Innovating and the dynamics of temporal scaffolding

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Abstract

Despite the growing acknowledgement of temporal complexities associated with the process perspective on innovation, insights into how timing and temporal experiences shape innovating; remains nascent and under researched. Why might this be the case and how can we gain better insights into the temporal dynamics which unfold while innovating? In this paper, I address this puzzle by tracing the theoretical origins of current limitations in literature to the distinction between the 'substantialist' and 'processual' ontologies in process research. Specifically, I demonstrate two major implications of adopting the 'substantialist' perspective in process research. These are first, the false opposition between persistence and change resulting in theories such as the 'punctuated equilibrium model'**;** and second, the nature of 'substantialist' and 'processual' time. These insights are then woven into a conceptual framework which informs the process research methodology used to investigate, two new product development projects at a Scottish high value manufacturing firm. Analysis of the data illuminates the unfolding of three distinct yet intertwined processes which I've called the process of setting temporal boundaries, the process of temporal prioritising and the process of temporal sequencing. Taken together, these processes constitute a dynamic process, I call the 'Dynamics of temporal scaffolding'. I conclude by outlining the theoretical and practical implications of the 'dynamics of temporal scaffolding' for innovation research and practice. Such an approach, I believe, would allow us to integrate the temporal experience of organising while innovating with process theories in innovation research.

Key words: innovation, process research, temporality

'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'

George Kubler (1962) in *The shape of time: Remarks on the history of thing* (p. 65)

1.0 Introduction

For some time now, the role and nature of temporality while innovating has either implicitly (Eisenhardt & Tabrizi, 1995; Brown & Eisenhardt, 1997) or explicitly (Van de Ven, et al., 1999; Garud, et al., 2011), received the attention of innovation theorists. While the former perspective has focussed on characteristics of the phenomena and identified innovation as a complex process, laden with non-linear dynamics (Van Oorschot, et al., 2013), the latter perspective has refined these insights by identifying contents constituting the process such as 'motors of change' (Van De Ven & Poole, 1995) and 'complexity arrangements' (Garud, et al., 2011) required to sustain innovating in organisations. Despite the growing acknowledgement of temporal complexities associated with the process perspective on innovation, insights into 'how timing and temporal experiences shape entrepreneurial innovations' (Garud, et al., 2014, p. 1185) remains nascent and under researched. Why might this be the case and how can we gain better insights into the temporal dynamics which unfold while innovating?

Following that preamble, I shall now go on to lay out the burden of my argument for this paper. I begin with a summary review of the extant time and temporality literature in organisation theory focussing particularly on its links with innovation and process theory. The literature review makes transparent the 'substantialist' ontology and outlines the meta-theoretical underpinnings which have informed empirical process research on temporal complexities within organisations, particularly in innovation research. Next, I turn to British social anthropologist Tim Ingold (1986; 2000), whose ideas provide an admirable foundation for simultaneously, deconstructing the 'substantialist' perspective on time in process research as well as re-conceptualising it along 'processual' lines. More specifically, I demonstrate two major implications of adopting the 'substantialist' perspective in process research. These are first, the false opposition between persistence and change resulting in theories such as the 'punctuated equilibrium model' (Gersick, 1991) ; and second, the nature of substantialist and processual time (Bergson, [1911]/1998). The conceptual framework is then incorporated into a research methodology which is inherently sympathetic to process and movement as fundamental features of reality. This methodology was 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 processes which I've called the process of setting temporal boundaries, the process of temporal prioritising and the process of temporal sequencing. Taken together, these processes constitute the 'Dynamics of temporal scaffolding.' Finally, I conclude by outlining the theoretical, methodological and practical implications of these contributions. Such an approach, I believe, would allow both theorists and practitioners to integrate the temporal experience of organising while innovating with a deeper understanding of the dynamics of the innovation process.

