffold, innovating unfolds "willy nilly". Innovating destabilises the temporal scaffolds and triggers organising. If we were to compare the planned deadline with the realised launch date for both the innovations, we see a considerable amount of departure. The Alpha project was expected to be concluded by September 2013 and was only concluded in mid-November 2013. Similarly, going by the original deadline, the Theta Corona was supposed to be shipped by the first week of September 2013 but was launched only by mid-March 2014. So why the slippage?

Examining the temporal sequence of development of the two innovations reveals that innovating processes were constantly destabilising the enacted temporal scaffold by generating complexity that needed to be temporalized. Failure to temporalize the emergent complexity resulted in a collapse of the temporal scaffold. In the absence of temporal stability, innovating proceeds along the 'critical path'. Progress would then depend on the re-enactment of the temporal scaffold. This was the case when innovating created two separate generator models in the Alpha project. This was also evident when the temporal scaffold guiding innovating resulted in an upgraded Precision series generator for Theta. The rejection of this product concept based on the CMS-PSA technology, triggered temporal work. The temporal work re-enacted the temporal scaffolds to orient innovating. When compared with the Theta Corona project, the impact of the dynamics of temporal scaffolding was more pronounced within the Alpha Panda 2 project.

Organising the temporal complexities as innovating unfolds, was one of the dominant process threads to emerge from the two field studies. The exasperation of dealing with the dynamics of temporal scaffolding is nicely captured by the Engineering Director,

> "The thing for me, the thing that really annoys me is the length of time it takes. And I don't know really how we can survive taking two years, to a year to develop a simple generator. I mean it is not rocket science. You are not designing a brand new piece of technology, its building blocks that have

> existed and in bits of technology that we have experience and knowledge in. Why does it take so long?"

The remark, highlights how the dynamics of temporal scaffolding unfold and challenge organising while innovating. So in sum, organising stabilises the dynamics of temporal scaffolding to trigger innovating by enacting temporal boundaries, setting temporal priorities and varying temporal sequence of activities. Innovating, on the other hand, destabilises the temporal scaffolds and triggers organising. Further evidence for the processes of temporal boundaries, temporal prioritising and temporal sequencing which constitute the dynamics of temporal scaffolding can be found in the illustrative quotes displayed in Appendix IV.

6.3 Dynamics of Relational Coherence

The final key dynamic which surfaced from the field studies related to the continuous work involved in connecting and disconnecting various organising processes as innovating unfolded. The following remark by the Engineering Director captures the co-ordination challenges of sustaining innovating within an organisational context:

> "Where I am really trying to get to is getting the right measure in place because I think some of the behaviours we have in different departments are, they are not touching into the same point. They are pulling away! The bigger we get, the more people we bring on, the offices we get overseas and everything else, it is going to diverge even further. We want it to converge."

His statement reveals the difficulty of aligning actions emerging from the organising processes undertaken by the various functions within Peak with the action required for sustaining innovating. Both the field studies captured a rising sense of the challenges of maintaining an alignment between the organising and innovating activities during NPD. I call the dynamic, which I shall define later, the dynamics of relational coherence. The data analysis was able to untangle three distinct yet intertwined sub-processes which constitute the dynamics of relational coherence. These processes pertained to (1) regulatory coherence, (2) procedural coherence and (3) cross functional coherence. The sections that follow unpack, explore and then integrate each of these processes.

6.3.1 Process of Regulatory Coherence

There were two distinct regulatory processes that shaped organising while innovating. The first of these was the Canadian Standards Association (CSA) regulatory requirements which are mandatory for all electro-mechanical devices exported for sale in North America. The second regulatory process was the Conformité Européenne (CE), popularly known as CE regulatory requirements which is required for selling electro-mechanical devices within the EU. All of Peak's design and manufacturing processes are aligned to meet these regulatory requirements.

Now in the Alpha project, it was decided early on that since the timeline for new product development was too short, Peak would have to innovate by circumventing the constraints imposed by the CSA, and yet still align with its guidelines. Therefore, the decision was made to proceed by upgrading an existing Standard Alpha 3G generator system. Doing so would allow more time for new product development by cutting out the time and cost on new product certification. This strategy seemed to be working well for the first half of the project when things appeared to be on track. In fact back then, when asked by Alpha on the project status, according to the Design Engineer,

> "Yes, production is more or less ready. The first prototype built, we are working on the test procedure and it is getting final touches. And for the testing, a couple of validation tests to do but nothing major. So we are more or less on track. We are maybe even early at this stage so everything is good on our side."

And yet, when the product design was rejected on the grounds that it was too expensive, it was the regulatory coherence which threatened to derail the project. In the words of the Design Engineering Manager,

> "We cannot do that because the CSA certification for the Alpha 3G is tied to the name Alpha 3G. If we wanted to make a new model name, then we would need to get our CSA document updated. I also believe, that is an issue from your side as well, as you had the generator and Panda 2 tested on an Alpha 3G generator. So I believe, your certification is tied to the model name as well."

Since the final product would have to conform to the CSA certification requirements, we can see how regulatory processes intertwine and shape innovating. Likewise in the Theta Corona project, when Peak had to make a transition from the T-Compressor to the G-compressor, the Manufacturing Engineers discovered that the G-compressor was not CE certified. Without the CE certified G-Compressor, Peak would not be allowed to sell a gas generator designed with the G-compressor within the European Union and Japan. The complexities created by innovating for regulatory coherence are well illustrated in the excerpt below. The excerpt is from an e-mail sent by the Components Engineer in Manufacturing Engineering.

> "G-Compressors are built in USA and are CSA certified but lack CE certification. So [product certifying agency] who are authorised to issue the CE certificate to sell Peak Generators in Japan require all product components to be CE certified. As the G-Compressor is not CE certified, the Design Engineering Manager, Senior Manufacturing Engineer and I are working together with G-Compressor Manufacturers to get them to get a CE certificate for their compressors. G-Compressor Manufacturers are working on getting their component CE certified. The deadline for getting the product CE certified is 1st October. Without this certificate, the product currently being displayed at an exhibition, by Peak Engineering Director, cannot be sold."

In sum, the process of regulatory coherence refers to the ongoing alignment between the organising and innovating processes to conform to the regulatory process. The two examples discussed above are indicative of the role played by regulatory coherence within each of the projects while innovating. It was a key sub-process constituting the larger dynamics of relational coherence. Organising, as can be inferred, attempts to align the innovating process to conform to the regulatory processes. Innovating on the other hand, challenges the regulatory coherence by creating emerging dependencies.

6.3.2 Process of Procedural Coherence

The second sub-process which emerged while untangling the dynamics of relational coherence is what I call procedural coherence. At Peak, there were two major standard procedural templates used while innovating. These were internally referred to as Design Development Process (DDP) and New Product Introduction (NPI) respectively. These twin templates or routines, guide the 'repetitive patterns of interdependent organizational actions' (Parmigiani & Howard-Grenville, 2011, p. 413) required while innovating. The DDP is overseen by Design Engineers and the Manufacturing Engineers are responsible for the NPI. Now both these routines are specified in great detail as codified procedures to be followed while innovating. Except that the practice of innovating 'never' followed a plan. In both the field studies, the role of organising was to steer innovating and align it to the procedural templates. Innovating, on the other hand was repeatedly challenging the procedural coherence.

The importance of procedural coherence is evident from the following remark made by the Manufacturing Engineer who worked on the the Alpha Panda 2 project,

> "I think the DDP as it is laid out in the project plan, you can see if it is laid out from top to bottom, it is the idea of flow. But what is happening here is that with customer requirements and time constraints, it is a bit like yesterday's meeting we had on the Infinity. Some of the NPI work has to be worked alongside the design development in order to speed up the process. So when the design is finally verified, we are finally up and running into production. But it is making sure that anything communicated gets followed through and it is a controlled exercise."

We can see that despite efforts to clearly define and lay out procedures, innovating is seldom, to use the Manufacturing Engineer's words, 'a controlled exercise'. This is not to deny the conscious attempts made to control innovating. Of course, both the field studies are replete with such attempts. However, in both the field studies, what was observed was aligning rather than controlling of the emerging dynamics by invoking the procedural templates.

In the Alpha Panda 2 project for instance, when the price on the newly designed product was rejected, Peak then had to develop and support two separate gas generator systems. This meant two separate product lines, one for the Infinity 1031 gas generator and the other for the Infinity 1035 gas generator. The decision put strain on the cohesiveness between the DDP and NPI processes. This was because the decision to separate the production lines for the two Infinity generators would have minimal impact on the DDP. But it created new links and dependencies within the NPI which substantially increases the workload of the Manufacturing Engineers. While the Design Engineers would have to change the product name, the Manufacturing Engineers would have to recreate two separate production processes by undoing all their current tasks and then redo those tasks for a second product line. The strain is expressed in the following remark made by one of the Manufacturing Engineers responsible for the Alpha project.

> "That one, I'm kind of loathe to do it, but see at the moment, the way the Alpha Table BOM is setup, it is a mess because you have got common parts which are technically no longer common parts. So, they have been common parts in the past. So we now have three different versions of the Alpha Table. We have got five different work instructions. What I was considering doing was flattening the BOM structure. It would give me a better feeling knowing the BOM was bang on. At the moment I've got the overall parts and the common parts within there and I've got other parts coming in and so it is pretty messy dealing with."

The remark highlights how the innovating process has redefined the procedural dependencies between DDP and NPI which have significantly deviated from the script. Managing this dynamic on an ongoing basis was a constant challenge in the Alpha project. In yet another example, when change to the generator model name was not acceptable to Alpha because of the regulatory constraints, the complexities which emerged challenge the organising processes within NPI. The NPI template could not support two products with the same name but different functions, through the production process. In the words of the Senior Manufacturing Engineer:

> “How would people know it is two different machines? It’s going to be different part numbers, different brackets and there would be two new mass flow controllers but Peak now have to ensure that the machine must have the right settings."

The emerging dependencies also impact the DDP. According to the Design Engineer on the Alpha project,

> "No the stressful bit is to ensure that the testing I’ve done is done correctly. All the measurement I’ve done I’ve done correctly. If today Alpha calls and asks us to increase the flow or whatever, that would not cause any direct issues, direct change for the BOM. We would just have to reset things."

Resetting the DDP also has consequences for the NPI process. The neat logic which links the two procedures on paper has now, virtually disappeared. As the Manufacturing Engineer working on Alpha puts it:

> “If you look at the Panda project, at the moment, if you look at that [project plan], then it looks like we have not done anything. Because at the moment, I’m standing at probably five or six weeks just waiting to get the NPI signed off. But various things like changes from Alpha, Design Engineer not being about, Design Engineering Manager not wanting to have the meeting, it just looks like our section has just moved from completing that and then the next task is NPI sign offs. So there is no connection between what is actually happening and why that task moved away out.”

The challenges for maintaining the procedural coherence are also evident from the Theta Corona project. This is well illustrated in the episode where the Design Engineering Manager sees merit in fast tracking the DDP for both the Theta Corona Projects. According to him,

> "The Engineers Meeting took place last Wednesday for the Theta Corona and there were discussions for the need to have short cut development processes for low risk development projects. DDP revision might be required from project to project based on validation. There is also need to sync the DDP with the NPI process followed by Manufacturing Engineering.".

However, here too we see how quickly, the low risk turns to high risk when the failing compressors force Peak to alter the DDP and NPI process. The incident creates new dependencies between the DDP and NPI processes. Another example which illustrates the challenges of maintaining procedural coherence is when Peak's Product Manager suggests that Theta may now order the new units on a 'supply on demand' basis rather than the initial arrangement which was to manufacture 45 units at a time. According to her,

> "I've got a feeling that we are going to supply on demand. The only reason they (Theta) did that with the competitor was to get a better price. So it doesn't apply to us. We gave them a good price to begin with."

This change alters the new product introduction process which would now have to scale down production procedures being planned. The development requires increased co-ordination effort between the NPI process and the Production processes which are managed by two different departments.

In sum, *the process of procedural coherence refers to the ongoing alignment between the defined organising procedures and the emerging innovating process.* The examples from the field studies illustrate how organising attempts to maintain procedural coherence by aligning the emerging dependencies triggered while innovating with the organising processes. The following remark by Peak's Engineering Director, both sums up the ongoing challenges of maintaining procedural coherence and sets us up to explore the third sub-process, maintaining cross functional coherence.

> "I now understand why the processes are there and it needs to be done in a controlled way, but I just have this concern that we have lost so much of this flexibility and responsiveness. I want more commitment from Engineering. I see a lack of commitment. Maybe that is unfair with some people. But I've seen a lack of drive, a lack of drive in that team in design. And I don't know if I've got a problem in management?"

6.3.3 Process of Cross-Functional Coherence

The third and final sub process which surfaced during the data analysis was the fluctuating dependencies within and between the various departmental functions while innovating. For instance, in the Alpha Panda 2 project, when the customer requirements document was updated by Product Management after the detail design review was completed by Design Engineering, it caused a disruption to organising processes carried out by Manufacturing Engineering. According to the Manufacturing Engineer working on the Alpha project,

> "I think where the ME's struggle is when the design is not fully tested. This is the danger of having fast tracking projects that are more than just tweaks. We have something which is not fully tested and we are already underway designing it and suddenly, you can't use that component anymore and the consequences of that are sometimes going back to square one."

Manufacturing Engineers feel that the reason their project is disrupted is because Design Engineering have handed over an incomplete design which has now changed. The challenge for the Design Engineers, however, is the instability of customer requirements for which they rely on Product Managers. Innovating therefore alters existing functional processes by creating new cross functional dependencies. The split between the technical and commercial negotiations within the Alpha Panda 2 project is a good example of the altering of existing departmental dependencies and the emergence of new ones. In the words of the Design Engineering Manager,

> "I think the Alpha Manager and Peak's Director Sales and Operations need to discuss (pricing), because we are adding components to the current generators, so there will be a price difference. So the Alpha Manager and Peak's Director Sales and Operations are in discussion with regards to price reduction. There is possibly an agreement between them what pricing changes they want. So long as you are happy with the technology changes, we can crack on with the current generators that will support Panda 2."

Here we can clearly see that even though the technical requirements and commercial preference on the new product are closely linked, the organising is being handled separately by two different functions. Innovating challenges the traditionally defined functional boundaries by creating cross-functional dependencies. Organisations rely on flexibility and responsiveness to maintain the cross-functional coherence. But while innovating, the logic underpinning the source of flexibility and responsiveness is threatened. In the words of the concerned Engineering Director,

> "We built our reputation on being flexible and responsive and particularly in engineering, I have concerns because I don't see that we are as flexible, responsive as we used to be."

The flexibility and responsiveness are challenged because of the newly emergent dependencies. Similarly, in the Theta Corona project, the responsibility for details on the product costing and sales volumes were transferred from the Peak Product Manager and assigned to the Peak Territory Manager USA. This disrupted the informational flow required for managing the innovation. As the miffed Product Manager explains,

> “But look at Theta, the Peak Territory Manager USA is talking to a Product Manager at Theta. He is not a senior person. He passes everything that the Peak Territory Manager USA is telling him to a senior person. So why? I don’t get it. I can tell him exactly the same and he passes it on to the senior person. If the Peak Territory Manager USA then wants to meet senior people, then go for it. That is what he should be doing. But they don’t get it. But they don’t want to let you in either. They say ‘Oh I’m at a senior level here and I’m speaking with that senior level there.’ But the fact is that that senior level is probably going to speak to their Product Manager to get the information our senior level is asking. It is absolutely not working.”

Innovating, here had transferred the onus of gathering information on customer requirements from Product Management which falls under Marketing to the Sales Department. The transfer of responsibilities creates new dependencies between Sales and Product Management while at the same time alters the relationship between Product Management and Design Engineering. Design Engineering are now dependent on the Territory Sales Manager for information on customer requirements. The fluctuating coherence between the Design and Manufacturing Engineers was felt when the design for the Theta Corona Nitrogen was rejected not being ‘service friendly’ and difficult to manufacture. The Manufacturing Engineering Manager captures the mood succinctly when he remarked,

> "There is a ‘them and us’ attitude among engineers. Engineers from both sides are becoming critical of other engineers."

The crux of the problem here was that the DDP and NPI were running in parallel and so the Design Engineer was under pressure to have the detailed design review on the Theta Corona Nitrogen (compressor free system) completed to concentrate on the Theta Corona Air (compressor based system). All the Manufacturing Engineers were busy supporting Production by replacing the T compressor designs with the G-compressors. Minimum production down time was their priority. In their perception, the failure of the products was because of faulty design. As one informant remarked,

> "We have got all these systems but there is no enforcement of it." *(Manufacturing Engineer).*

They were therefore reluctant to approve an untested design because, since the DDP and NPI processes were running in parallel, if errors were discovered during the NPI phase, they would have to repeat the NPI process again. Yet another instance of maintaining cross-functional coherence was when the Theta project NPI process was ready to be rolled out, only to find out that the Production technicians (from the Operations Department) were unavailable. On being asked about why the NPI was being delayed, this is what the Manufacturing Engineer had to say,

> "Like I say, that has been requested so I don't know if it is going to happen or not. Need to speak to the Production Manager this morning and see where we are at. The plan is to have a review and a Stage 1 sign off today. I think it can still happen given what the Design Engineer said. If we can get it in by the end of this week we can still meet the target. I don't expect there to be too many changes from the train the trainer build."

While the organising processes in Manufacturing Engineering are oriented towards New Product Introduction, the organising processes at Operations are designed to meet generator production targets to satisfy sales orders. Innovating therefore, challenges the coherence between the organising processes within the two departments by creating new links and dependencies.

In sum, the third and final sub process which was identified during the data analysis is the fluctuating process of cross functional coherence. *Process of cross functional coherence refers to the evolving informational and task dependencies between the various functional units while innovating.* The examples highlight the significance of cross functional coherence while innovating. Also revealed are some of the challenges created by the emerging dependencies for the maintenance of cross functional coherence. Here too, organising strives to maintain the cross-functional coherence while innovating alters the coherence by creating new dependencies. This in turn triggers organising.

6.3.4 Dynamics of Relational Coherence: The Process Complex

In the previous sections, I've untangled and expanded three sub-processes which I've called the process of regulatory coherence, process of procedural coherence and the process of cross functional coherence respectively. These sub-processes when taken together reveal the relational complexities encountered while innovating. In this section, I explore the relationships between the various sub-processes in greater detail. I do so by restoring the three sub-processes, untangled for analytical reasons, into the dynamic unfolding process from which they were abstracted.

In the Alpha Panda 2 project, we see that the regulatory coherence to the CSA certification process influenced the decision to upgrade the Standard Alpha 3G Panda 2 generator system. Stabilising the unstable dynamic of regulatory coherence while innovating created new dependencies between the DDP and NPI procedures. Thus we see the intertwining of the process of regulatory coherence with the process of procedural coherence as innovating unfolds. Since procedural templates are enacted by functions within Peak which have their own organising processes, we see a confluence of the process of procedural coherence with the process of cross-functional coherence. The former alters the latter by creating new dependencies while innovating.

In the Panda 2 project, the design and the manufacturing engineering activities were procedurally aligned to support a product upgrade. When the product launch date was set by Alpha and they need the generator for the end of August 2013 or mid-September 2013, the maintenance of the intertwined coherence is well expressed in the following statement by the Design Engineer,

> "We already have a component which is being used by Alpha for some time now. So the only change on those are the flow and the pressure. So we kind of agreed, because they asked us for three products in such short time, we would only focus on first testing the pressure. We can deliver the pressure as we know that the hardware hasn't changed. So everything is the same."

However, when the preference changed, Peak were requested to consider the possibilities for two separate models. This challenged the prevailing procedural and cross-functional coherence between the various functions at Peak. As the Design Engineer puts it,

> "So I started to work on it but the problem is that every single week, they change the requirements, everything they wanted. So we went back and forth. We lost a bit of time at the beginning and even now I feel that it is not entirely clear."