2.0 Literature Review and Theory Development

Gregory Bateson, (1979, p. 63) once remarked, if "[t]he if…then of causality contains time", then how can the "if… then of logic" be timeless?'. The role of time and temporality has received considerable attention from theorists who incorporate it to conceptualise, among other issues, understanding of change (Chia, 2002; Pettigrew, 2012), temporal structuring in practice (Orlikowski & Yates, 2002; Schatzki, 2005; Schatzki, 2006; Simpson, 2009); organisational mprovisation (Crossan, et al., 2005); organizational identity formation (Schultz & Hernes, 2013), temporal work in strategising (Kaplan & Orlikowski, 2013) and organising in general (Hernes, et al., 2013; Hernes, 2014). Within innovation research however, 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, the identification and demonstration of how organising is made spatial '*in time'* and how that spatiality is shaped with the passing of time (Hernes, 2014, p. 76) has, till date remained elusive (Garud, et al., 2014).

The primacy accorded to the role of time, history and change along with their interconnectedness distinguishes a process theory of organizing from its non-processual counterparts. With a growing awareness of, what Langley and Tsoukas (2010, p. 10) call, the "inescapable reality" of time, several organisational researchers have acknowledged the need to pay closer attention to the temporal nature of organisational life (Hernes, et al., 2013). A major reason for this call, asking organisation scholars to make more time for time within their theorising (Pettigrew, et al., 2001; Hernes, 2014), is the growing dissatisfaction with impoverrished insights derived from theories which compress temporal complexities into variables like fast and slow or dynamic and stable (Langley & Tsoukas, 2010). In such theories (cf. Eisenhardt & Tabrizi, 1995), time is treated as a secondary factor that becomes relevant only when the question of organisational change or adaptation is raised. The result for organisation theory in general and innovation research in particular has been a growing accumulation of 'know-that' type of knowledge with little or no insights into the complementary yet essential 'know-how' knowledge (Langley, et al., 2013) sought by practitioners.

Process theories focussing on an empirically evolving phenomenon; seek to redress this lacuna by restoring time to theoretical explanations of social practices which sustain organising. The explicit incorporation of the temporal progressions of activities as elements of explanation and understanding in process theories, counters the theoretical distortions of temporal compression inherent in the variance approach (Mohr, 1982; Poole, et al., 2000). However, the differing ontological and epistemological issues between 'process' research anchored in substantialist metaphysics (a world made of thing) as opposed to processual metaphysics (a world made of processes) suggests that there must be at least two conflicting conceptualisations relating history, change and time.

3.0 Conceptual Framework

To anticipate our conclusion, this is because processes in substantialist metaphysics represent change in things (Van de Ven & Poole, 2005; Pettigrew, 2012) and therefore deal in simultaneities and successions, thereby invoking a chronological – hence mechanical, eternal and abstract – sense of Newtonian time. History, here is thus, nothing but a concatenation of discrete, isolable empirical entities called events which are pegged along the metaphorical temporal clothes line. In processual metaphysics, by contrast, things are reifications of processes (Tsoukas & Chia, 2002) and social life is a process in real, creative and cumulative Bergsonian time. Events are moments or 'nexus' in the unfolding of a total process. History therefore is a descriptive integration of events rather than a chronological relation between them (Ingold, 1986, pp. 99,138).

Put differently, an organisation exists as a definable entity only in so far as it exists in a stationary state; change then involves the abrupt substitution of one state for another. Thus nothing can change where nothing persists; nor can we know *what* has changed except in the context of an assumed equilibrium. That is why it is contradictory to say, as Brown and Eisenhardt (1997) does, that innovating involves continuous change – or any kind of entity –is *constantly* changing. And for the same reason, we must conclude that the opposition between persistence and change is not congruent to that between continuity and discontinuity. It is a fatal error, born out of a tendency to conceive a world already parcelled up into discrete blocks, to equate continuity, like Van de Ven and Poole (1995) do, with the persistence of form.