The real challenge which emerged was for a solution to be designed that would still adhere to the CSA certification guidelines. Yet, the details of this solution were hazy to Design Engineering. Manufacturing Engineers now have to deal with a NPI template where they do not know what they are introducing and yet ensure that it is CSA compliant. The threat to the procedural and cross functional coherence because of these developments can be seen in the following exchange between the Design Engineering Manager and Senior Manufacturing Engineer,

> "I've seen this happen before [Design Engineering Manager], and you don't hand over full information and it costs us [Manufacturing Engineering] time and resources." *(Senior Manufacturing Engineer)*

So finally, the solution which emerged required intense managerial effort. The effort was directed towards ensuring that the regulatory coherence was re-established and the procedural and cross functional coherence restored. The episode highlights how the three sub-processes, rather than unfolding individually, implicate one another to make up a relational dynamic as innovating unfolds.

Within the Theta Corona project, the impact of the intertwined coherence began to unfold with the change in the chassis dimension. When the size of the generator was increased, the co-ordination between the DDP and NPI procedures was strained. The delay in design would induce a delay to the NPI impacting the process of procedural coherence. However, when it was decided that the project would be fast tracked with the DDP and NPI running in parallel, the process of procedural coherence altered the prevailing process of cross-functional coherence.

With the unpredicted rise in the number of compressor failures, the complexity involved in maintaing procedural and cross-functional coherence increased. This was also the point when the requirements of the CE regulatory requirements intertwined with the two other processes. The episode highlights the entwined nature of the dynamics of regulatory, procedural and cross functional coherence. The decision to change the compressors meant that the Manufacturing Engineers would now have to change work priorities and concentrate on supporting an existing product rather than get involved in new product development. Therefore the intended procedural coherence was strained. This strain was evident when the Manufacturing Engineer made the following remark during the detailed design review for the Theta Corona Nitrogen where the design was rejected.

> "I can understand that we [Design and Manufacturing] are all one department. There is no need to show all that but sometimes it doesn't feel like that. Changes can happen at any point. It will happen."

The delays in the DDP caused further friction between Product Management and Sales. When the decision to discuss product pricing which until then was being managed by the product manager was assigned to the Peak Territory Manager USA, it increased the managerial challenge of co-ordinating evolving customer requirements with the design development process. According to the Product Manager,

> "I think our senior management need to learn how to let go, and manage more rather than get themselves involved in individual projects."

The dynamics alter the flow of information between the various functions collaborating on the Theta project. The emergence of these new dependencies further challenges the functionally defined roles within Peak. This shows how the process of cross functional coherence entwines with the process of procedural coherence. Commenting on the difficulties of stabilising this emergent dynamic, Peak's Product Manager explains,

> "Yeah, the information is known I think but when you get a Sales person to become involved in Product Management, I think the relationship is probably still strong. It's probably stronger than for me to develop but however, the key questions that we need asked are not being asked. Because they don't want to tarnish the relationship. But then we don't have the relationship with the customer so we can't go diving in. We are repeating ourselves."

The remark illustrates how the challenges of maintaining cross-functional coherence are very closely intertwined with the process of procedural coherence. The delays to the DDP also impacted the activity sequence within the NPI. Yet another instance of the unfolding relational dynamics can be found when production technicians were unavailable in late January 2014, shortly before the newly developed Theta Corona Nitrogen generator was to be introduced into Production. Assuming product ownership, at this stage would result in Production being unable to meet their monthly production targets. This caused a further delay in the new product introduction process being managed by Manufacturing Engineering. According to the Manufacturing Engineering Manager,

> "Production [Operations Department] has this system where towards the end of the month, they go hell for leather because they have to meet the numbers. At the beginning of the month, they coast. I don't understand what is it that they are trying to achieve."

The episode highlights how the processes of cross-functional coherence and procedural coherence are intertwined. Since the organising processes within Manufacturing Engineering and Production are oriented towards maintaining the procedural coherence, (meet the production targets and carry out NPI respectively), the emergent cross functional dependency challenges this procedural dynamic. Therefore, we see an intertwining of the process of procedural and cross-functional coherence, unfolding as a relational dynamic while innovating.

In sum, *the dynamics of relational coherence, refers to the changing patterns of dependencies between various organising processes as innovating unfolds.* It is made up of three sub-processes which I've called the process of regulatory coherence, the process of procedural coherence and the process of cross-functional coherence. The episodes show how each sub-process entwines while innovating to constitute the dynamics of relational coherence. Maintaining relational coherence, therefore require effortful organising.

6.3.5 Dynamics of Relational Coherence: Summary Insights

The dynamics of relational coherence was identified as a key process complex with which innovators have to grapple. The focus of this section was to untangle, explore and elaborate the dynamics of relational coherence. Three distinct yet intertwined processes were identified as constituting the dynamics of relational coherence. These sub-processes were regulatory, procedural and cross-functional coherence. In both the field studies, the dynamics of relational coherence were seen to create new dependencies between existing organisational processes as innovating unfolded. Managers responsible for innovating had to come to grips with this dynamic to ensure the maintenance of stability while innovating.

It was observed that organising processes attempted to maintain relational coherence to facilitate innovating. In both projects, we see acts of organising like circumventing of the CSA certification process in the Alpha project and running design development in parallel with new product introduction for the Theta Corona project. A significant amount of organising time and effort is required to maintain this coherence. While discussing the implications of the compressor changes, Peak's Engineering Director remarked,

> "We must be spending an awful lot of time finitely adjusting the work instructions to the tiniest details. The whole process behind that, through the ECN [Engineering Change Notification] process is so time consuming. We have certain criteria that we have to meet for controlling our processes. If we control, if we change anything of significance, we have to notify our customers, we have to seek approval throughout the organisation because one thing might affect somebody else down the line and what they do, so I understand the requirement for that!"

The statement points to the intense organising effort required while innovating. Every change here requires organising to ensure an alignment between the existing and emerging processes. This means ensuring that the regulatory CE certification process destabilised by the change of compressors, is aligned with the procedural and cross functional organising processes. This requires ongoing co-ordination between various functions.

Innovating, it was observed, decreases relational coherence by creating new dependencies, thus triggering organising. As new dependencies emerge while innovating, we see that organising processes are invoked to sustain the project. For instance, when the price for the newly upgraded generator was rejected, the relational coherence between the innovation and the organising processes supporting it through the production shop floor was challenged. Thus organising was triggered to maintain the current Infinity 1031 generator as well as clear the ground for managing the newly developed 'Hi-Flow' generator through the production lines. Similarly, for the Theta Corona project, when the decision was taken to change the program on the compressor after new product introduction had been completed, organising processes were invoked to reflect the new requirements and contain disruption. The Manufacturing Engineering Manager explains:

> "It is an issue of at what point does Manufacturing get involved? We have been pushing back in terms of the NPI process to get it but there is still an element where the designer still probably hasn't got in his own mind, his own head what he is wanting to do. To have somebody come in is more of a nuisance that it is a help. So they tend to push back. It is a case of trying to get them to understand that the ME is there to help and not to interfere or hinder. So it is about striking that balance."

The observation highlights the need to 'balance' the emerging dependencies created by innovating with the existing organising processes. The processual quality of the dynamic requires ongoing alignment between the current and emergent dependencies between organising processes. In order to illustrate the challenges of maintaining relational coherence while innovating, it is helpful to revisit the dependencies which emerged from the compressor changes within the Theta Corona project. The change in compressor, with the design development process and new product introduction process running in parallel, meant that relational coherence was contingent on preferences remaining stable. However, when Peak realised that the change in compressors would allow them to switch from six months to an annual service contract, this meant that upstream changes to the compressor control program made by Design Engineering would disrupt the new product introduction managed by Manufacturing Engineers. In the words of the Design Engineering Manager,

> "We tweaked the process so that we could do the New Product Introduction in parallel along with the validation stage. We hadn't then decided if we wanted to change the program. We then decided that now is the time to standardise the program."

Innovating, by changing the program, has now created a new set of dependencies between the DDP and NPI processes. It has also altered the cross functional coherence between Manufacturing and Production. Stabilising the dynamics of relational coherence would now require effortful intervention by Manufacturing Engineers. They would have to reconnect and align the various organising processes. Such interventions are necessary to stabilise the production environment where even minor product changes can be disruptive.

To summarise, we can see that the dynamics of relational coherence is a process complex which binds the organising and innovating processes. Organising attempts to stabilise the dynamics of relational coherence to facilitate innovating. Innovating decreases relational coherence by creating new dependencies, thus triggering organising. Further evidence for the processes of regulatory coherence, procedural coherence and cross functional coherence which constitute the dynamics of relational coherence can be found in Appendix V.

6.4 Process Complexes: An Interweaving

The study thus far has examined and explicated three distinct process complexes which emerged from the two field studies. The identified process complexes were (i) dynamics of preferential equivocality, (ii) dynamics of temporal scaffolding and (iii) dynamics of relational coherence. In this section, I explore the relationship between these process complexes to further examine the links between organising and innovating. Doing so would once again require us to restore these process complexes to the unfolding process of innovating from which they have been abstracted.

In the Alpha project, when Peak were approached to develop a solution for the Panda 2 application, we see that Peak decided to upgrade an existing generator rather than build a new generator. In the words of the Design Engineering Manager,

> "Now at the time, because we were working under such a tight time line originally, it was understood that we didn't have the time to go back and get the CSA file updated. Now that we know that the launch has been delayed, with hindsight we could have probably got the CSA file updated. There would have been a cost involved in that as well."

As the observation shows, the decision to upgrade an existing Alpha 3G generator system was a preferential dynamic. The tight 'timeline', refers to the dynamics of temporal scaffolding

The CSA certification process, as the discussion on the dynamics of regulatory coherence has shown is a relational dynamic. We therefore see the interplay between dynamics of preferential equivocality, the dynamics of temporal scaffolding and the dynamics of relational coherence. *The dynamics of preferential equivocality here were shaped by the dynamics of temporal scaffolding and the dynamics of relational coherence.*

Further, the processual nature of these three intertwining processes is also highlighted in the above remark. Because, now if the project had to be re-commenced, the manager would rather update the CSA files than circumvent the updating process. This is possible because the re-interpretation of the past gives new meaning to the dynamics of temporal scaffolding which shapes the preference. Also, consider the following remark made by the Product Manager responsible for the Alpha Panda 2 project,

> "Again Alpha, all that time spent, changing requirements, changing requirements, changing requirements when the Design Engineer had two other projects sitting in the line that he could have been working on which he could have possibly even have completed having waiting had this not been a priority"

The intertwining between the dynamics of preferential equivocality and dynamics of temporal scaffolding is nicely captured in this remark. The instability of the dynamics of preferential equivocality has shaped the dynamics of temporal scaffolding. That is the reason why the reference to temporal prioritising has been invoked by the Product Manager. Dynamics of preferential equivocality, therefore, shape the dynamics of temporal scaffolding. This was true, even in the Theta Corona project where the temporal boundary shifted to January 2014 when preference changed from the PSA technology to Membrane technology.

While changes in customer requirements, triggered by preferential dynamics, normally shift the enacted temporal boundaries, this need not necessarily be the case. In the Theta Corona project for instance, after the revised temporal boundary was enacted for January 2014, the preferential dynamics did not initially shift the boundaries. However, if the boundaries do not shift, then we can observe changes in the temporal priority and temporal sequence of innovating as it unfolds. This was evident when a change from the T-Compressor to the G-Compressor was effected without changing the temporal boundaries. As the Design Engineering Manager put it,

> "I think it might be ok for the compressor box. It might be the case of sitting down and going through his template. The last I looked at it, it wasn’t quite as straightforward as I was looking for. But I

> think it highlights what needs to be done. In my mind, the validation that needs to be done on this is a slight change to the metal work."

Here, the changes to the compressor (dynamics of preferential equivocality) have not altered the temporal boundary but have destabilised the dynamics of temporal scaffolding. Shuffling temporal priorities and rearranging the temporal sequence, in other words, are used to stabilise the preferential dynamics. Eventually however, the temporal boundaries shifted as a result of the changes in the compressor control program. These examples show how the dynamics of preferential equivocality are intertwined with the dynamics of temporal scaffolding. To conclude, *the dynamics of preferential equivocality shapes and is shaped by the dynamics of temporal scaffolding.*

In the Alpha Panda 2 example, I've shown that the dynamics of preferential equivocality were shaped by the dynamics of relational coherence. Here, it was the relational coherence with the certification process that lead to two generator models: the Infinity 1031 and Infinity 1035 Nitrogen generators (as these generators weren't tied to the CSA certification). In the end it was the relational coherence with the existing production process, which could only support one name, one product that led to the change in preference to Infinity 1031 'Hi Flow'.

Similarly in the Theta Corona project, it was the existing relational coherence between the service contract and the service life of the compressor that justified the decision to run the DDP and NPI in parallel. Once this preference changed while innovating, so did the relational coherence and both the procedures had to be re-run sequentially while the control program was being updated. Also, when the DDP and NPI were running in parallel, the Manufacturing Engineers became over cautious about the robustness of the product design. According to the Manufacturing Engineering Manager

> "For me what has happened is that all the design has been based on function. There has not really been that much emphasis on manufacturing. There is a mind-set that needs to be created that when you are doing a design, you are doing it with manufacturing processes, current and future in mind!"

This is because any change downstream after the production documents and procedures have been finalised would mean repeating the entire NPI template again. This was partly responsible for the rejection of the initial detailed design for the Theta Corona Nitrogen. The rejection, as the remarks suggest, also temporarily strained the cross-functional coherence between Design and Manufacturing Engineering. Senior Management had to step in and intervene to restore the relational coherence which could then stabilise the preferential dynamics. In sum, as the episodes reveal, *the dynamics of preferential equivocality are shaped by, and shape, the dynamics of relational coherence.*

Finally, let us turn our attention to the links between the dynamics of temporal scaffolding and the dynamics of relational coherence. In the Alpha project, as the opening quote in this section by the Design Engineering Manager suggests, it was the dependency between the time required for the CSA certification and the deadline enacted by Alpha which influenced Peak's decision to circumvent the CSA certification process. The incident reveals how temporal prioritising and temporal sequencing which constitute the dynamics of temporal scaffolding are closely intertwined with the process of procedural coherence and cross-functional coherence.

For instance, when the relational coherence between the existing production templates, which could support only a single name for a single product, clashed with the enacted timeline for delivery of the new solution, the timelines had to be postponed. The unstable process of procedural and cross functional coherence shifted the temporal boundary for the 'Hi-Flow' generator model into mid-November. This shifting of temporal boundaries also changed the temporal priorities of tasks within the DDP and NPI which constitute the process of procedural coherence. The 'Hi-Flow' model was launched an entire month later, in mid-November 2013, due to the absence of relational coherence.

Again, in the Theta Corona project, it was the scarcity of time after the 'non-service friendly' Theta Corona Nitrogen design was rejected which triggered the move to 'short-cut' the DDP and NPI and run it in parallel. Had the pressure to launch by the end of January 2014 not been there, both the DDP and NPI processes would have been run sequentially. The challenges to stick with the procedural template and work within the temporal scaffold are well articulated in the following remark made by the Design Engineer during a Theta product management meeting,

> "Product Manager (Peak), are there any curve balls coming up? Or are you looking at shipping it in January? Do you expect any changes?"

The 'curve balls' refer to the potential destabilising of the dynamics of preferential equivocality which can alter the dynamics of relational coherence particularly procedural coherence. Unstable procedural coherence challenges cross-functional stability causing changes to the dynamics of temporal scaffolding. A final example which illustrates the links between temporal scaffolding and relational coherence was when the Manufacturing Engineer working on the Theta Corona Nitrogen was asked to work on a British Standards Institute (BSI) regulatory audit for an unrelated project. This in turn delayed the time for rolling the product out on the shop floor. The management concern is captured by the Design Engineering Manager,

> "My own concern is, the plan is still showing him working full time on it (Theta) and (the) Industrial (project) is not on that. It seems a little bit flighty as to when he is needed on Industrial (project). So it would be nice to understand what he does on that."

The reason why the Design Engineering Manager finds the plan 'flighty' is because the links between the dynamics of temporal scaffolding and the dynamics of relational coherence are now unstable. New dependencies in the cross-functional coherence have altered the temporal priorities, destabilising both process complexes. This shows how the dynamics of relational coherence and the dynamics of temporal scaffolding implicate one another. Ultimately, when the Manufacturing Engineer returned, the production technicians were not available which further challenged both the relational coherence and temporal scaffold. We can therefore conclude that: *The dynamics of temporal scaffolding are shaped by, and shape, the dynamics of relational coherence.*

In sum, by restoring the three process complexes with innovating as it unfolded, we see the emergence of an analytical framework which links these process complexes. The exercise reveals that

i) Dynamics of preferential equivocality are shaped by, and shape, the dynamics of temporal scaffolding.

ii) Dynamics of preferential equivocality are shaped by, and shape, the dynamics of relational coherence.

iii) Dynamics of temporal scaffolding are shaped by, and shape, the dynamics of relational coherence.

The emergent analytical framework is summarised in Figure 45 below.

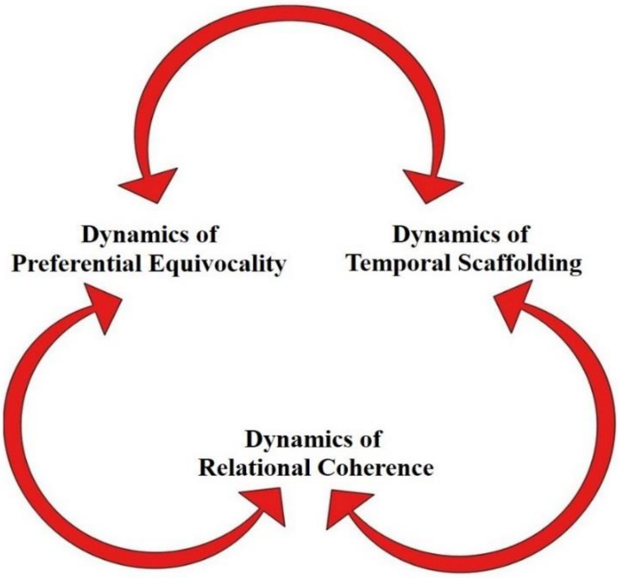

Figure 45: Emergent Analytical Framework

6.5 Conclusion

I began this chapter with the aim of developing an analytical framework that furthers understanding of the entwinement between the organising and innovating processes. Three distinct yet intertwined processes complexes emerged from the study of the empirical evidence. These were:

i. *Dynamics of Preferential Equivocality,* which refers to a gradual emergence and revealing, over time, of various preferences that shape innovating. It is constituted by the entwinement of four distinct sub-processes which I've called the processes of product function, technology, target costing and design preferences, respectively.
ii. *Dynamics of Temporal Scaffolding,* which refers to the ongoing enactment and maintenance of temporal boundaries by regulating development priorities and activity sequence while innovating. It is constituted by the entwinement of three distinct sub-processes which I've called the processes of setting temporal boundaries, temporal prioritising and temporal sequencing, respectively.
iii. *Dynamics of Relational Coherence,* which refers to the changing patterns of dependencies between various organising processes as innovating unfolds. It is constituted by the entwinement of three distinct sub-processes which I've called the

processes of regulatory coherence, procedural coherence and cross-functional coherence, respectively.

The study also revealed organising attempting to stabilise the dynamics of

i. preferential equivocality by narrowing the range of possibilities,
ii. temporal scaffolding by enacting temporal boundaries, setting temporal priorities and varying the temporal sequence of activities, and
iii. relational coherence by maintaining relational coherence, all of which allows innovating to unfold.

These insights are diagrammatically expressed in Figure 46 A & B below. Organising (in green) and innovating (in orange) are represented as open ended bundles of entwined lines that alongly unfold. The knot in Figure 46A, represents attempts by the organising process to stabilise the innovation dynamics by binding the innovating process. Figure 46B, highlights the ongoing attempts by organising to stabilise innovating.

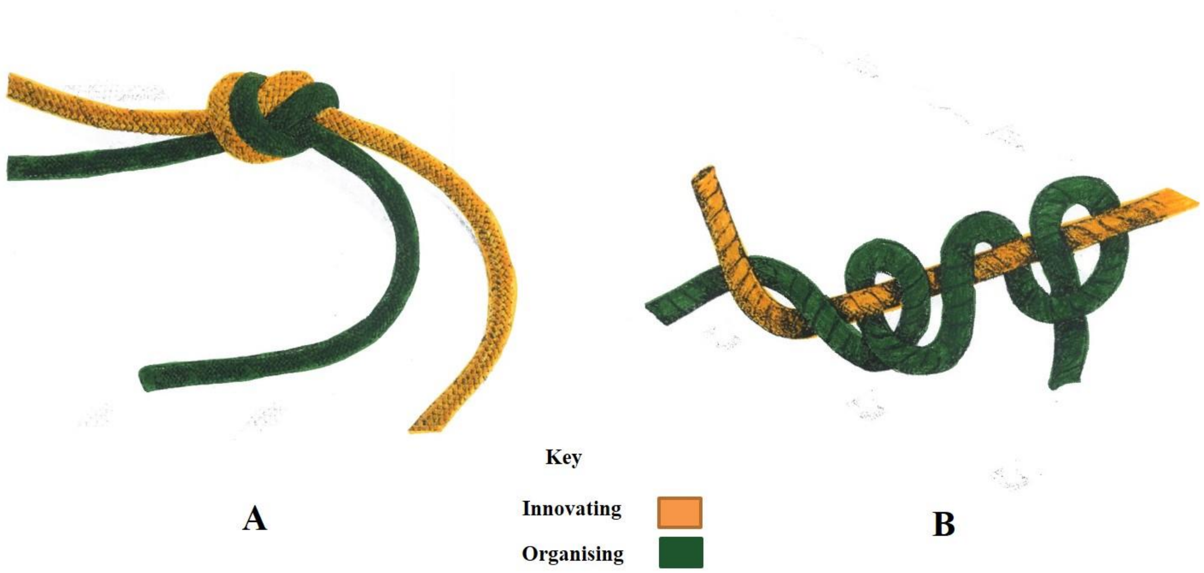

Figure 46: Organising attempting to stabilise innovating

Innovating on the other hand, destabilises the dynamics of

i. preferential equivocality by creating new knowledge which alters preferences,
ii. temporal scaffolding by altering temporal boundaries, temporal priorities and the temporal sequence of activities, and

iii. relational coherence by challenging the relational coherence, all of which triggers organising.

Figure 47 below, highlights how the tightly bound knot between organising and innovating (Figure 46 A) is now loose as innovating has destabilised the organising process. This in turn triggers organising.

Figure 47: Innovating triggering organising

Finally, the findings also demonstrate that the three process complexes that emerged from the data were all entwined. Dynamics of preferential equivocality are shaped by, and shape, the dynamics of temporal scaffolding. Dynamics of preferential equivocality are also shaped by, and shape, the dynamics of relational coherence. And finally, the dynamics of temporal scaffolding are shaped by, and shape, the dynamics of relational coherence. Since each of these dynamic process complexes are an entanglement of lines with knots, they can be considered as meshworks of knotted lines. This emergent meshwork, which I call the 'The Tensegrity model of organising while innovating', provides *an answer* to the links between organising and innovating. This model is taken up for discussion in the next chapter.

7 Knitting a Process Yarn

Our choicest plans have fallen through,
Our airiest castles tumbled over,
Because of lines we neatly drew,
And later neatly stumbled over.

Piet Hein (1969)

7.0 Introduction

Underwriting my thesis thus far has been an *Ingoldian becoming perspective* which is analytically oriented towards processual lines that embody movement, duration, creativity and purpose. I've applied this perspective to delineate three distinct yet entangled process complexes which constitute the dynamics of organising while innovating. I've called these complexes, the Dynamics of Preferential Equivocality, the Dynamics of Temporal Scaffolding and the Dynamics of Relational Coherence. These meshworks of process complexes *co-respond*, shaping not just one another but also the unfolding dynamics of organising while innovating. These observations leave us with a vexing puzzle. If indeed, as the field studies suggest, innovating is such a fluid, dynamic and emergent process, how then is organisational stability being maintained? Put differently, what is the *principle* that binds organising while innovating to ensure that *organisations remain stable by changing*?

In this chapter, I tackle this vexing puzzle using the analytical framework developed in the previous chapter. After restoring the process complexes to the stream of events from which they have been abstracted, I use them to study episodes of 'breakdowns' within the innovation journeys. Breakdowns refer to discrepancies between the expectations and actual experience of organisational actors that temporarily disrupt organising while innovating (Lok & De Rond, 2013, p. 187). The occurrence of breakdowns, therefore, suggests severance in *correspondence* between organising and innovating. Investigating breakdowns within both, the Alpha Panda 2 and Theta Corona projects, reveal *tensegrity* as the stabilising principle. Tensegrity is a portmanteau word combining tension and integrity (Volokh, 2011). It refers to an architectural principle whereby stability is engineered through the distribution and balancing of counteracting forces of tension and compression along their component lines. Breakdowns in the innovation journeys occurred when tensegrity, sustained by correspondence between the three process complexes, was disrupted. Continuing the innovation journey then required organising processes to restore *correspondence* between the three process complexes.

The remainder of this chapter is organised as follows. First, I provide a brief overview of the tensegrity principle. The overview reveals how tensegrity is not merely an architectural principle. It is also ubiquitous in nature playing an important role in the life process. Next, I illustrate how severance in correspondence between the three process complexes as they alongly unfold, results in a disruption of tensegrity which in turn disrupts innovating temporarily. Organising processes then restore correspondence which in turn regenerates tensegrity between the three process complexes. Tensegrity, in other words, provisionally answers our original research question: How do we organise while innovating? I conclude by outlining the implications of the *Tensegrity principle of organising while innovating* and its constituent process complexes for the theory and practice of organising while innovating.

7.1 The Tensegrity Principle

Up until this point, my analysis was devoted to untangling and describing the Dynamics of preferential equivocality, the Dynamics of temporal scaffolding and the Dynamics of relational cohernce. Identification of these three process complexes raises a puzzling question. If organising and innovating are indeed fluid, open ended socio-technical processes, how then is organisational stability maintained while innovating? Managing the innovation journey requires an understanding of how these dynamics entwine to constitute a stabilising effect. In the absence of such an explanation, the process complexes identified are akin to parts which constitute an internal combustion engine. Just as how a mere understanding of parts which make up an internal combustion engine does not explain how the engine actually powers an automobile, likewise identifying process complexes which unfold while innovating will do little to solve the organising puzzle if we do not understand the *principle* for their configuration. Towards this end, I propose tensegrity as the principle which configures organising while innovating.

Tensegrity, which stands for tensional integrity (Volokh, 2011; Ingber, 1998), was originally coined by the American architect Richard Buckminister Fuller. Fuller of course, is better known within the scientific community and among the public at large for the design of his geodesic dome structure to which the carbon C60 molecule (Figure 48) bears great resemblance. Thus the C60 molecule is referred to, scientifically, as Buckminsterfullerene (Kroto, et al., 1985) or more colloquially as buckyballs. However, the stability of geodesic domes or the C60 Buckminsterfullerene carbon moclecule depends on *tensegrity*. Tensegrity refers to a principle through which stability is attained by distributing and balancing the countervailing forces of tension and compression within the structure (Volokh, 2011; Ingber, 1998). Crucially for my argument here, tensegrity is not just an architectural principle but is also ubiquitous in nature, sustaining the process of life. In the words of Harvard based cell biologist Donald Ingber (1998),

> "An astounding wide variety of natural systems, including carbon atoms, water molecules, proteins, viruses, cells tissues and even humans and other living creatures, are constructed using a common form of architecture known as tensegrity" (p. 48).

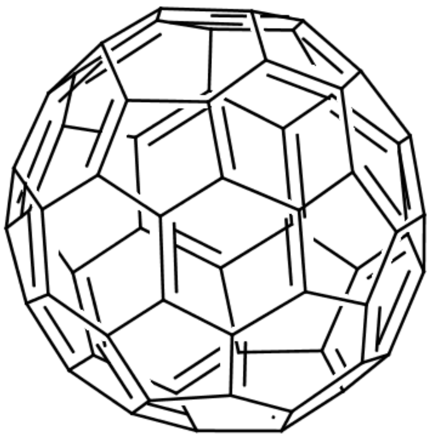

Figure 48: C60, Buckministerfullerene Molecule

Tensegrity, has gathered analytical traction among cellular biologists primarily through the work of Ingber (1997; 1998). Ingber (2008; 1998) has demonstrated how tensegrity explains several bio-physiological mechanisms ranging from the transmission of electrical signals by nerve cells which constitute the nervous system to the cytoskeleton architecture which resembles geodesic domes and provides cells with stiffness required to counteract the force of gravity. In fact according to Ingber (1998),

> "Only tensegrity, for example, can explain how every time that you move your arm, your skin stretches, your extracellular matrix extends, your cells distort, and the interconnected molecules that form the internal framework of the cell feel the pull—all without any breakage or discontinuity" (p. 56).

Movement, in other words, is crucial to the tensegrity principle. This is because mechanical stability of tensegrity structures *does not* depend on the strength of their individual constitutive elements. Rather it is an outcome of the configuration process through which the various mechanical stresses are distributed and balanced. There are two categories of tensegrity structures (Volokh, 2011; Ingber, 1998). In the first category which includes Fuller's geodesic domes, forces of either tension or compression are made to be borne by a meshwork of rigid struts. In the second category, inspired by sculptor Kenneth Snelson, tension bearing structural members are distinct from those that bear compression. In this configuration, prior to the application of an external force on the structural elements, all structural members are already in tension or compression. This phenomenon, known as prestress, serves to stabilise the structure. Ingber (1998) explains,

> "Within the structure, the compression-bearing rigid struts stretch, or tense, the flexible, tension-bearing members, while those tension-bearing members compress the rigid struts. These counteracting forces, which equilibrate throughout the structure, are what enable it to stabilise itself" (p. 49).

These differences notwithstanding, in all tensegrity structures, tension is continuously transmitted across all structural members. Therefore in a tensegrity structure, as Ingber (1998) writes, "an increase in tension in one of the members results in increased tension in members throughout the structure—even ones on the opposite side. This global increase in tension is balanced by an increase in compression within certain members spaced throughout the structure. In this way, the structure stabilizes itself through a mechanism that Fuller described as continuous tension and local compression" (pp. 49-50). In other words, it is movement that maintains tensional integrity.

In sum, tensegrity refers to a principle where dynamic stability (tensional integrity) is created by configuring countervailing forces of tension and compression. It is not merely an architectural princple but is also an important naturally occuring principle regulating various life processes. Stability depends on the configuration of various processes rather than the strength of any particular process. Movement, therefore, is implied within the tensegrity principle. *Since there is nothing equivalent to tension and compression within processes, I use tensegrity analogically rather than literally for my study.* With this, I return to the field studies to investigate if tensegrity indeed is the principle deployed by organising to stabilise innovating?

7.2 Breakdowns in the Innovation Journeys

In the previous chapter, we have seen how the three process complexes *co-respond* shaping one another as they alongly unfold while innovating. The data also revealed that organising, among other things, also attempts to stabilise these dynamic process complexes while innovating destabilised these process complexes to trigger organising. This correspondence between organising and innovating as they unfold alongly, created a transient order while innovating. In the previous section, I proposed tensegrity as the principle that maintains organisational stability. According to this principle, stability is maintained by configuring the dynamic process complexes in a countervailing manner.

So if tensegrity indeed is the principle by which organising maintains stability, then breakdowns where things did not go according to plan while innovating, signals instability which suggests that stability has been disrupted. Therefore, I focus on 'breakdown' episodes within the two innovation journeys to investigate the tensegrity principle in practice. In what follows, I use the analytical framework which emerged from the data analysis to investigate a) the stream of events leading to breakdowns and b) the restoration work which followed the breakdowns, for both the Alpha Panda 2 and the Theta Corona projects. If tensegrity is indeed the regulating principle, then the former must demonstrate how stability was disrupted while the latter should demonstrate how it was restored. The sections which follow investigate breakdown episodes.

7.2.1 Breakdowns in the Alpha Panda 2 Project

There were three major breakdown episodes within the Alpha Panda 2 project. In what follows, I shall expand and elaborate on the changing dynamics between the three process complexes which led to these breakdowns. Then, by concentrating on how these breakdowns were resolved, I again focus on the three process complexes to provide incontrovertible evidence for the tensegrity principle.

7.2.1.1 Episode 1

In early June 2013, Alpha confirmed an end of August or early September (2013) launch date for their Panda 2 instrument. They request Peak to provide them with a gas generator solution for their Panda 2 instrument. The impact of this episode on the three process complexes in summarised in Table 8 below.

Table 8: Impact of Episode 1 on the Process Complexes

Dynamics of Preferential Equivocality	Dynamics of Temporal Scaffolding	Dynamics of Relational Coherence
Originally**,** Alpha wanted an upgrade kit for the existing Standard Alpha 3G generator system. But now for their Panda 2 instrument, they change their original requirements which was a System with three Nitrogen gas outputs. They now want a System with one nitrogen gas output and two air outputs. These gas flow rates are higher than the existing Standard Alpha 3G generator system. They would also like the system to be less noisy. Alpha need the generator system urgently but cannot confirm the number of units or the final product specifications of the Generator system. They however, would like Peak to proceed with the project as there is not enough time between now and the target launch date for Panda 2.	The launch date for the Panda 2, is set by Alpha for the end of August 2013 or mid-September 2013. So Peak have exactly six weeks to design and manufacture a new gas generator for Alpha Panda 2. Though the exact product specifications are yet to be confirmed.	All the Alpha 3G generators and the Alpha Table for the Alpha 3G System require CSA certification. It takes four weeks to complete a new product certification process. The timeline for the Panda 2 product launch is tight, and does not allow Peak to both develop and certify a new Alpha 3G System.

Applying the analytical framework, we can see that originally, the customer requirements, the time required to develop the upgrade kits and the internal organising processes were all in sync or corresponding. Thus the project was stable with the dynamics of preferential equivocality, temporal scaffolding and relational coherence all co-responding. However, a change in the customer requirements, a shortened timeline and the need for a CSA certification has destabilised the provisionally stable project. Therefore, the altered correspondence between the dynamics of preferential equivocality (which has changed) and the dynamics of temporal scaffolding (which hasn't changed), severs the correspondence between the dynamics of temporal scaffolding and the dynamics of relational coherence.

The relational dynamic is unstable because the CSA certification required cannot be obtained in the given timeline. Therefore, the process of regulatory coherence which is a relational dynamic is disrupted. This in turn severs correspondence between the three process complexes. Severance in correspondence between the three process complexes disrupts tensegrity which regulates these dynamics, triggering the breakdown. Figure 49, summarises the resulting breakdown in terms of the analytical framework. Breakdowns, as Figure 49 indicates, does not imply absence of any process complex. Rather it shows a lack of correspondence between them.

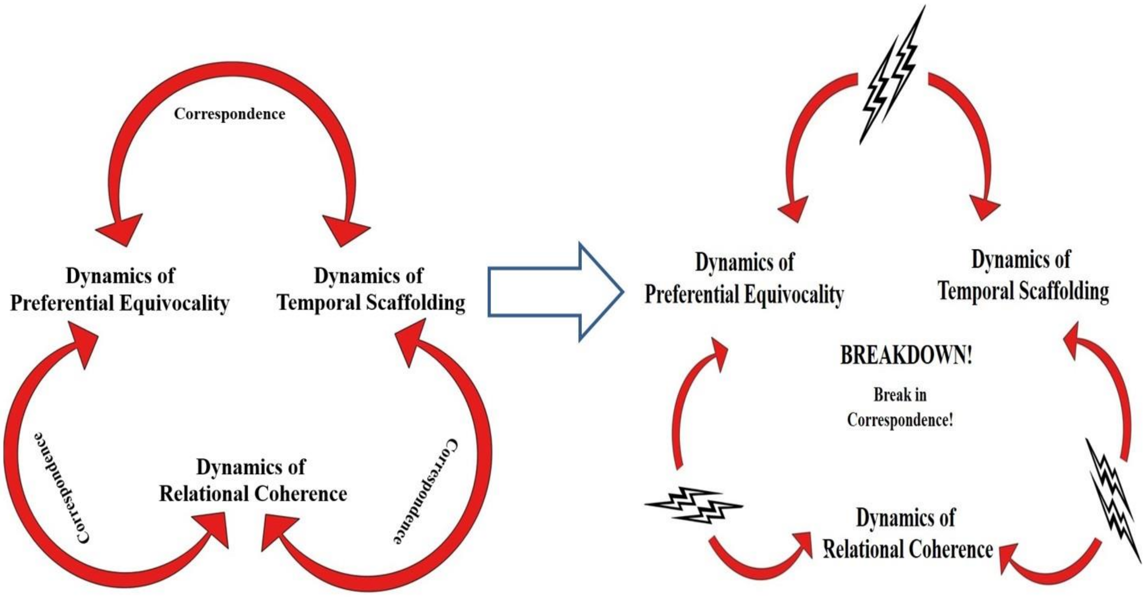

Figure 49: Breakdown in Correspondence

Peak's senior management team sat together to resolve this breakdown. The only difference between the new system requirements and the current Standard Alpha 3G system are noise reduction and a higher gas flow rate. Engineering Management suggested that if Alpha agree to use the new system being designed for the Panda 2 instrument for all their applications, including current ones, then Peak can upgrade the current Standard Alpha 3G system and circumvent the CSA certification.

This creative solution would prove advantageous to all. Peak would not have to increase its product portfolio with yet another Alpha 3G Generator System. Alpha would have a generator in time for their Panda 2 product launch which is also compatible with all their current applications. This allows both organisations to maintain the CSA certification and the cost saving on the CSA certification can be shared by both organisations. This suggestion is internally approved within Peak and then sent to Alpha for approval.

Applying the analytical framework, we see that the decision to upgrade the current Standard Alpha 3G System to meet customer requirements, readjusts the dynamics of preferential equivocality. This in turn allows Peak to maintain the CSA certification on the product. Maintaining CSA certification resets the dynamics of relational coherence by adjusting the process of regulatory coherence. These acts of organising allow Peak to meet the deadline for the Alpha Panda 2 product launch. Thus, correspondence between the dynamics of preferential equivocality, temporal scaffolding and relational coherence is restored by organising. The tensegrity principle thus ensures that a dynamic equilibrium between the process complexes is re-established and stability returns.

7.2.1.2 Episode 2

In early September 2013, Alpha rejected price increase on the upgraded Standard Alpha 3G System. The price increase and product upgrade which was being overseen by Peak's Director Sales and Operations fell apart. Alpha could no longer pay more for the upgraded System. The project breaks down. The impact of this episode on the three process complexes in summarised in Table 9 below.

Table 9: Impact of Episode 2 on the Process Complexes

Dynamics of Preferential Equivocality	Dynamics of Temporal Scaffolding	Dynamics of Relational Coherence
Peak had gone ahead and designed the upgraded Alpha 3G Generators, Alpha 3G Tables and the Infinity 1031 generators each of which required additional components.	The launch date for the Panda 2, is pushed back by Alpha from early September to mid-October 2013.	Manufacturing Engineering had already designed production processes to support one upgraded product through their production shop floor.

Applying the analytical framework, we can see that originally the process of product costing preference, the time required to launch the upgraded Standard Alpha 3G System, and the process of procedural coherence between the DDP and NPI processes were all in sync or corresponding. Since the troika of process complexes were all corresponding, the project was provisionally stable. However, the rejection of the product cost and the change in temporal boundaries disrupted the correspondence between the processes of procedural and cross functional coherence. Since these constitute the dynamics of relational coherence, the disruption precipitates a severance in correspondence between the relational and temporal dynamics as well as the relational and preferential dynamics. The result is a severance of correspondence between the three process complexes which in turn disrupts stability, triggering breakdown.

In order to resolve this breakdown, Peak decide to introduce the upgraded product as a new system and maintain the old system. The new system could now justify a price increase. Since the Alpha 3G generators and the Alpha Tables are CSA certified, Peak decide to change the name of the Infinity 1031 generator to Infinity 1035. Since the Infinity generator is not CSA certified, this allows Peak to creatively maintain their CSA certification as well as differentiate the two systems internally on their Production shop floor. Manufacturing Engineering created separate production processes for both the models of the Alpha 3G System.

In terms of our analytical framework, the decision to introduce two separate models of the Alpha 3G System, each priced differently to meet customer requirements, readjusts the dynamics of preferential equivocality. The decision to create two separate production processes for both the models of the Alpha 3G System requires readjusting the processes of procedural and cross functional coherence. This resets the dynamics of relational coherence. Further, setting the process of procedural coherence adjusts the process of temporal sequencing and temporal prioritising. Thus the dynamics of temporal scaffolding are reset. These acts of organising restore correspondence between the dynamics of preferential equivocality, temporal scaffolding and relational coherence. Again the tensegrity principle ensures that a dynamic equilibrium between the process complexes is re-established and stability returns.

7.2.1.3 Episode 3

In late September 2013, Alpha informs Peak that they have not been able to make changes to their regulatory paper work to support two different gas systems for their product range. So, Alpha want Peak to change the Infinity 1035 to Infinity 1031. This causes the project to breakdown. The impact of this episode on the three process complexes in summarised in Table 10 below.

Table 10: Impact of Episode 3 on the Process Complexes

Dynamics of Preferential Equivocality	Dynamics of Temporal Scaffolding	Dynamics of Relational Coherence
Peak had gone ahead and designed two separate Infinity generators. The Infinity 1031 and Infinity 1035 internally differentiates between the two Alpha 3G Systems and still maintain the CSA certification. Alpha now want one Infinity 1031 generator to ensure that the Panda 2 Alpha 3G System conforms to their regulatory paper filings. These filings are important to Alpha as their Panda 2 is meant for the medical market which require these certifications.	The launch date for the Panda 2, is pushed back by Alpha from mid-October to mid-November 2013.	Manufacturing Engineering have already designed and created production processes to support two Infinity generators (Infinity 1031 and Infinity 1035) through the production shop floor. Reverting back to one Infinity generator would not allow them to differentiate between the Standard Alpha 3G System and the upgraded Standard Alpha 3G System. This disrupts the Production process.

Applying the analytical framework, we can see that originally the preferential dynamics, the temporal dynamics and the relational dynamics were all corresponding and keeping the project stable. However, the need to revert back to Infinity 1031 altered the preferential dynamics. This changed the temporal boundaries for the Panda 2 product launch which in turn disrupted procedural and cross functional coherence. These relational processes were organised to manufacture the Infinity 1031 and the Infinity 1035 generators. The provisional stability resulting from corresponding process complexes was thus destabilised. Correspondence between the three process complexes got severed, disrupting stability and triggering the breakdown.

Resolving this breakdown involved redesigning the front panel of the components and 'Hi-Flow' was engraved. The engineers redesigned the Alpha 3G System and redeveloped the production processes by incorporating this new design to meet customer requirement. In terms of our analytical framework, the decision to modify the process of product design preference with 'Hi-flow' to meet customer requirements, readjusts the dynamics of preferential equivocality. This triggers organising that reconfigures the processes of procedural and cross-functional coherence which resets the dynamics of relational coherence. Further, adjusting the process of procedural coherence adjusts the process of temporal sequencing and temporal prioritising which resets the dynamics of temporal scaffolding. These acts of organising restore correspondence between the dynamics of preferential equivocality, temporal scaffolding and relational coherence. Here too, the tensegrity principle is seen to ensure that a dynamic equilibrium between the process complexes is re-established and stability is reinstated.

To conclude, in this sub-section, I have discussed three major breakdown episodes within the Alpha Panda 2 project using the analytical framework developed in the previous chapter as an interpretive lens. The study reveals how the tensegrity principle configures correspondence between the three process complexes to create stability. Stability was disrupted when correspondence between the three process complexes was severed. This precipitated breakdowns. Restoring stability after breakdowns required organising to reconfigure the process complexes to re-establish correspondence. Tensegrity thus ensures that project stability is re-established.

Table 11, provides further evidence to demonstrate the tensegrity principle within the Alpha Panda 2 project. These episodes, show how organisational responses which were apt and timely, quickly reconfigured the non-corresponding process complex to maintain correspondence relative to the other process complexes and prevented project breakdowns. Failure to remedy such interruptions in correspondence often led to its permeation into the other co-responding process complexes, disrupting stability and triggering breakdowns.

Table 11: Correspondence and Process Breakdowns in the Alpha Panda 2 Project

SI No	Episodes	Organisational Challenge	Has Correspondence been disrupted? (Breakdown)	Dynamics of Preferential Equivocality?	Dynamics of Temporal Scaffolding?	Dynamics of Relational Coherence?	Organisational Response
1	No orders come through for either additional kits or for the modified generator system requested by Alpha	Keep the exploration work going or abort the project?	No	Corresponding	Not Corresponding	Corresponding	The project was set aside and the Design Engineer was redeployed to work on another project. This adjusts the preferential, temporal and relational dynamics to maintain stability.
2	The Panda 2 product launch date has been set by Alpha for the end of August 2013 or mid-September 2013. Alpha want a quick product launch for the Panda 2 instrument. Not enough time to have the new solution CSA certified, yet maintaining CSA certification is mandatory for exporting the System	Peak has to decide if they can develop a solution and have it CSA certified.	Yes	Not Corresponding	Not Corresponding	Not Corresponding	(Refer Section 7.2.1.1 Episode 1)

3	Customer Requirements for the gas generator change.	To continue or not to continue new product development with this uncertainty?	No	Not Corresponding	Corresponding	Corresponding	Peak decide to keep the project going by updating customer requirements which aligns the preferential, temporal and relational dynamics to maintain stability.
4	Alpha want to increase the output flow rate of the Infinity 1031 generator.	Additional changes have to be made to the product design which would mean introducing a new product model	No	Not Corresponding	Corresponding	Corresponding	The Infinity 1031 generator was upgraded called Infinity 1035. This aligns the preferential, temporal and relational dynamics to maintain stability.
5	Alpha want to a single upgraded Alpha 3G system. This requires upgrading the current Alpha 3G generator, Alpha Table and Infinity 1031 generator and retain all the original names.	All the testing documents with test results previously handed over to Alpha have to be updated and no new generator model needs to be introduced	No	Not Corresponding	Corresponding	Corresponding	Documents for the planned upgrade were modified and sent across to Alpha This aligns the preferential, temporal and relational dynamics to maintain stability.
6	Alpha want further test results on the upgraded products and the generator. Alpha push the Panda 2 product	Peak was working to support Alpha for a September 2013 product launch and so had postponed product testing	No	Corresponding	Corresponding	Not Corresponding	The priority between product testing and product building is changed. Testing is brought forward which allows commercial discussions to begin. This aligns the preferential, temporal and

	launch to October 2013						relational dynamics to maintain stability.
7	Alpha reject price increase on the updated Alpha 3G System.	The upgraded product model is going to be more expensive to manufacture compared to the previous model because of all the new components which have been added.	Yes	Not Corresponding	Not Corresponding	Not Corresponding	(Refer Section 7.2.1.2 Episode 2)
8	Alpha have not been able to make changes to their regulatory paper work to support two different gas systems for their product range. Alpha want Peak to change the Infinity 1035 to Infinity 1031	Peak cannot change Infinity 1035 to Infinity 1031.The production processes cannot support two different products with same product name	Yes	Not Corresponding	Not Corresponding	Not Corresponding	(Refer Section 7.2.1.3 Episode 3)
9	Manufacturing Engineers now have to modify the production documents, work instructions for the three components and re-train the production technicians	All the production processes for the manufacture of the two Alpha 3G systems must be reset	No	Corresponding	Corresponding	Not Corresponding	The Manufacturing Engineers repeat the NPI process with the required changes to produce the System with the new chassis design. This aligns the preferential, temporal and relational dynamics to maintain stability.

7.2.2 Breakdowns in the Theta Corona Project

The Theta Corona project too had three major breakdown episodes. In what follows, I shall expand and elaborate on the dynamics between the three process complexes which led to these breakdowns. By concentrating on how these breakdowns were resolved, I explore how correspondence between the three process complexes re-establishes tensegrity.

7.2.2.1 Episode 1

In early July 2013, the design for Theta Corona based on the CMS-PSA technology platform was rejected as it was deemed very expensive. This results in a major breakdown. The impact of this episode on the three process complexes in summarised in Table 12 below.

Table 12: Impact of Episode 1 on the Process Complexes

Dynamics of Preferential Equivocality	Dynamics of Temporal Scaffolding	Dynamics of Relational Coherence
The goal was to design a product using the CMS-PSA technology platform. However, when this design was reviewed by the SMT, it was declared very expensive to manufacture. Thus the process of product cost preference altered which impacted the process of product technology preference.	The launch date for the Theta Corona which was set for end of July 2013 can no longer be met. The temporal scaffold has been breached.	The changes in technology and the breaching of the temporal scaffold disrupts the DDP and NPI processes. This destabilises the relational dynamics.

Applying the analytical framework, we can see that originally the preferential, temporal and the relational dynamics were all in sync or corresponding. Thus the project was provisionally stable. However, change in the process of product cost preference altered the process of product technology preference. This destabilised the dynamics of preferential equivocality. The destabilisation also breached the current temporal scaffold. The new technology platform could not be incorporated within the then temporal boundary.

Thus the correspondence between the dynamics of preferential equivocality and the dynamics of temporal scaffolding was severed. This instability within the two process complexes impacted the processes of procedural and cross functional coherence. These processes were organised to manufacture Theta Corona based on the CMS-PSA technology platform. Thus, correspondence between the three process complexes is disrupted which in turn triggers the breakdown.

In order to resolve this breakdown, Peak extended the temporal boundary by shifting the launch date of Theta Corona to January 2014. This stabilised the dynamics of temporal scaffolding. A NPD process was initiated to design a new generator from scratch based on the membrane technology. Also, a new target BOM cost was issued. These organising activities simultaneously stabilised both the dynamics of preferential equivocality and the dynamics of relational coherence. This in turn restored correspondence between the three process complexes. The tensegrity principle thus ensures that the dynamics of organising while innovating are stabilised.

7.2.2.2 Episode 2

In early September 2013, failures in the field of Peak generators, based on the T-Compressor architecture, stalled the Theta Corona Air project. The impact of this episode on the three process complexes in summarised in Table 13 below.

Table 13: Impact of Episode 2 on the Process Complexes

Dynamics of Preferential Equivocality	Dynamics of Temporal Scaffolding	Dynamics of Relational Coherence
A decision was taken to switch from the T compressor to the G compressor based architecture. The original Theta Corona Air design was based on the T-Compressor architecture.	Even though the temporal boundaries are not changed, the temporal priorities and temporal sequence within this project are changed. The priority is now to get the G-compressor architecture, designed and validated.	The G-Compressor is not CE certified and the Theta Corona Air requires CE certification. Also, the change in temporal priorities alters the procedural and cross functional coherence within the Theta Corona project.

Applying the analytical framework, the T-Compressor architecture was the locus around which correspondence between the preferential, temporal and relational dynamics was being accomplished. This locus shifted as news on the rise in the number of field product failures for Peak's compressor based systems began to trickle in. The decision to substitute compressor architectures created a new locus around which organising activities were yet to be configured. This resulted due to a severance in correspondence between the dynamics of preferential equivocality and the dynamics of relational coherence which in turn threatened the project stability. Further instability within the relational dynamic rippled through the process of temporal prioritising and temporal sequencing. Even though the temporal boundary remained unchanged, the unstable prioritising and sequencing processes destabilised the dynamics of temporal scaffolding. Cumulatively, these instabilities triggered a breakdown.

This breakdown was resolved by initiating a new sub-project dedicated exclusively to developing and validating the G-compressor architecture for Peak's compressor based solutions. Links were made between procedural coherence and cross functional coherence of this sub-project and Theta Corona Air. This stabilised the dynamics of relational coherence which in turn damped the dynamics of temporal scaffolding. It did so by stabilising the temporal priorities and the associated temporal sequence of organising and innovating activities. These actions when taken together restored correspondence between the preferential, relational and temporal dynamics. Stability was thus restored with the tensegrity principle ensuring that a dynamic equilibrium between the process complexes is re-established.

7.2.2.3 Episode 3

In late September 2013, the design for Theta Corona Nitrogen was rejected in the Detail Design Review because of concerns raised by the Global Product Service Training Manager and Manufacturing Engineering. Both departments felt that the current design for the Theta Corona Nitrogen makes the machine difficult to assemble on the Production line and service it in the field. This lead to a major breakdown in the Theta Corona project. The impact of this episode on the three process complexes is summarised in Table 14 below.

Table 14: Impact of Episode 3 on the Process Complexes

Dynamics of Preferential Equivocality	Dynamics of Temporal Scaffolding	Dynamics of Relational Coherence
This marks a change in the Product design preference. Serviceability and time to assemble the design became an evaluation criteria to judge the innovation.	The project was on a tight timeline owing to a prior redesign undertaken to incorporate the Membrane technology platform. Design modifications which had to be made stretches the product timeline.	The differences between the Design and Manufacturing Engineering Management (lack of cross-functional coherence) surfaced as the discussion turned to who was responsible for this oversight. Either additional resources or changes to the organising process are required to meet the product deadline.

Applying the analytical framework, here, instability was triggered by the process of cross functional coherence. Since Manufacturing Engineering were busy supporting Production with the changes to the compressor architecture discussed earlier, not enough time was devoted to analyse the manufacturability of the Theta Corona Nitrogen design. Manufacturing Engineers perceived Design Engineering as being responsible for the failure of the T-Compressor architecture which they were fixing. They were therefore reluctant to approve a design which they considered difficult to service.

Design Engineering, on the other hand were concerned about meeting the revised timelines for this redesigned product. They viewed this feedback from Manufacturing Engineering as an obstacle preventing them from completing their tasks. Taken together, differing temporal priorities led to lack of correspondence between the relational, preferential and temporal dynamics which disrupted project stability.

This breakdown was resolved after the Senior Managers from Design and Manufacturing Engineering stepped in and assuaged the concerns of engineers from both departments. This restored the cross-functional coherence which in turn readjusted the procedural coherence between the two departments. The design modifications would have to be made. The project was also 'fast-tracked' to meet the launch deadline. Readjusting the procedural coherence also dampened the dynamics of temporal scaffolding by realigning the processes of temporal prioritising and sequencing. These actions, considered in unison, restored correspondence between the three process complexes. Organisational stability was thus dynamically accomplished by the tensegrity principle.

In conclusion, in this sub-section, I have discussed three major breakdown episodes within the Theta Corona project. I've interpreted these breakdowns by applying the framework which emerged from the data analysis. This provides further evidence for the tensegrity model of organising while innovating. It also demonstrates how tensegrity is related to correspondence between the dynamic process complexes. The episodes reveal how disruptions to correspondence between process complexes precipitated breakdowns. The organising efforts which followed these breakdowns aimed to restore tensegrity by reconfiguring the process complexes to re-establish correspondence.

The episodes in Table 15 below, provide further evidence for the tensegrity principle within the Theta Corona project. These episodes highlight how appropriate and timely organisational responses to interruptions in correspondence, reconfigured the non-corresponding process complex to maintain correspondence relative to the other process complexes, thereby preventing project breakdowns. Failure to do so causes these interruptions to ripple across other co-responding process complexes, disrupting stability and triggering breakdowns.

Table 15: Correspondence and Process Breakdowns in the Theta Corona Project

SI No	Episodes	Organisational Challenge	Has Correspondence been disrupted? (Breakdown)	Dynamics of Preferential Equivocality?	Dynamics of Temporal Scaffolding?	Dynamics of Relational Coherence?	Organisational Response
1	The Design proposal submitted by the Design Engineer is rejected. The CMS-PSA technology platform which was chosen as the technology platform for designing the new generator was deemed very expensive.	A new product development project has to be initiated with a different technology platform. This would delay the target delivery date of the generator by approximately six months to mid-January 2014.	Yes	Not Corresponding	Not Corresponding	Not Corresponding	(Refer Section 7.2.2.1 Episode 1)
2	The size of the generator chassis is increased to match the size of the Theta's Analytical Equipment.	The product design work initiated by the Design Engineer has to be revised and fresh design / product modelling needs to be initiated.	No	Not Corresponding	Corresponding	Corresponding	The customer requirements were updated and the Designer was asked to modify the product design. This aligns the preferential, temporal and relational dynamics to maintain stability.

3	A rise in the number of field product failures for Peak's compressor based systems forces Peak to switch compressors within their compressor based product architecture	Organisational resources have to be diverted to supporting the compressor changeover. The new compressor design is going to be used for the Theta Corona Air which is the compressor based system being developed.	Yes	Not Corresponding	Not Corresponding	Not Corresponding	(Refer Section 7.2.2.2 Episode 2)
4	Theta confirm that they will place orders for Theta Corona Nitrogen in the beginning of January 2014. Pricing discussions are currently on with the Territory Manager USA. The Product Manager wants to plan the product launch with the Engineering and Production departments	Theta have indicated that they might order 45 units as soon as the new product is ready. Producing 45 units of a new generator model would be unprecedented at Peak. Production is designed to produce small batches of a new product and then ramp up production.	No	Corresponding	Corresponding	Not Corresponding	The Management decides that so long as the project sticks to the current timeline, production can be ramped up to meet customer requirements. This aligns the preferential, temporal and relational dynamics to maintain stability.

5	The design for the Theta Corona Nitrogen is rejected. The Design Engineer and the Manufacturing Engineer begin quibbling over who was responsible for the rejection of the design as this issue of 'serviceability' was not picked up in the Engineering Review which was held prior to this Detailed Design Review.	Design modifications have to be made which stretches the product timeline. The differences between the Design and Manufacturing Engineering Management surfaced as the discussion turned to who was responsible for this oversight.	Yes	Not Corresponding	Not Corresponding	Not Corresponding	(Refer Section 7.2.2.3 Episode 3)
6	Product Manager at Peak receives information from Peak Brazil and Peak China that the compressor based Theta Corona Air solution is more popular than the compressor less Theta Corona Nitrogen.	This information contradicts the current product development priorities although there has been no word from the Theta headquarters USA.	No	Corresponding	Not Corresponding	Corresponding	The information was not acted upon as it was yet to be officially confirmed by Theta. The project priorities remained the same. This aligns the preferential, temporal and relational dynamics to maintain stability.

7	On Theta Corona Nitrogen, a decision is taken by Engineering to run the NPI process managed by Manufacturing Engineering in parallel with prototype build and validation testing managed by Design Engineering	Manufacturing Processes must be designed for a product still in technical development	No	Corresponding	Corresponding	Not Corresponding	Both the Design Development Process and New Product Introduction Process which are normally run sequentially are now run in parallel by readjusting the processes of procedural coherence and temporal sequencing. This aligns the preferential, temporal and relational dynamics to maintain stability.
8	New requirements for an output flow of 10 litres per minute is requested by Theta for both the products.	The Theta Corona Nitrogen is in the product prototype stage and running the DDP in parallel with the NPI process means that changes would have to be made to both processes	No	Not Corresponding	Corresponding	Corresponding	Since the new design requirements owing to the previous redesign was flexible to updating, an update was undertaken and both the Design and Manufacturing Engineers were asked to make the modifications. The product launch date was shifted from January to February 2014. This aligns the preferential, temporal and relational dynamics to maintain stability.

9	Production technicians are not available for new product introduction of Theta Corona Nitrogen	The technicians are all busy meeting month end production deadlines to support a surge in Sales. This meant that the training for the technician product build would have to be postponed	No	Corresponding	Corresponding	Not Corresponding	The NPI was postponed to early February 2014 when the technicians were available. Thus the processes of cross-functional coherence and temporal sequencing were reconfigured. This aligns the preferential, temporal and relational dynamics to maintain stability.
10	The compressor service plans are changed from 6 months to an annual service plan.	The software design on the compressor control would have to be updated by the Design Engineer before it can be handed to Manufacturing Engineering.	No	Not Corresponding	Corresponding	Corresponding	The Design Engineer is tasked with modifying the program for the compressor based units. This required realigning the preferential, temporal and relational dynamics to maintain stability.
11	A software bug is discovered in the old program as it is being updated. This has to be fixed before it can be uploaded into the new Theta Corona Air	Most of the NPI work on the Theta Corona Air too is completed. Modifications to the program would require modifying the production processes and documents by the Manufacturing Engineers	No	Corresponding	Corresponding	Not Corresponding	The Design Engineering Manager takes over the new program redesign. Adding new resources reconfigured the process of cross functional coherence and shifting the temporal boundary altered the temporal scaffold. This re-established correspondence between the preferential, temporal and relational dynamics to maintain stability.

7.2.3 Summary

In this section I have demonstrated how episodes of breakdowns within both the Alpha Panda 2 and the Theta Corona projects can be explained through the concepts of correspondence in tensegrity. The study reveals that organising processes strive to sustain stability between various process complexes. This is accomplished by maintaining correspondence between these process complexes. Innovating on the other hand, interrupts correspondence between the process complexes. In the absence of commensurate organising effort to counter these interruptions, correspondence between the process complexes is disrupted, triggering breakdowns. Figure 50 below summarises the Tensegrity model of organising while innovating.

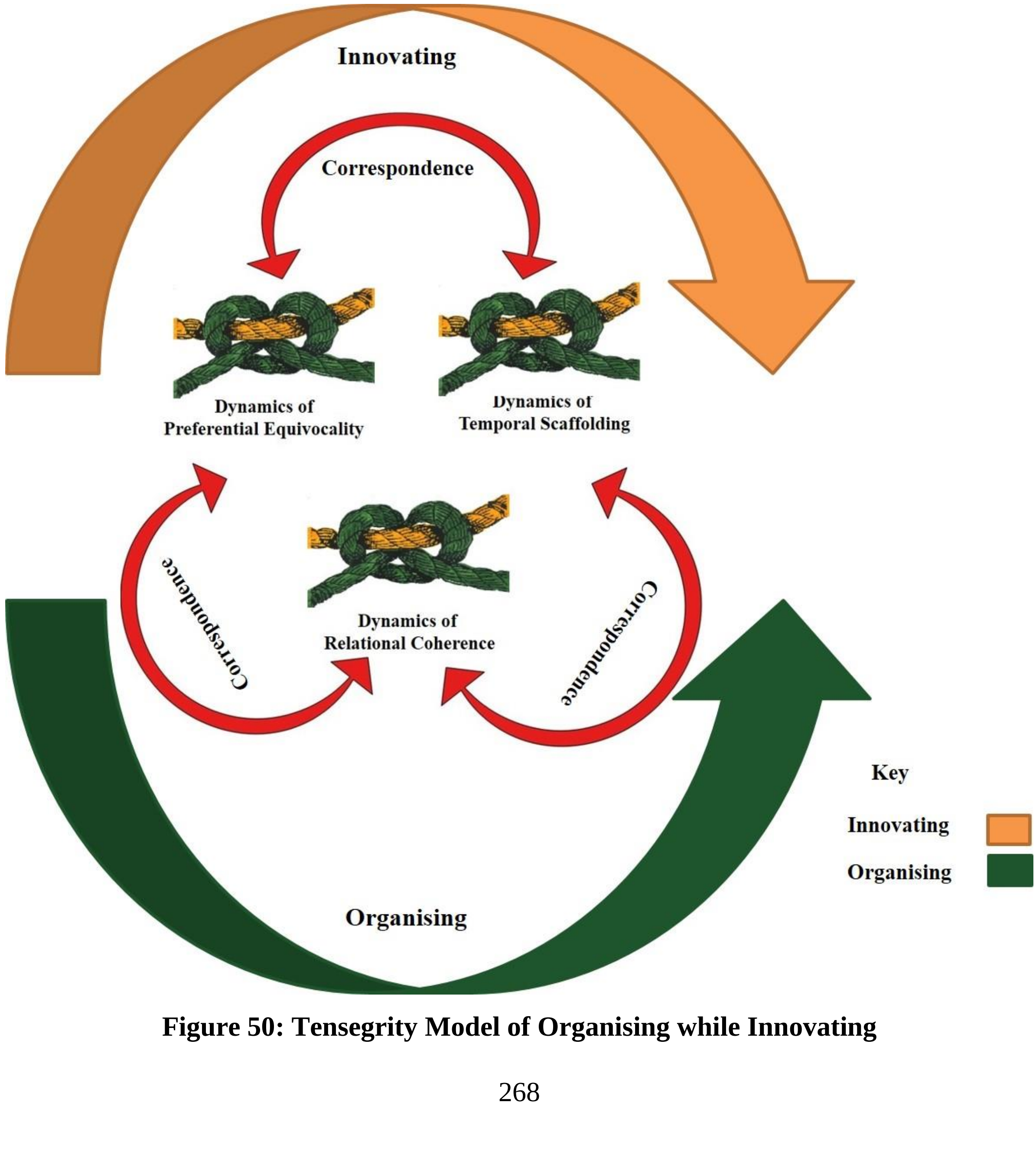

Figure 50: Tensegrity Model of Organising while Innovating

The tensegrity model of organising while innovating offers a 'processual' explanation for the dynamics of organising while innovating. Here each process is represented as a line. Consistent with the Ingoldian becoming perspective, organising and innovating (in green and orange respectively) processes are represented as bundles of open ended lines that embody movement, duration, creativity and purpose. The bundles are in turn made up of various entwined sub-processes that constitute each of the three process complexes.

For example, the bundle of organising and innovating lines that constitute the dynamics of preferential equivocality result from the entwining of lines representing the processes of product function, technology, target costing and design preferences, respectively. Likewise the bundle of organising and innovating lines that constitute the dynamics of temporal scaffolding result from the entwining of lines representing the processes of temporal boundaries, temporal prioritising and temporal sequencing, respectively. Finally the bundle of organising and innovating lines that constitute the dynamics of relational coherence result from the entwining of lines representing the processes of regulatory, procedural and cross functional coherences respectively.

Organising and innovating processes constitute three heterogeneous complexes called Dynamics of Preferential Equivocality, Dynamics of Temporal Scaffolding and Dynamics of Relational Coherence which are distinct yet entwined. The teleology or purpose embodied within organising processes allows them to temporarily stabilise innovating processes by binding them in knots as shown in Figure 50. For example, in the Alpha Panda 2 project when innovating threatened to disrupt the process of regulatory coherence, all organising was focussed towards stabilising the dynamics of relational coherence. This involved organising stabilising various innovating process dynamics by binding them in knots. This ongoing knotting and binding between various lines that constitute the three organising and innovating process complexes results in a *meshwork of interwoven lines with knots*.

Each process complex therefore is a meshwork of lines with knots rather than a network of points with nodes. This distinction underwrites the difference between a 'processual' and 'substantialist' worldview. Lines represent dynamic processes whereas points represent static entities. Interwoven lines of the meshwork *correspond alongly* as they unfold thereby shaping one another. Points can only *interact laterally* which reduces change to a series of static states. Correspondence between process complexes is an ongoing accomplishment achieved by organising processes that attempt to stabilise the various process complexes. This in turn regulates organising while innovating. Innovating processes interrupt correspondence between the three process complexes to trigger organising. Stability while innovating is thus regulated by the tensegrity principle which attempts to configure organising and innovating processes in a countervailing manner.

Thus, tensegrity of organising and innovating processes rather than 'plasticity' (Lok & De Rond, 2013, p. 205) of institutional structures, is responsible for the maintenance of stability. Within a substantialist worldview, organisational stability is attributed to the degree of "plasticity" of an institutional script. It is this plasticity that determines the extent to which an institutional structure can be stretched to accommodate an ever-changing practice performance (Lok & De Rond, 2013). Stability therefore depends on the extent to which these scripts can resist change. Tensegrity on the other hand relies on movement and dynamics for maintaining stability. It is therefore rooted in a processual worldview which celebrates the fluxing, flowing and transient nature of lived experience.

Breakdowns in the tensegrity model occur when organising cannot readily configure processes in a countervailing manner to sustain stability. Crucially, breakdowns suggest a *disruption in correspondence* between the process complexes rather than *absence* of any process complex. Therefore repairing breakdowns in the innovation journey involves restoring stability by re-establishing correspondence between the various process complexes. All of these seem to suggest that while innovating and organising have been treated as two separate processes, they appear to be not so much categorically different as transforms of one another. Innovating has a way of turning into organising and vice versa.

In sum, the dynamics of organising while innovating are continuously stabilised using the tensegrity principle. Movement, duration, creativity and purpose are all integral to this model. Tensegrity configures the dynamics of preferential equivocality, temporal scaffolding and relational coherence to counterbalance one another as they unfold alongly while innovating. This creates a transient stability which enables innovating to continue. Tensegrity allows the process complexes to absorb the shocks generated by innovating. Absence of stability, it was seen, led to breakdowns in the innovation journeys. Progress then depended on the ability of organising processes to restore stability. The tensegrity model of organising while innovating, thus, provides us with a clearer understanding of how innovations are forged into existence within the crucible of organising processes.

7.3 Reflecting on Theory and Practice

By conducting two real time longitudinal field studies on innovating, I have identified and described three process complexes and their co-ordination principle which illustrates the dynamics of organising while innovating. By doing so I have shown how an organisation is able to repeatedly sustain stability that enables innovating, and yet deal productively with the change dynamics which unfold while innovating. The tensegrity model of organising while innovating builds a 'processual' theory on how and why organisations coordinate their activities in order to innovate. It challenges assumptions grounded within a 'substantialist' ontology which considers stability as antithetical to change by demonstrating how the two dynamically complement each other to facilitate innovating. In the remainder of this section, I focus on the implications of the Dynamics of Preferential Equivocality, Dynamics of Temporal Scaffolding and Dynamics of Relational Coherence for theory and practice. I conclude by highlighting the theoretical and practical implications of the Tensegrity Model of Organising while Innovating.

7.3.1 Dynamics of Preferential Equivocality

To state that the innovating process by nature is uncertain and ambiguous is no major revelation. Research into such complexities and uncertainties has been the mainstay of innovation research and many scholars, to this effect, have weighed in on these features (March, 1991; March, 1999; Van de Ven, et al., 1999; Tidd, 2001; Gupta, et al., 2007; Garud, et al., 2013). One of the most explicit distinctions between the meaning of uncertainty and ambiguity can be found in a study on internal corporate venturing by Garud and Van De Ven (1992). For them, uncertainty implies "imperfect knowledge about the causal relationships between means and end", while ambiguity refers to the dilemma of "which ends are worth pursuing" (p. 93). Since the distinction is couched in terms of ends, the underlying premise is that 'preference' or 'expectation' about these ends is given exogenously prior to and independent of the innovating process. Put differently, innovating here is the means of directing an uncertain preference towards ambiguous ends.

Yet, this notion is not one that readily admits itself to *innovating-in-practice*. Empirical evidence from these field studies is replete with examples of unstable preferences which evolve along with the innovating process, even though these innovations were merely incremental. Evolving preferences implies that innovating embodies generative dynamics. Explicating these dynamics requires us to pay careful attention to the social and historical contexts within which actions unfold. March (2008) puts it well when he writes "If actions depend on expectations and preferences, then we need to ask where the expectations and preferences came from. If action depends on matching rules to situations, then we need to ask how the matches are defined and interpreted." (p. 48). Preferences or expectations influencing actions while innovating, rather than being assumed, must be demonstrated. This means showing how people shape their preferences through histories of continuing involvement with human and non-human constituents while innovating.

A richer interpretation of action is possible only if we can understand and account for the evolution of preferences and expectations whilst innovating. Therefore assuming an unchanging preference is to undermine the role of the 'historical, social and interpretive contexts' (March, 2008, p. 37) within which innovations are forged. Indeed, such an assumption, as Ingold (2014) puts it, "implies a certainty about ends and means that, in practice, is largely an illusion". Weick (1995) in fact alludes to this when he urges researchers to demonstrate the construction of meaning or purpose in contexts that are often vague and confusing. It is for this reason that I've chosen to call 'preferences', which reflect *purpose* in the Ingoldian becoming perspective, as equivocal. Not uncertain or ambiguous. An equivoque, consistent with the notion of process as lines, "is a pun, a term with at least two meanings, *two disparate strings of thought tied together by an acoustic knot*[7]" (Weick, 1979, p. 174 my emphasis). According to Weick (1979),

> "Equivoques are indeterminate, inscrutable, ambivalent, questionable, and they permit multiple meanings. It is important to realise that an input is not equivocal because it is devoid of meaning or has confused meaning (both of these connotations associated with the words ambiguity and

[7] Weick was citing Koestler (1978) who made this original point.

> uncertainty). Instead, equivocal inputs have multiple significations. They are difficult to classify and manage precisely because they fit numerous classifications and might be indications of any of several states of the world" (p. 174).

Nor is equivocality the same as noise, an important concept in systems thinking. The distinction is that when for a known input one cannot predict what the output will be, noise is assumed to be present. "The problem of equivocality", as Weick (1979) argues, "is that, given an output, the receiver cannot decide, what input generated it. Two or more possible inputs are implied in that single output message, and the recipient faces the question of which of those possible meanings are the appropriate ones" (p. 180). Thus the notion of equivocality rather than uncertainty or ambiguity, is more appropriate to describe the preferential dynamics of innovating.

My findings reinforce studies that suggest neither the nature nor trajectory of innovating is obvious ex ante. Preference or expectation, which is widely assumed to be given prior to innovating, is in practice emergent from the very processes which it drives. Both field studies reveal how the process of preferential equivocality is not just exhibited but is also exploited and expanded. Examples here show how preferences involving function, cost, technology and design emerged as their respective process threads entwined alongly as innovating unfolded. The Dynamics of Preferential Equivocality also highlight how purpose, despite or perhaps because it was evolving, binds organising to the innovating process. It bends innovating to enable the generation and forging of a creative product. Harrison and Rouse (2014) have alluded to a similar dynamic in their theory of elastic co-ordination which enables creative work. Yet unlike their assumption, here, creativity inheres in the *process of realisation* rather than in any *pre-determined plan*. This explains why innovators generate multiple options through continual prototyping. The creative process of prototyping allows innovators to damp preferential dynamics by incorporating different preferential dimensions "ranging from performance to aesthetics to cost" (Garud, et al., 2013, p. 795).

Equivocality also means that confused and unstable preferences are the norm rather than the exception while innovating (Tsoukas & Dooley, 2011). This calls into question, the role of decision making processes which guide organising while innovating. While theories grounded in bounded rationality (Cyert & March, 1992/1963) can account for risks associated with certain decisions, it cannot provide guideline to managers negotiating 'equivocal' preferential dynamics. This is because "risk implies that the decision maker knows the possible outcomes associated with a decision and their probability, whereas uncertainty implies that the decision maker does not know the possible outcomes associated with a decision nor their probability" (Alvarez, et al., 2013, p. 311). Understanding organising and innovating as unbounded, socio-technical processes requires deeper understanding of *how managers bind their rationality* in equivocal contexts. Chia (1996) has described such a decision making process as "incisions into the flow of reality". Exploring such decision making processes can therefore be a fertile area for additional research.

These observations on decision making also raise questions for organisational learning and the knowledge creation process. While acts of organising attempt to enact preferential stability, these acts are delimited by the existing state of knowledge. Innovating, on the other hand creates new knowledge (Nonaka & Takeuchi, 1995) which in turn shapes preferences. By corresponding, innovating conditions the organising process to accommodate this new knowledge. Such knowledge is generated from activities like customer feedback, design reviews or embodied within the product design itself. Prior research on innovation has speculated that organisational memory, developed by learning from the experiences of innovating, plays a key role in sustaining the process of innovating (Bartel & Garud, 2009). Therefore focussing on the learning processes which allow innovators to successfully cope with and adapt to the newly generated knowledge becomes another area requiring additional research.

In sum, the Dynamics of Preferential Equivocality and evolution of preference as innovating unfolds, despite both innovations being incremental (Henderson & Clark, 1990), suggests that preferential equivocality must be understood as emergent "properties of an interacting ecology" (March, 1994, p. ix) of processes which alongly unfold while innovating. The dynamic both shapes and is shaped while innovating. Acts of organisng are attempts directed towards the establishment of a workable level of certainty required for innovating. Organising therefore embodies teleology or purpose. Innovating, on the other hand, triggers organising by increasing preferential equivocality. It does so by generating new knowledge which can shape preferences. This in turn, widens the range of possibilities which organising must stabilise on an ongoing basis. Innovation as becoming, therefore, requires us to treat 'preferences' as an emergent and dynamic property of innovating and not as something that is given in advance, awaiting execution.

7.3.2 Dynamics of Temporal Scaffolding

Bateson, (1979) once remarked, "if '[t]he if…then' of causality contains time then how can the 'if… then of logic' be timeless?" (p. 63). Within innovation research, it is the process perspective (Garud, et al., 2013) which most explicitly acknowledges the temporal complexities confronting innovation managers. Despite calls for adopting a temporal perspective on innovating, identifying and demonstrating how organising is made spatial '*in time'* and how that spatiality is shaped with the passing of time (Hernes, 2014, p. 76) has till now remained elusive (Garud, et al., 2014; Garud & Gehman, 2012). The irony of this oversight is succinctly summed up by theoretical physicist Lee Smolin (2013) who writes "We act inside time but judge our actions by timeless standards." (p. xiii). Prior research has acknowledged the 'temporal complexities' (Garud, et al., 2011) involved while sustaining the process of innovating. Yet insights into "how timing and temporal experiences shape entrepreneurial innovations" (Garud, et al., 2014, p. 1185) remain underdeveloped. The dynamics of temporal scaffolding is aimed at addressing this lacuna.

Temporal scaffolding refers to the shaping of organisational spatiality with the passing of time. Previous scholars, notably Orlikowski and Yates (2002) have used the term "temporal structuring", to explain how actors produce and reproduce a variety of temporal structures which in turn shape the temporal rhythm and form of their ongoing practices. After careful consideration, I've opted for the notion of scaffolding rather than structuring. Structuring is laden with a process / structure duality which for me does not adequately convey the eternal infirmities and precarious stability of the enacted temporal frame. Scaffolds, on the other hand evoke a sense of impermanence. They capture the delicate temporal stability enacted and maintained while innovating. Organisational actors derive meaning by enacting temporal scaffolds which they constantly carve out an initially undifferentiated temporal flux. The dynamics of temporal scaffolding address temporal complexity in four salient ways.

First, by adopting a Bergsonian, rather than a Newtonian perspective on temporality, the dynamics of temporal scaffolding are able to explicate the temporal dynamics of organising while innovating in *durational* rather than synchronic or diachronic terms. This is because a chronological perspective regards time as abstract, homogeneous, and transcendent whereas from a durational perspective time is perceived as concrete and immanent within becoming.

Past research, notably the narrative perspective on innovation (Garud, et al., 2014), has identified the need to move beyond the "asynchronies and diachronies associated with innovation" (Garud, et al., 2013, p. 802) to explore *durational* (Garud & Gehman, 2012) facets of temporal co-ordination while innovating. My findings identify the processes of temporal boundaries, temporal prioritising and temporal sequencing as resources used by innovators to achieve temporal co-ordination. Temporal scaffolding, then becomes the *durational mechanism* through which these processes are configured while innovating to achieve temporal co-ordination.

Second, the troika of temporal processes along with their durational mechanism, goes beyond simple chronological conceptions of time (Van de Ven, et al., 1999; Brown & Eisenhardt, 1997). It does so by capturing the uncertainty and urgencies of organising by embracing "a phenomenological sense of time as individuals simultaneously attend to the past, present, and future" (Bartel & Garud, 2009, p. 108) while innovating. Dynamics of temporal scaffolding demonstrate how organising achieves or fails to achieve "links in time" (Brown & Eisenhardt, 1997, p. 25) to prevent or precipitate the snowballing of unattended problems into "vicious cycles" (Van de Ven, et al., 1999, p. 24). The dynamics of temporal scaffolding has expanded and elaborated on how these challenges are experienced and overcome while innovating within both, the Alpha Panda 2 and the Theta Corona projects.

Previous research has highlighted how inadequate temporal co-ordination while innovating leads to "performance problems such as slipping schedules, budget overruns, missed specifications, firefighting and scope creep" (Van Oorschot, et al., 2013, p. 285). Since all innovation projects are guided by connecting ideas developed in a temporal sequence, lack of temporal co-ordination can result in projects sliding down the slippery temporal slope. Slipping schedules were observed repeatedly in both the Alpha Panda 2 and the Theta Corona projects. Adjusting the temporal scaffold by extending timelines or altering the development priorities and sequence, became the preferred way for dealing with the persistently widening gap between the original and actual project timeline. Doing so allowed problems to temporarily disappear from the managerial agenda.

Third, the entwined processes of temporal boundaries, temporal prioritising and temporal sequencing, which constitutes the temporal scaffold, highlights the intertwining of the past, present and future (Hernes, et al., 2013) while innovating. Temporal boundaries illustrate the active role played by innovators in shaping temporal flexibility by “determining what portions of the past they would like to mobilize in support of their imagined futures” (Garud, et al., 2010, p. 763) while innovating. Temporal prioritising highlights the changing interpretations of past activities and future expectations by various actors as the innovating journey unfolds. Temporal sequencing highlights how the emergent dynamics while innovating allow actors to create new connections to the past and sequence it to newly imagined futures.

Temporal boundaries regulate how temporal complexities are experienced while innovating. In the absence of temporal boundaries, unregulated temporal complexities could lead to neglect of the organizational infrastructure required in order to maintain continued and timely new-product development (Burgelman & Valikangas, 2005). Also, temporal sequencing alone might not always facilitate the temporary decentralization followed by reintegration (Siggelkow & Levinthal, 2003, p. 665) required for effective innovation. Such decisions must be taken only after considering temporal sequencing in unison with temporal boundaries and priorities. All of this suggests that stabilising the temporal dynamics involves active temporal work (Kaplan & Orlikowski, 2013). Temporal work, here refers to, how organisational actors caught in “the flow of time” (Hernes, 2014, p. 3) maintain coherence between an equivocal past, challenging present and indeterminate future. Furthermore, the links between temporal work and temporal slack within the temporal scaffold is interesting to investigate further (Van Oorschot, et al., 2013, p. 304). Adopting a durational perspective, future research should investigate, in greater depth, other ways in which temporal work can sustain temporal scaffolds.

Fourth, the endogenised notions of time within the dynamics of temporal scaffolding have implications for the discovery versus creation perspectives on innovation. They further reconcile these perspectives by acknowledging, that “….no new idea emerges full blown and ready for implementation. It requires time and effort to take any idea from conception to reality, and the process is never linear. There are false starts and dead ends, ups and downs, and ‘backing and forthing’ ” (Garud & Giuliani, 2013, p. 158) as the innovation journey unfolds. The journey as well as routines such as the DDP and NPI processes within the journey, does have recognisable phrases. These phases could include “emergence, development, implementation, and diffusion” which constitute a cycle (Van de Ven & Sun, 2011, p. 69) or ‘design inputs, design proposal, concept, detail design and validation’ which constitute a routine. These phases do lend a certain temporal shape to the overall movement. Yet these phases or ‘temporal milestones’ (Gersick, 1991, p. 25), like ‘initiates in a rite of passage’

(Ingold, 1986, p. 158), are nothing but by products of a substantialist ontology. By invoking Newtonian time, it divides the lived experience of innovating from innovating as thought about by the intellect.

In conclusion, dynamics of temporal scaffolding are an effort to provisionally stabilise temporal complexity extracted from the past, into plausible temporal frames in the present, from which actors can extract cues to guide their ongoing/future actions. Organising activities enacted temporal scaffolds whereas innovating breached the scaffolds to trigger organising. The temporal complexities are regulated by scaffolding activities such as time horizons, timeframes, timelines, deadlines, priorities, workloads and sequence, all of which unfold *in time*. The dynamics of temporal scaffolding, reveals how the "ways in which people understand their own relationship to the past, future, and present *make a difference* to their actions; changing conceptions of agentic possibility in relation to structural contexts profoundly influence how actors in different periods and places see their worlds as more or less responsive to human imagination, purpose and effort" (Emirbayer & Mische, 1998, pp. 973, emphasis in original).

7.3.3 Dynamics of Relational Coherence

Co-ordination is central if organisations have to successfully innovate. This relational challenge has previously been framed as "the structural problem of managing part-whole relationships" (Van de Ven, 1986, p. 591) while innovating. Articulated in structural terms, the relational facet focuses on how '*translation*' (Garud & Gehman, 2012, p. 980) as a mechanism constitutes agency "through existing and anticipated relationships across social and material elements" (Garud, et al., 2014, p. 1181). This reveals the underlying substantialist conception of organisations as entities or substrates awaiting the imprint of translatory activities that may be conducted upon it. This substantialist perspective frames the challenge of maintaining relational coherence in terms of negotiating coherence between '*assemblages*' (Garud & Gehman, 2012, p. 984) of 'agent-networks'.

Innovation research has offered several templates to connect different parts of an organization to the larger whole so as to bring new ideas to life. But such assemblages of agent-networks, as I have shown in the conceptual framework, is constituted by joined up lines which connect distributed nodal entities to form networks. In the 'processual' framework, by contrast, organisations are process complexes constituted by a meshwork of interwoven lines. Here, organisations are no longer substrates awaiting imprinting activities but are themselves a congelation of past activities. Put differently, organisations are also known as *firms* because they result from a 'firming' up of organising processes. These organising processes furnish innovators with all the lineaments of personal and social identity, providing each with a specific role and a specific responsibility.

Therefore, innovators perceive an organisation, not as a bounded entity but a zone in which their several pathways, constituted by organising processes, are thoroughly entangled (Ingold, 2007, p. 103; Hernes, 2008). These pathways with their varied functions of connecting and reinforcing reveal the underlying fragility and impermanence of organising processes. “Less of a stable object”, to paraphrase Cooper (2005), “the organisation has to create its daily appearance out of the continuous threat of its disappearance” (p. 1692). Enmeshed within this fragility, innovating threaten these organising processes by creating new dependencies. The new dependencies come largely from the in-situ solutions that innovators improvise in the face of emerging constraints (Emirbayer, 1997, p. 292). Progress is therefore contingent on ensuring coherence between the emerging relational dependencies of organising processes. It is this changing patterns of dependencies between various organising processes as innovating unfolds that I’ve called the dynamics of relational coherence.

Three dynamic sub-processes were seen to constitute the dynamics of relational coherence. Of these the least flexible process was the process of regulatory coherence. Here the regulatory compliance process was laid out by industry regulatory authorities like CSA and CE. The impact of regulatory coherence on organising and innovating was experienced within both projects at Peak. Previous innovation research has identified how the trajectory of a technology’s development could be shaped by the beliefs regulators hold about “the efficacy of specific policy instruments” (Garud & Karnoe, 2003, p. 280). Standard setting bodies, by facilitating multiple connections among firms while setting industry-wide standards, are seen as crucial for knowledge capabilities while innovating for innovation (Dougherty & Dunne, 2011, p. 1217).

Yet, research on how the evolution of competing technology standards, notably for the Blu-Ray versus HD-DVD, USB versus Firewire, and WiFi versus HomeRF technologies, also reveals how standards can constraint actions while innovating (van den Ende, et al., 2012, p.

730). These contradictory findings, which pit social action against social constraints, suggest the need for further research using the 'processual' framework. More insight into how firms co-shape the process of regulatory coherence rather than passively adhere to them is an area ripe for future research.

The process of procedural coherence has direct implications for the theory and practice of routines within innovation research. The findings suggest that management must try and keep routines as flexible as possible to sustain co-ordination while innovating. Decentralising control to those enacting the routines is one strategy which might enhance routine flexibility. The role of senior management then, would be to *steer* the emergent routine dynamics towards project goals *rather than prescribe* its execution at the outset. The variability within the DDP and NPI processes also calls into question the current conceptualisation of the 'ostensive-performative' duality within routines literature (Pentland & Feldman, 2005; Pentland, et al., 2012).

Such a conceptualisation is possible only because routines have been de-temporalised (Obstfeld, 2012). Only by removing the experience of time from routine-in-action can routines to be divided along relatively fixed and mostly variable components known as ostensive and performative respectively. In practice, this division is largely illusionary. Routines dynamics are impossible to understand without accounting for the role of duration and purpose while it is being enacted. This observation opens up new and exciting opportunities for theorising routines from a holistic rather than the current dualistic perspective, using the Ingoldian becoming perspective developed here.

Cross functional coherence has been identified as a key ingredient for successful product innovation (Marion, et al., 2012; Marion, et al., 2014). The process of cross-functional coherence had important implications within the two innovation projects. We see that organisational structure rather than being imposed was in fact emerging from the various organising processes. These processes not only regulated the internal innovation dynamics evident during price negotiations within both the projects, but also resulted in restructuring the strategic management team at Peak.

Cross functional coherence, therefore, results from a sedimentation of organising and innovating processes rather than a joining together of structured parts to constitute the whole

(Van de Ven, 1986). This means that research should shift focus from the structure of innovation teams to process which result in these observed structures. Future research could investigate the organising processes deployed to create and sustain effective cross functional collaborative structures (Marion, et al., 2014).

In sum, we have seen how innovating is carried out within a continually unfolding field of relationships which I've called the Dynamics of relational coherence. 'Relationality', here is aligned to Cooper's (2005) 'processual' notion where "an entity is not just an entity and where movement is not just movement, but where entity and movement form a unity" (Bakken & Hernes, 2006, p. 1604). Put differently, *what* an innovation is inseparable from *how* it is realised and how it is realised is always intertwined with the practical activity in which the innovators are currently engaged (Ingold, 2000, p. 260). Both, the Alpha Panda 2 and the Theta Corona projects emerged from a series of relational dynamics involving regulatory, procedural and cross-functional processes, all of which found new affinities within a "kaleidoscope of historical elements" (Trilling, 1976, p. 184). In this sense, innovations "*are their relations*" (Ingold, 2011, p. 70 my emphasis). Relations, here, refer not to connection between pre-determined entities but to a meshwork constituted by the totality of innovating and organising processes.

7.3.4 Tensegrity as a way of becoming

Prior research on innovation has identified the need for 'integrity' (Dougherty, 2008, p. 419) to sustain innovating. The tensegrity model of organising while innovating demonstrates how tensional integrity is maintained to sustain innovating. It does so by continuously configuring the dynamic process complexes in a countervailing manner to maintain organisational stability. The tensegrity model also fits Brown and Eisenhardt's (1997) notion of 'semi-structure' referring to the limited structure which "provides the overarching framework without which there are too many degrees of freedom" (p. 16), required while innovating. In doing so, it responds to calls for reimagining 'organizing to incorporate sustained product innovation in complex organizations' (Dougherty, 2001, p. 628).

By demonstrating how innovations are managed in real time, the tensegrity model shows how managers, by focusing on process rather than content, "establish and modify the direction and the boundaries within which improvised, self-organized solutions can evolve" (Dougherty

& Dunne, 2011, p. 1218). They steer the emergent dynamics, observe outcomes, and configure the dynamic process complexes by altering the constraints. This might result in certain impediments which could cause future breakdowns to be unintentionally but repeatedly shifted. Managers in a bid to restore tensegrity in the short-term, might resort to symptomatic fixes of problems rather than working out comprehensive solutions. Breakdowns within both the projects reported here resulted from short term fixes which restored stability in the short run but increased the likelihood of breakdowns in the longer run.

The tensegrity model also offers a dynamic perspective on organizational persistence by identifying the generative processes and configuring principle which sustains innovating. Organisation process theories, till date, have devoted very little attention to self-reinforcing mechanisms which drive organizational dynamics. The tensegrity model addresses this gap by moving beyond well-known concepts like structural inertia, imprinting and institutionalization by demonstrating the "logic of the very process producing organizational persistence" (Schreyögg & Sydow, 2011, p. 322) despite movement, flux and dynamics. To conclude, the tensegrity model offers an alternative 'processual' theory which reconciles movement, duration, creativity and purpose into a unified framework to explain the dynamics of organising while innovating.

7.3.5 Summary

In this section, I have analysed the theoretical and practical implications of the three process complexes which constitute the tensegrity model of organising while innovating. The tensegrity principle ensures that process complexes by corresponding with one another attains a dynamic equilibrium. Sustaining stability while innovating involves effortful, creative and continuous organising. The theory thus provides an alternative perspective to current innovation process theories which are rooted in a substantialist ontology and a process epistemology. It does so by inverting the ontological priorities between stability and change. Organising and innovating here are emergent properties of processes which embody movement, duration, creativity and purpose.

7.4 Conclusion

This chapter began with a puzzle. If innovation entails persistent change then how is stability being maintained while innovating? Tensegrity, a principle where dynamic stability is maintained through the continuous configuration of tension and compression in a countervailing manner, answers this puzzle. Crucially, tensegrity is also ubiquitous in nature and vital to the life process. I've applied the tensegrity principle analogically to demonstrate how the dynamics of preferential equivocality, temporal scaffolding and relational coherence correspond to create stability which sustains organising while innovating. Within this tensegrity model, it is the pre-stress resulting from knotted process complexes rather than plasticity of institutional structures that sustains stability. Stability was disrupted when correspondence between the three process complexes was severed, leading to breakdowns. Organising then had to restore correspondence between the process complexes to reinstate stability.

Finally, I have reflected on the findings from the tensegrity model of organising while innovating with management theory and practice. Some of the observations are consistent with the extant literature on innovation – for instance, the equivocal nature of the process of innovating, the need to temporalise complexity, the need to maintain flexible organising routines or the need to foster cross functional collaboration. Specifically, I theorise that the dynamics of organising while innovating are better understood as a meshwork of interwoven processes which embody movement, duration, creativity and purpose. These dynamics are regulated by the tensegrity principle. Taken together, the tensegrity model of organising while innovating combines a process ontology with a process epistemology to create a 'processual' theory on how to organise while innovating.

8 Conclusion

For the seeker the journey will never end

Though he may delude himself at every bend

Ghulam Rabbani Taban[8]

8.0 Introduction

This journey began with a simple question: "How do we organise while innovating?" Given the importance of innovations for organisational survival and societal prosperity, answering this question is of paramount importance. The quest for an answer began with a review of the innovation literature. Within this vast, impressive and still growing body of scholarship, I had hoped to gather clues which would aid my search. The review revealed two divergent theoretical paths, one where innovations were regarded as outputs and the other where innovation was considered a process. Of these, because of its explicit concern with the dynamics of organising and innovating, I took the more promising and less travelled 'innovation as process' path. However, my journey was interrupted when I ran into four distinct theoretical puzzles which pitted persistence against change, synchrony against diachrony, necessity against chance and structural determinism against agentic free will. These puzzles had until now obstructed the conceptual and empirical development of the 'innovation as process' perspective (Garud, et al., 2013).

By addressing these puzzles, this thesis extends the 'innovation as process' perspective in four specific ways. First, by identifying the theoretical puzzles and tracing their origins to their substantialist underpinnings, I have added clarity which can aid the theoretical development of the process of innovating. Second, I've introduced and integrated an alternate Ingoldian perspective which reformulates organising and innovating along 'processual' lines. This perspective offers the conceptual depth required to further the 'processual' paradigm within other areas of management research and scholarship. Third, I've also developed and deployed

[8] The original couplet was titled 'Safar' which means 'Journey' in Urdu and Hindusthani. Translated by Kushwanth Singh and Kamna Prasad.

a theory of method, sympathetic to process onto-epistemology, which integrates the practical task of gathering and analysing empirical data. This methodology offers guidance to future researchers interested in extending the processual paradigm within other streams of management research. Finally, the *Tensegrity model of organising while innovating* provides the first clear prototypical process for the management of innovation. In other words, we now have an answer to the original question, “How do we organise while innovating?”

The remainder of this chapter is organised as follows. First, I begin by summarising the contributions of this thesis towards organisation theory in general and innovation theory in particular. Here, I outline the contribution of my thesis and spell out the key implications of my findings for practitioners entrusted with the challenge of executing innovations within their organisational contexts. The next section highlights the limitations of this study by offering some suggestions and directions for future research. Finally, I conclude with a brief summary of key insights which emerged from this study on organising while innovating.

8.1 Contributions towards Theory and Practice

The advent of the process movement within management research, had led theorists to wonder about the form “knowledge eventually take if organizational scholars were able to create valid scientific theories of dynamic processes in human organizations?” (Monge, 1990, p. 409) However, till date the ‘innovation as process’ perspective remains under developed (Crossan & Apaydin, 2010, p. 1167; Garud, et al., 2013). The central contribution of this thesis has been to strengthen the ‘innovation as process’ perspective, conceptually, theoretically, methodologically, empirically and practically by developing an alternative ‘processual’ theory on organising while innovating. The *Tensegrity model of organising while innovating*, responds to long standing calls from previous scholars who have asked researchers to identify and specify the processes and mechanisms which guide organising while innovating (Gupta, et al., 2007; Dougherty & Dunne, 2011; Garud, et al., 2014). In the sections which follow, I shall specify and expand on various facets of the central contribution of this thesis.

8.1.1 Conceptual Contributions

In this thesis I make a contribution towards the conceptual development of process research by extending the 'organisational becoming' perspective (Chia, 1997; Chia, 1999; Tsoukas & Chia, 2002; Chia & MacKay, 2007; Hernes, 2014; Hernes, 2008) within management research. I do so by deconstructing various current conceptualisations of 'process' which previous theorists, notably Pettigrew (2012; 1990), Burgelman (2011; 1996; 1991) and Van de Ven and Poole (1990; 2010; 2000) to name a few, have used to formulate organisational dynamics. The deconstruction reveals the fundamental tensions inherent within these various perspectives. I have also traced the origins of these tensions to their 'substantialist' ontological underpinnings. This exercise highlights the stark contrast between 'process' theories rooted within a substantialist ontology but process epistemology, and 'processual' theories which emanate from a process onto-epistemology.

While the process epistemology is now widely recognised within management research, its success in explicating organisational dynamics has been much more muted. Process ontology in contrast, despite its potential, continues to remain underdeveloped within management research. As recently as 2013, according to Hernes, Simpson and Soderlund (2013), "process approaches continue to be seen as ''just entering'' the field" (p. 1). By weaving together various insights from Ingold's oeuvre, in this thesis I have introduced an alternate 'processual' perspective which allows us to rebuild our process theories from a process onto-epistemology. This re-conceptualization, where processes are seen as unfolding along lines embodying movement, duration, creativity and purpose, has the potential to accelerate 'processual' research within management. Emanating from an 'anti-dualist ontology' (Tsoukas & Dooley, 2011, p. 732), it equips theorists to better formulate organisational dynamics by preserving the inherent complexity within the phenomena. By doing so, it extends the *organisational becoming* perspective within management research.

To conclude, conceptually, this thesis offers two significant contributions. One, it offers a comprehensive critique of the 'substantialist' position within current process theories, especially those related to innovation. Two, it introduces an alternate Ingoldian 'becoming' perspective which reformulates process as unfolding along lines that embody movement, duration, creativity and purpose. Additionally, the concepts of correspondence and meshwork which are introduced here provide us with the conceptual suppleness required to formulate the dynamics of organising and innovating from a becoming perspective.

8.1.2 Theoretical Contributions

The fundamental theoretical contribution of this thesis is the *Tensegrity model of organising while innovating*. I am not aware of past studies which have investigated 'organisational becoming' by juxtaposing organising and innovating processes as they unfold over time. By doing so, in this thesis I have delineated and developed three dynamic process complexes which I've called the dynamics of preferential equivocality, the dynamics of temporal scaffolding and the dynamics of relational coherence. Each of these process complexes is constituted by heterogeneous processes that entwine to shape the dynamics of organising while innovating. Additionally, the tensegrity mechanism which I've introduced offers an explanation for how organisational stability is maintained despite various dynamics.

By identifying and developing three dynamic process complexes and their regulating principle, this model answers previous calls from scholars to pry open the 'black boxes' (Ahuja, et al., 2008; Burgelman, 1996; Pentland & Feldman, 2005; Crossan & Apaydin, 2010) which until now had concealed organisational dynamics while innovating. Further, this model also contributes towards current "*constitutive approaches"* (Garud, et al., 2014, p. 1178) which attempt to integrate the role of actors and contexts in the emergence of innovations. Specifically, the dynamics of preferential equivocality, temporal scaffolding and relational coherence refine and extend the *'narrative perspective'* (Bartel & Garud, 2009; Garud & Giuliani, 2013; Garud, et al., 2014) by adding further clarity to the relational, temporal and performative efforts of innovators as they organise while innovating.

In sum, this thesis extends innovation and organisational theory in three specific ways. First, it breaks with a past tradition in organisational theory and innovation research which tends to theorise organisational and innovation dynamics separately rather than explore the possibilities opened up by their interplay. Second, it has identified and developed three heterogeneous process complexes which when taken together constitute the dynamics of organising while innovating. Third, it has identified and demonstrated how the tensegrity principle regulates and configures these process complexes in order to maintain organisational stability. Overall, the tensegrity model offers the first ‘prototypical process theory’ (Gupta, et al., 2007) to guide organising while innovating

8.1.3 Methodological Contributions

This thesis also offers a methodological contribution towards the practice of process research. Three points are salient within this methodology. First, it investigates processes holistically by doing away with ‘levels of analysis’ (Gupta, et al., 2007). Second, it can be counted amongst the few empirical studies in management research that has embraced a ‘post processual’ practice perspective (Chia & MacKay, 2007) to investigate organising and innovating processes. Third, by developing process threads that embody ways of becoming rather than categories of concepts, it offers guidance to reformulate organisational dynamics in a manner which resonates with practice. The remainder of this section expands on these three points.

In this methodological approach, I’ve shadowed the product development process from initiation to product delivery in order to follow innovation becoming. In doing so, I have not restricted the study of the phenomena to any particular level of analysis (Gupta, et al., 2007). In my opinion, levels of analysis tend to be unnecessarily restrictive while theorising the dynamics of organising and innovating. Additionally, I have also done away with the intra-inter distinction which organisation theorists like Burgelman (1991) and Van de Ven (cf. Van de Ven & Sun, 2011) make when they theorise about processes. The inherently dynamic formulation of the process worldview means that we no longer have to think in terms of the spill over impact of variables across multiple levels. The approach adopted here allows us to develop theories which are simultaneously dynamic, contextual and resonant with the practitioner’s experience.

This methodological approach also embraces the ‘post processual’ perspective in practice research advocated by Chia and MacKay (2007). Van de Ven’s (1992) distinction which separates processes as ‘a category of concepts or variables that refers to actions of individuals or organizations’ from processes as ‘a sequence of events that describes how things change over time’ (p. 169) is no longer tenable from a process onto-epistemology. This means that researchers must study activities of practitioners to then infer the processes which they are attempting to enable or stabilise. Put differently, activities can be observed but processes must be inferred. By inferring processes from practitioner activities, irrespective of whether they are micro or macro (Seidl & Whittington, 2014; Jarzabkowski, et al., 2012; Autio, et al., 2014), this methodological approach connects "action (praxis) with the managerial and academic theories (practice)" (Crossan & Apaydin, 2010, p. 1179), thereby addressing the current praxis-practice gap in innovation research.

Yet another distinctive contribution of this methodological approach is that it concentrates on understanding ways of becoming by eschewing the *study of practice* for the *study with practice* (Ingold, 2013b). Practice, here of course, refers to what practitioners know about innovation. The former approach, evident in much of current practice theories (Jarzabkowski, et al., 2012; Feldman & Orlikowski, 2011), allows theorists to isolate, classify and develop various typologies of activities within the practice. This no doubt allows us to learn *about* the practice by generating lots of insights, yet we learn nothing *from* practice. To study with practice, by contrast, entails participant observation where the researcher joins the practice of innovating as it unfolds. In stark contrast to classificatory knowledge, such an approach allows processual knowledge to grow from the inside of being as innovating unfolds (Ingold, 2013b, p. 8).

Overall, the methodological approach developed and deployed here embraces a 'post-processual' practice perspective, concentrates on action and ways of becoming. It shadows the phenomena under investigation as it unfolds, irrespective of the levels of analysis. By doing so, it avoids 'micro-isolationism', "whereby a local empirical instance is interpreted wholly in terms of what is evidently present, cut off from the larger phenomena that make it possible" (Seidl & Whittington, 2014, p. 2), evident in so many process and practice theories. These methodological guidelines might be useful to future researchers interested in theorising from the process onto-epistemology.

8.1.4 Empirical Contributions

This study also makes two important empirical contribution towards process and innovation research. First, it is among the few empirical studies which has investigated organising and innovating from a process onto-epistemology. Second, although past research has theorised the process of innovating using historical data, case studies and interviews spread over time, there is a dearth of real time field studies on the process of innovating (Gupta, et al., 2007; Crossan

& Apaydin, 2010; Keupp, et al., 2012; Garud, et al., 2013). The empirical material presented here addresses this gap by gathering real time data on innovating and organising. I elaborate on why these aspects are significant.

Prior research on innovation has suggested a need for empirical studies to embrace a 'dynamic approach' (Crossan & Apaydin, 2010, p. 1177) while studying innovation. Empirical studies, therefore need to reflect the complexity of the phenomena that complement the process onto-epistemological perspective. The empirical material presented here achieves this by gathering and showcasing "connectivity, recursive patterns of communication, feedback, non-linearity, emergence, ineffability and becoming" (Tsoukas & Dooley, 2011, p. 731) of the organisational phenomena, all of which are aspects of the process onto-epistemology.

To date, the number of real time studies on innovation remain few and far between. Since real time studies eliminate hindsight bias (Van Oorschot, et al., 2013; Hoholm & Araujo, 2011), it is possible to better account for the temporal complexities of innovating. This study makes an empirical contribution by adding to the rare category studies which have investigated the process of innovating devoid of any retrospective bias. Hoholm and Araujo (2011) offer three reasons why real time ethnographic field studies, such as this one, are significant:

> "First, real time ethnography can give us a heightened sense of the uncertainties, contingencies and choices faced by situated actors, and to see agential moments as the capacity to contextualize interpretations of the past and future projects (Emirbayer & Mische, 1998). Secondly, real-time ethnography can shed light on how contexts of action are interpreted and constructed by situated actors as much as the choices they face. Thirdly, real-time ethnographies can give us a better analytical grip on controversies, tensions and fissures provoked by the existence of alternative choice paths, and the political processes involved in selecting and discarding options. Taken together, these points suggest a need for reinforcing the notion of innovation processes as messy, uncertain and prone to multiple and often conflicting influences" (p. 938).

To conclude, there exists relatively little systematic empirical (as opposed to theoretical) evidence to substantiate process onto-epistemological management research. This thesis offers an empirical contribution by shifting the content and methods of innovation research to understand the manifold complexities of the process of innovating using the process onto-epistemology. By doing so it attempts to improve our understanding of contextualised and temporalized dynamics of the process of innovating (Autio, et al., 2014).

8.1.5 Practical Contributions

Being a process theory, this study also makes a practical contribution by responding to calls asking scholars to create *know how* knowledge, prized by theorists and practitioners alike (Langley, et al., 2013). The findings from my research offers practitioners the practical wherewithal to navigate the innovation journey. Two important practical implications of the findings are elaborated in this section.

First, the tensegrity model acknowledges that innovation projects tend to be complex and recognises that we cannot predict in advance when a particular dynamic will be destabilised. However, it still allows practitioners to prepare for such eventualities by expanding their repertoire of conceptual models that guide how they might organise while innovating. In doing so, the model provides insight into what intervention strategies might work to sustain innovating. This in turn strengthens action and reflection strategies (Van de Ven & Sun, 2011) which practitioners use while innovating.

Second, since all models present a simplified version of reality, practitioners can only use the tensegrity model effectively when they combine the tool with "their personal knowledge, developed from a historically informed, relationally constituted, bodily felt and situationally-based reading of the situation they are immersed in" (Tsoukas & Dooley, 2011, p. 731). The model only provides evidence for the entwined nature of three specific dynamics and how they shape one another. It allows practitioners to narrow down the possibilities from which the future course of action must be chosen. However, it cannot identify *a specify course* of action or the *effectiveness of any specific course* of action. The personal knowledge of the practitioner plays a vital role in such situations.

Innovating then, to paraphrase Ingold (2013c), means "to push one's boat out into the stream of a world in becoming, with no knowing what will transpire". Organising and innovating, in practice, flow side by side along with the things we cannot possibly know in advance of the innovation journey. The innovator's true dilemma (Christensen, 1997) therefore, to paraphrase James (1890), "is less what he shall now choose to do than what being he shall now resolve to become" (p. 228). Here, organising is to innovating as silence is to speech. "It is like the silence that is the necessary background to speech but which also withdraws when speech expresses itself and yet is always present as a supportive absence" (Cooper, 2005, p. 1692). Practitioners must then constantly feel their way "*through* a world that is itself in motion, continually coming into being though the combined action of human and non-human agencies" (Ingold, 2000, p. 155 emphasis in original).

To summarise, in this section I've shown how the tensegrity model offers novel insights into organising while innovating. In particular, it allows practitioners to understand organising and innovating as intertwined social processes, thereby redressing the benign neglect accorded to the twin processes by artificially separating them in theory. When such an understanding is coupled with the Tensegrity Model, it allows practitioners to pick up warning signals from unstable dynamics. When these unstable dynamics are left unattended, it could lead to an immanent breakdown. Consequently, this model offers both theorists and practitioners a rich understanding of how innovations are brought into being.

8.2 Directions for Future Research

This theory, developed by juxtaposing organising and innovating raises interesting questions and opens up new possibilities for future management research. The process onto-epistemological perspective developed here has the potential to influence various streams of organisational scholarship, most notably research on innovation, change, routines and practice within organisational theory. The remainder of this section expands on some of the unanswered questions which this study has raised which could benefit from further academic attention.

The tensegrity model was developed by gathering empirical material from a single site. It would therefore be useful to analyse the theory by extending it to other innovation contexts. Doing so will deepen our understanding of various other organising mechanisms which firms use to navigate their innovation journeys. However, as pointed in the methodology section, the advantage of theorising from a process onto-epistemology is not to *'generalise-from-the-particular'* but rather to see the '*general-in-the-particular*'. Since the theory focusses on "explicating process dynamics" (Rerup & Feldman, 2011, p. 606), extending its insights is unlikely to be problematic like some of the other single case study based research (c.f. Corley & Gioia, 2004: 205; Burgelman, 2011).

This study raises several new and exciting questions for research. Among a number of theoretical concerns which need to be accounted for, the role of learning within the process of innovating remains under researched. Since learning allows organisations to adapt while they innovate (March, 2008; Lavie, et al., 2010), exploring the learning process becomes an important avenue for further research. Also, the dynamics of relational coherence discussed here raises theoretical challenges for the current routines literature rooted in an 'ostensive-performative' duality (Pentland & Feldman, 2005; Rerup & Feldman, 2011). Since maintaining procedural coherence involves enacting flexible routines, shifting the conceptualisation of organisational routines from dualistic to a holistic perspective becomes an important agenda for future research. Since routines are also intertwined with organisational learning (Bresman, 2013), tackling these issues jointly from a process onto-epistemology becomes an important later task that remains to be done.

The tensegrity model presented here has been developed by shadowing 'incremental' innovation (Henderson & Clark, 1990). It would be interesting to explore if and how the troika of dynamics uncovered here might entwine while organising for 'radical' innovations which are much more uncertain. Prior research has suggested that "the occurrence of innovations that are radical in their consequences does not rule out reliance on stable and incremental processes" (Farjoun, 2010, p. 212). However, as argued earlier, since incremental and radical are often judgments in retrospect, researching innovations which are declared radical at the outset from a process onto-epistemology can shed light on whether organising and innovating entwine differently in such situations?

Future research could also concentrate on exploring the impact and effectiveness of various practices deployed to sustain tensegrity while innovating. By embracing the 'post-processual' practice perspective, research should investigate the various means through which practitioners heedfully and mindfully grapple with innovation problems (Dougherty & Dunne, 2011). This study provides future researchers with the conceptual wherewithal required to theorise links between process, praxis and practitioners. Alternate means through which the various strands of organising are interwoven to sustain innovation still remains an open question. Research which explores how various practices knot with ongoing processes to affect the type, quality or direction innovation and the negotiated order which emerge from these entanglements could benefit from additional scholarly attention.

The process onto-epistemological perspective developed here also has profound implications for how we understand and theorise organisational dynamics. It means that while researching organisational change or the dynamics of a phenomenon, theorists can no longer be satisfied with 'stage models' (Meyer, et al., 2005; Kaplan & Tripsas, 2008; Bartunek, et al., 2011; Van de Ven & Sun, 2011; Burgelman, 2011). The reconceptualization of 'process' presented here can be deployed in field studies which investigate change management within organisations. This would allow theorists to develop a newer and more dynamic understanding of 'action' and 'reflection' strategies (Van de Ven & Sun, 2011).

All in all, I invite scholars to further develop the process onto-epistemology conceptually, theoretically, methodologically and empirically. Doing so can aid research which seeks to explicate process dynamics and mechanisms associated with various organisational phenomena. While innovation research has taken several important strides toward understanding the antecedents and consequences of various innovation determinants, it has enjoyed little success, if any, when it comes to relating these theoretical insights to the pressing problems of practitioners (Ahuja, et al., 2008; Lavie, et al., 2010; Crossan & Apaydin, 2010; Keupp, et al., 2012). The genre of field research undertaken here has the potential to be not just theoretically and empirically rigorous, but also be profoundly managerially relevant.

8.3 Closing Remarks

Bateson (1972) once recalled a tale about a candidate in ancient Rome who, during his oral doctoral examination, was asked by the learned doctors to state the "cause and reason" why opium puts people to sleep. To this, the candidate's triumphant answer was "Because there is in it a dormitive principle!" Bateson expands on this response by writing,

> "Either the opium contains a reified dormitive principle, or the man contains a reified need for sleep, an adormitosis, which is "expressed" in his response to opium. And, characteristically, all such hypotheses are "dormitive" in the sense that they put to sleep the "critical faculty" (another reified fictitious cause) within the scientist himself" (p. xxvii).

In this thesis, I have tried my best to avoid "dormitive" principles while uncovering the dynamics of organising while innovating. Dormitive principles originating from a substantialist worldview has thus far hampered theory development within process research. To paraphrase Max Weber (1949), while the process epistemology rooted within a substantialist ontology has and can continue to serve "as a harbour until one has learned to navigate safely in the vast sea of empirical facts" (p. 355), in light of the puzzles that have surfaced, it eventually reaches its explanatory dead end. Progress, therefore requires embracing a process ontology where processes are conceptualised as unfolding along lines which embody movement, duration, creativity and purpose.

To conclude, this thesis should be treated as no more than a milestone within the journey of scholarship that explores organising and innovating. We get a glimpse into the inner workings of the dynamics of organising while innovating. By doing so it complements the theoretical work on process research (Langley, et al., 2013) and focus on process onto-epistemology dovetails with and extends work by, among others, Chia (1997; 1999; Chia & MacKay, 2007), Tsoukas (Tsoukas & Chia, 2002; Tsoukas & Chia, 2011; Tsoukas & Dooley, 2011) and Hernes (2014; 2008). The comparative study of two innovation journeys, which revealed three dynamics and their stabilising principle, is a significant first step towards building process onto-epistemological theories on organisations in general and innovation in particular. The insights offered will hopefully drive the future research agenda in this important domain which by bridging the theory-practice divide will make practice more theoretical and theory more practicable.

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Appendix I

Appendices

Table 16: Event Chronology for the Alpha Panda 2 project

Date	Events
Early December 2012	Peak receive an inquiry from Alpha for an upgrade kit for their Standard Alpha 3G generator systems
Early December 2012	Peak Design Engineering Manager assigns a Design Engineer
Mid December 2012	Design Engineer assembles the kit
Mid December 2012	Kit is dispatched to Alpha.
Late December 2012	Some research work is undertaken on the design for a three Nitrogen gas output generator system.
Late December 2012	No orders come through for either additional kits or for the modified generator system.
Mid-January 2013	The research and development are set aside.
Early June 2013	Alpha contact Peak.
Early June 2013	The Panda 2 product launch date has been set by Alpha for the end of August 2013 or mid-September 2013.
Early June 2013	Alpha need the generator system urgently but cannot confirm the generator system volume or the final product specifications.
Mid June 2013	New Product Development is initiated by Peak.
Early July 2013	Alpha confirms customer requirements for upgrading three existing products: the Alpha 3G generator, Alpha Table and Infinity 1031 generator.
Early July 2013	The Design Engineer is assigned to the project
Mid July 2013	Three Manufacturing Engineers are assigned to each of the three components of the Panda 2 system.
Late July 2013	The Alpha 3G generator and the Alpha Table for the Standard Alpha 3G systems are certified by the Canadian Standards Association (CSA). The upgraded system too would require a CSA certification.
Late July 2013	Peak product team decide to skip CSA certification
Early August 2013	Customer Requirements change.
Early August 2013	Project put on hold
Mid-August 2013	Meeting scheduled between Alpha and the Peak project management team to discuss uncertainty in customer requirements
Mid-August 2013	The Design Engineer informs Alpha that 50% of the design work was completed
Mid-August 2013	The new product design would be more expensive than the current version.
Mid-August 2013	Panda 2 prototype is fully working and so Alpha confirm customer requirements

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Mid-August 2013	The Design Engineering Manager sends an updated customer requirements form for Alpha approval
Mid-August 2013	Alpha confirm a 6 week lead time to develop the new system
Mid-August 2013	Alpha chooses a rolling purchasing order (RPO) for the new product.
Mid-August 2013	Peak decide to upgrade the Alpha 3G generator and Alpha Table with no change in names. The Infinity 1031 generator would require no changes.
Mid-August 2013	The Manufacturing Engineer for the Alpha 3G generator is replaced
Mid-August 2013	Design Engineer presents the Detailed Design for the new upgraded design at a review where it is internally approved.
Mid-August 2013	Manufacturing Engineers begin work on the New Product Introduction (NPI) process.
Mid-August 2013	Design Engineer carries out bench tests on the new upgraded product designs
Mid-August 2013	Alpha, confirm the updated customer requirement form sent by the Design Engineering Manager.
Mid-August 2013	However, Alpha want to increase the output flow rate of the Infinity 1031 generator.
Mid-August 2013	Peak upgrade the Infinity 1031 nitrogen generator by increasing the output flow and the new unit is called Infinity 1035
Mid-August 2013	Alpha request Peak for Product test results for the Alpha 3G generator, Alpha Table and Infinity 1035 generator.
Late August 2013	Test Results for upgraded Alpha 3G generator, upgraded Alpha Table and Infinity 1035 Nitrogen generator are recorded and sent to the Alpha technical team
Late August 2013	Alpha confirm the test results
Late August 2013	Alpha want to a single upgraded Alpha 3G system. So upgrade the current Alpha 3G generator, Alpha Table and Infinity 1031 generator and retain all the names.
Late August 2013	Alpha want further test results on the upgraded products and the generator name changed on the test report from Infinity 1035 to Infinity 1031
Late August 2013	Alpha push the Panda 2 product launch to October 2013
Late August 2013	With technical specifications signed off, commercial discussions begin between Alpha Manager and Director Sales and Operations at Peak
Late August 2013	Works order raised by Manufacturing Engineer
Early September 2013	Product prototype is ready for the upgraded system
Early September 2013	Meeting scheduled between Alpha and the Peak Project Management Team to discuss project delivery time
Early September 2013	Additional test results received and approved by Alpha
Early September 2013	Director Sales and Operations informs Alpha that the price of the upgraded unit will increased by $300.
Early September 2013	Alpha reject the price increase

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Early September 2013	Alpha inquires about the possibility of two separate model names, one for the old product and the other for the upgraded product
Early September 2013	Product prototype for the upgraded system is shipped to Alpha to be tested with their Panda 2 instrument
Early September 2013	Processes are ready for 'Train the Trainer' product build for the modified Alpha Table
Early September 2013	The Infinity 1031 generator has been upgraded
Mid-September 2013	Alpha have not been able to make changes to their regulatory paper work to support two different gas systems for their product range
Mid-September 2013	Peak changes the product name of the upgraded Infinity 1031 to Infinity 1035 and now have to create and maintain two systems for Alpha products
Late September 2013	Upgraded Alpha Table is ready for production
Late September 2013	Two different processes are now created by Manufacturing Engineers to produce two different components Alpha 3G generators and Alpha Table and their upgraded versions respectively
Late September 2013	The Infinity 1035 is now ready for production
Late September 2013	Alpha schedule a meeting with Peak to change the Infinity 1035 to Infinity 1031
Late September 2013	Peak cannot change Infinity 1035 to Infinity 1031
Late September 2013	Panda 2 launch date is set for mid-October 2013
Late September 2013	Design Engineering Manager proposes changing the front panel design of the newly upgraded Alpha 3G generators, Alpha Table and Infinity 1031 generators to engrave 'Hi-Flow'
Early October 2013	The 'Hi-Flow' proposal is accepted by Alpha. So while the product names remain the same, the two product front panels would be different.
Early October 2013	Alpha Panda 2 launch date shifted to 12th November 2013
Early October 2013	Design Engineer makes the required modifications to the design
Mid October 2013	ECN (Engineering Change Notification) raised for the Infinity 1031 to reflect the changes
Late October 2013	Manufacturing Engineers now modify the production documents and work instructions for the three components
Late October 2013	Initial quotes for modified front panel design are very expensive and so Purchasing Department is now involved in component sourcing
Late October 2013	Design modifications which are required are discovered in the Standard Alpha 3G generator by the Manufacturing Engineer while developing the new work instructions
Early November 2013	The modifications are made by Design Engineering and the Production documents are ready for both the products
Early November 2013	The Bill of Materials (BOM) is finalised
Early November 2013	The factory settings for the new Alpha 3G system for the Panda 2 is confirmed

Appendix I

Mid November 2013	The Validation Review and NPI review are scheduled and signed off and the product is launched.

Appendix II

Table 17: Event Chronology for the Theta Corona Project

Date	Events
Early March 2013	The Director of Engineering, Peak is approached by representatives from Theta for a solution to their new Corona application.
Late March 2013	The Director of Engineering, Peak Scientific forwards the proposal to the Design Engineering Manager
Early April 2013	The Design Engineering Manager assigns a Design Engineer to modify the current generator
Mid-April 2013	Design Engineer modifies a current Precision series generator and confirms that the solution is working
Late April 2013	The modified generator is shipped off to Theta for testing
May 2013	The Engineers at Theta confirm that the Peak solution works
Early June 2013	A meeting is scheduled between Theta and Peak.
Early June 2013	The customer requirements document is filled out for a new product development.
Early June 2013	A Management Team comprising the Product Manager, Design Engineering Manager and Senior Manufacturing Engineer is assembled and the target date for completion is set for the end of July 2013
Mid June 2013	The Carbon Molecular Sieve (CMS) Pressure Swing Adsorption (PSA) technology platform is the chosen platform for designing the new generator
Late June 2013	The Design Engineer works on the Design Proposal for the new product
Early July 2013	The Design Engineer presents the Design Proposal to the Senior Management Team.
Early July 2013	The Design proposal is rejected.
Mid July 2013	A conference call is scheduled between Peak and Theta to update them on the delays to new product development
Mid July 2013	Theta confirm product requirements for two products: Theta Corona Nitrogen (non-compressor based solution) and Theta Corona Air (compressor based solution)
Mid July 2013	The new deadlines for the Theta Corona Nitrogen and the Theta Corona Air are set to January 2014 and February 2014 respectively
Late July 2013	Design Engineer presents a new design proposal with four different ideas to the Product Management Team.
Late July 2013	Concept 4 is chosen and given the go ahead.
Early-August 2013	Two projects, Theta Corona Nitrogen and Theta Corona Air are sanctioned. The same Design Engineer is assigned to design both the products.

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Mid-August 2013	Two Manufacturing Engineers are assigned to assist the Design Engineer. Assisting him on Theta Corona Nitrogen would be ME-1. ME-2 would be assisting him on Theta Corona Air.
Late August 2013	The size of the generator chassis is increased to match the size of the Theta Analytical Equipment.
Late August 2013	The new product launch date set to last week of January and last week of February 2014 respectively
Late August 2013	Planning for the Theta Corona Air is being jointly undertaken by the Design Engineer and ME-2.
Early September 2013	The Design Engineering Manager sees merit in fast tracking the design development process.
Early September 2013	A rise in the number of field product failures for Peak's compressor based systems. The Engineering Director discusses the issue with the Engineering Department and the need to modify/replace the compressor on which these units were based is identified.
Early September 2013	A decision was taken to switch from the T compressor to the G compressor and a separate project was set up to roll out these changes within Peak.
Early September 2013	The G compressor is not CE certified which is required for the product to be sold in the EU market
Early September 2013	A Manufacturing Engineer is assigned to co-ordinate the certification process with the G compressor manufacturer
Mid-September 2013	Product Manager wants Senior Management to plan for production of the Theta Corona Nitrogen generators
Mid-September 2013	Product costing and production volumes for the Theta Corona Nitrogen and Air are assigned to Peak Territory Manager USA.
Mid-September 2013	Theta confirm that they will place orders in the beginning of January 2014. Pricing discussions are currently on with the Territory Manager USA.
Late September 2013	The new design for the Theta Corona Nitrogen is presented at a design review.
Late September 2013	The design for the Theta Corona Nitrogen is rejected.
Late September 2013	The Design Engineer and the Manufacturing Engineer begin quibbling over who was responsible for the rejection of the design as this issue of 'serviceability' was not picked up in the Engineering Review which was held prior to this Detailed Design Review.
Early October 2013	The Design Engineer makes the modification recommended in the detailed design review.
Early October 2013	The Design Engineer requests Manufacturing Engineering for additional resources. He wants it doubled if possible.
Early October 2013	The G compressors are approved for design of the Theta Corona Air generator

Appendix II

Early October 2013	Testing plans for making the switch from the existing T compressor design to the G compressor design are drawn out and assigned to the Testing Lead within Design Engineering.
Mid October 2013	ME-2 is investigating the current schematics and pneumatic diagrams for the Theta Corona Air but is still awaiting inputs from Design Engineering.
Mid October 2013	The modifications to the Theta Corona Nitrogen generator are shared in an internal Engineering review
Mid October 2013	The product design is cleared by the Engineering Department for the Detailed Design Review.
Late October 2013	The detailed design for the Theta Corona Nitrogen is presented at the review.
Late October 2013	The Theta Corona Nitrogen design is cleared for product prototype build
Late October 2013	The BOM (bill of materials) for this new model (Theta Corona Nitrogen) is set up.
Late October 2013	ME-1 verifies the BOM with the model, and the orders have been placed for the Theta Corona Nitrogen metal work.
Late October 2013	ME-1 begins designing the work instructions required to build the Theta Corona Nitrogen unit.
Late October 2013	The Design Engineering Manager approves the switch to the G compressor
Late October 2013	The Design Engineer schedules an Engineering Review for the Theta Corona Air Design
Late October 2013	The Theta Corona Air design is approved in the Engineering Review
Early November 2013	Product Manager at Peak receives information from Peak Brazil and Peak China that the compressor based Theta Corona Air solution is more popular than the compressor less Theta Corona Nitrogen.
Early November 2013	On Theta Corona Nitrogen, a decision taken by Engineering to run the New Product Introduction (NPI) process managed by Manufacturing Engineering in parallel with prototype build and validation testing managed by Design Engineering
Early November 2013	Validation testing is being carried out on the new G compressor design.
Early November 2013	The Manufacturing Engineers are working on updating existing work instructions to support the switch in compressors from T compressors to G compressors
Early November 2013	Decision on the service plan for the Theta Corona Air is postponed until the validation testing is concluded.
Mid November 2013	Detailed design for the Theta Corona Air is presented for Review
Mid November 2013	The Detailed Design Review for the Theta Corona Air is approved
Mid November 2013	The BOM (bill of materials) for this new model (Theta Corona Air) is set up.
Mid November 2013	ME-2 verifies the BOM with the model, and the orders have been placed for the Theta Corona Nitrogen metal work.

Appendix II

Mid November 2013	Theta requests a customer requirements update to Theta Corona Nitrogen (with twin Design and Manufacturing Engineering processes running in parallel)
Mid November 2013	Negotiations on the product cost are on between Theta and Peak
Mid November 2013	The Product Manager suggests that Theta may now order the new units on a 'supply on demand' basis.
Mid November 2013	The works orders for the sub assembly builds for the Theta Corona Nitrogen generators are raised by ME-1.
Late November 2013	The prototype for the Theta Corona Nitrogen was completed by the Design Engineer who worked jointly with ME-1.
Late November 2013	A meeting is scheduled between Theta and Peak to discuss the changes in Customer Requirements.
Late November 2013	New requirements for an output flow of 10 litres per minute is approved by both Theta and Peak
Late November 2013	The product launch date for both the Theta Corona products is set for the end of February 2014.
Late November 2013	The Design Engineer makes the required modifications to the prototype unit to reflect the changes to the Theta Corona Nitrogen
Early December 2013	The Theta Corona Nitrogen unit is sent for CE certification
Early December 2013	Manufacturing Engineers complete the list of critical components (24 in all) required for the CE certification testing of the Theta Corona Nitrogen.
Mid December 2013	Prototype build on the Theta Corona Air (compressor based solution) is completed by the Design Engineer and ME-2.
Early January 2014	The New Product Introduction (NPI) process for the Theta Corona Nitrogen has begun. Work Instructions are being implemented and wiring tables being –prepared for the sub-assembly build by ME-1.
Mid-January 2014	The Theta Corona Nitrogen is approved with a CE certificate.
Mid-January 2014	Product Manager from Theta visits Peak in Glasgow to view the prototype units and sign off customer requirements
Mid-January 2014	The Manufacturing Engineer for Theta Corona Nitrogen, ME-1 is pulled out of the project.
Late January 2014	The Manufacturing Engineer ME-1 is reassigned to the Theta Corona Nitrogen project
Late January 2014	The work instructions for the Theta Corona Nitrogen is complete
Late January 2014	Production technicians are not available for new product introduction (NPI) of Theta Corona Nitrogen
Late January 2014	Theta place orders for Demo lab units of the Theta Corona Nitrogen.

Appendix II

Late January 2014	The New Product Introduction processes are finalised for Theta Corona Air is completed by ME-2
Early February 2014	The compressor based design service plans are changed from the every 6 months to annual.
Early February 2014	Product deadline for the Theta Corona Air is pushed to Mid-March 2014.
Early February 2014	Production build training for the Theta Corona Nitrogen is completed.
Mid-February 2014	A software bug is discovered in the old program as it is being updated. This has to be fixed before it can be uploaded into the new Theta Corona Air
Mid-February 2014	Validation Review for the Theta Corona Nitrogen is complete.
Mid-February 2014	ME-1 is still awaiting factory settings from Design Engineering to implement test procedures for product testing.
Mid-February 2014	The Design Engineering Manager takes over the project for implementing software changes within generators with the compressor based design.
Late February 2014	The test procedures are implemented and the product is handed over to Production
Late February 2014	Work instructions for the Theta Corona Nitrogen is now completed by the Manufacturing Engineer ME-2.
Late February 2014	The Design Engineering Manager now decides to standardise the compressor program across the compressor based product range for future ease of modification.
Early March 2014	The newly developed program is completed and uploaded into the Theta Corona Air
Early March 2014	ME-2 updates his production documents and retrains the production trainer
Early March 2014	Validation review for the Theta Corona Air is held
Mid-March 2014	Theta Corona Air is ready for Production and the process is signed off.

Appendix III

Table 18: Data Supporting Interpretation for Dynamics of Preferential Equivocality

Exemplar Quotes	Process Threads	Process Complex
"In the concept stage, ultimately, we got to two concepts. One was to have a shut off (Concept 3 in Figure 35), but that was going to add cost and complexity to the design; not a great deal but some more. We approached the customer and the customer then says, it (the generator) is going to run all the time, 24x7, it is not to shut off." (Design Engineer Theta Project)	Equivocal product functional Preferences	Dynamics of Preferential Equivocality
"It is like what I said at the SWOT (Strength, Weakness, Opportunities and Threats) meetings. We have what is known as moving the goal posts. One minute the goal posts are here and the next minute they are there. Because originally the generator was going to have two nitrogen outputs. It then became a nitrogen and an air output generator. Until the customers decide what they want, we will never be able to give them what they want. When you get something which is floating all over the place, and they are looking for it in a short space of time, we cannot deliver that" (Peak Design Engineer)		
"Absolutely! Now this does not mean that the company might later on want to approach you for a Nitrogen only gas generator. But we would like to increase the output flow on the Infinity 1031 by two litres/min. Is that possible?" (Technical Staff at Alpha)		
"We had a reply from Alpha as to up rev (revise), the current Alpha 3G, the current table and the current Infinity 1035 (to Infinity 1031). Current mass specs, and what we were proposing was to up rev all the additional components we need to support the Panda 2 product. You would buy the same of all the three under a new revision. This would support the Panda plus and all the Alpha products. Has this been agreed within your organization? Are you happy?" (Peak Design Engineering Manager)	Equivocal technological preference	
"Still not looked into that yet. How critical is that because it is not going to be an overnight fix with the T-compressor. The G-compressor doesn't have enough air for it (Theta Corona Application)" (Peak Design Engineering Manager)		
"Someone in the panel asked "Why are we using this technology?" This is a very expensive system that they are looking for. There is transfer price. Can we not use membrane?" And that is when everything fell over." (Peak Product Manager)	Equivocal cost preference	
"The issue that we have is if we are using the same model as our current production model, we will see a price increase which I cannot justify!" (Alpha Manager)		
"We like the way the generator stacks but it is a little smaller than our instrument." (Project Manager from Theta)	Equivocal design preference	
"By part number and physically, or is there a Hi-Flow tag on the front panel design now?" (Peak Design Engineer Alpha Panda 2)		

Appendix IV

Table 19: Data Supporting Interpretation for Dynamics of Temporal Scaffolding

Exemplar Quotes	Process Threads	Process Complex
"Up until then, we've (Peak) been angling, trying to get things done so that we can ship products, I think we said beginning of September (for Panda 2 launch). Given that time, we couldn't have the CSA files updated." (Peak Design Engineering Manager)	Temporal Prioritising	Dynamics of Temporal Scaffolding
"Having started the project, we are two weeks behind already because it was supposed to be the first week originally and then you asked for the second week and now it is the third week. So that is two weeks and this is a priority product. So can we do anything about that because I'm not very happy about it." (Peak Product Manager)		
"There is a bit of slack in there in the NPI (New Product Introduction) stage that I'd be hoping to take up. I think it was 4 days, so if we take that out we can get it in again. I'm just too apprehensive about taking that out at the moment." (Manufacturing Engineer Peak, Theta Project)		
"There could very much be a lack of understanding on what is required to produce a new product. The customer might think that January (2014) is plenty of time and there is nothing to worry about. They might think we have seen Peak do that generator, all they are doing is putting a new facial on it. Not understanding the implications of setting up the manufacturing facility, the regulatory requirements in place, they might not understand that. It is up to us as design engineers." (Design Engineer Peak Theta Project)	Temporal Sequencing	
"There will be a validation sign off review meeting which will be concluded on Wednesday this week. Just waiting for a couple of needs to be put into the QD09 (Quality Control System) to tie up the NPI (New Product Introduction) stages as well. So that is kind of on the cusp. What we still haven't heard on this one and we are waiting for you on this one Product Manager, is when are Alpha looking to start ordering Panda 2 products?" (Peak Design Engineering Manager)		
"The Theta Corona has been kicked back. Is that not because we have been waiting for parts?" (Product Manager Peak)		
"So basically the reason they (Peak) are not doing it is because we (Alpha) don't have time. If we had time, then they would go for a re-certification." (Alpha Manager)		
"It is a bit odd, especially in this project because the only thing they were sure of was the deadline. So it is 23rd August which is two weeks." (Peak Design Engineer Alpha Panda 2)	Temporal Boundaries	
"So in terms of launch date, we then have the third week of February. I'll send out an email with the minutes. Anything else?" (Product Manager Theta)		
"The lead time is 6 weeks, so if the order is 40 (units), then we need to factor a 6 week lead time." (Peak Design Engineering Manager)		

Appendix V

Table 20: Data Supporting Interpretation for Dynamics of Relational Coherence

Exemplar Quotes	Process Threads	Process Complex
"The different part numbers were originally issued when we thought we were going to give them a different name. But the CSA certification ties us to the names that we currently have. So the discussion we have had over the last couple of weeks has been to update the existing model so that all Alpha 3Gs fit the 1031s and the tables receive the additional components. That's the discussion we've had to confirm what we were doing." (Peak Design Engineering Manager)	Regulatory Coherence	Dynamics of Relational Coherence
"Now G-Compressors are built in USA and are CSA (Canadian Standards Authority) certified but lack CE certification. The G-compressor is not CE certified, and there was a overheating problem with the generator," (Peak Manufacturing Engineer)		
"It can be done but it is not ideal for us from a manufacturing standpoint. It's slightly disappointing because my understanding was that it was clear from the last call that we are going to call it the 1035 but obviously there has been some confusion." (Peak Design Engineering Manager)	Procedural Coherence	
"The main issue with the ECN (Engineering Change Notification) is we are supposed to be there just to issue them, we are virtually like goal keepers. It has been an absolute nightmare. There is so much information missing. It is totally different now from what was talked about." (Senior Manufacturing Engineer)		
"NPI (New Product Introduction) wise, we are really waiting on this program. We can't do unit retesting or confirm tests or QC (Quality Control) work instructions" (Peak Manufacturing Engineer Theta Project)		
"There has got to be an owner for the new product who should have this big long check list starting from prototypes to setting up suppliers, getting procurement involved, setting price on BOMs (Bill of Materials), train the trainer and all aspects of the product build. One person should actually be responsible for managing that, all those two hundred ticks. I don't think people appreciate how big or how important a role Product Management is. That doesn't happen today." (Peak Operations Manager)	Cross-Functional Coherence	
"It is teams, we want to build teams which include all of those functions. For me right now, it is setting ourselves up for success. The way I see it going, it is going to get progressively worse, not through anybody's fault but through a natural process of evolution and getting to this stage." (Peak Engineering Director)		
What I would say though between the two departments or the design engineers and manufacturing engineers, you put them in a room together, there is no physically a barrier there. It is the work that is causing a barrier. It is the work that is driving the barrier. (Peak Senior Manufacturing Engineer)		