Also, the dichotomy between synchrony and diachrony, an implication of conceptualising process in Newtonian time, 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. Far from apprehending change by putting together into sequence, what are really discontinuous entities, Van De Ven along with his colleagues (1999) proceed by cutting into segments what is really a continuous flow. The result is a punctuated series of equilibriums (Ingold, 1986, pp. 155, 156). The Table 1 below offers a summary of the process re-conceptualisation.

Substantialist		**Processual**
Persistence	Change	Movement
Synchrony	Diachrony	Duration

Table 1: Substantialist versus Processual perspectives

These insights open up possibilities for a deeper inquiry into the temporal dynamics of organising while innovating by simultaneously tracking movement and duration. Both, movement and duration drive the dynamics of temporal complexities which unfold while innovating. Hence our question: What are the temporal processes which constitute temporal complexities? How do these processes regulate organising while innovating? The sections which follow investigates these questions.

4.0 Methodology

In order investigate the temporal dynamics of the innovation process, I draw on my seven month long field study of two new product development projects at Peak Scientific Limited (henceforth referred to as Peak). The research site had to meet three specific criterion. First, in order to deploy a processual approach, it had to have substantial experience in new product development (NPD). Second, there must be several ongoing new product development projects, of which the ones being tracked are at a very early stage of development. Therefore tracking these projects over time would allow the gathering of comparative data on the temporal complexities involved while innovating. Further this data can be gathered in real time from the very early stages, right up until the projects have concluded. And thirdly, it must 'collectively represent a diversity of internal process characteristics in terms of size, rules, structure, and organization' (McCarthy, et al., 2006, p. 447).

4.1 Site of Investigation

Peak is a privately owned company headquartered in Inchinnan, a suburb on the south-west of Glasgow, in Scotland. Peak are one of Scotland's leading high value manufacturing enterprises, employing about 275 people with revenue close to £ 32 million at the end of 2014. They are a leading manufacturer of gas generators for scientific applications in the Analytical Instruments Industry. Their primary products include Nitrogen, Hydrogen and Zero Air gas generators, which are mainly used for Liquid Chromatography Mass Spectrometry (LCMS), Gas Chromatography (GC) and Total Organic Carbon (TOC) applications. 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. They are recipients of the Queen's award for Enterprise, an award conferred to outstanding businesses based in the United Kingdom, for the years 2005, 2007 and 2011.

I was invited by the Engineering Director at Peak to undertake this study. Field research at Peak offered several advantages to advance our understanding, both theoretically and empirically, of innovation management in practice. Firstly, it afforded that all but rare opportunity to gather data about innovation management 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. Secondly, 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. Thirdly, 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 new product innovation. Here, I've retained the original name of the organisation but for confidentiality reasons, anonymised the names of their clients (referred to as Alpha and Theta) for whom these innovations were being developed. Fourthly, this was *not action research*. I was in Peak as a resident innovation academic whose task 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 studied 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). Fifthly, 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. 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 the world, and not from the armchair! What makes studies in this genre truly processual, as Ingold so perceptively observes, is "that this world is not just what we think about but what we think with" (2011, 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.

4.2 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 entered the organisation, for the first three weeks, I was tracking five ongoing innovation projects within Peak. 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 the fieldwork and the projects being tracked were reduced to the two projects reported here. The decision to track the two projects 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 increaed likelihood of 'data asphixiation' (Pettigrew, 1990).

Research methods used must have the twin capacity to sufficiently respect both the primacy of theory and the primacy of evidence (Van Maanen, et al., 2007).The predominant source of data for this longitudinal field research was through participant observation. In order to scale the practical and useful heights in innovation management 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, nor to the translation of these objects into mental images or representations. 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’” as to “*watch what is going on.*” (p.223, emphasis in original). As mentioned earlier, I started field work at Peak in August just after both the projects reported here had gotten underway. 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, 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.

4.2.1 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. 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 you sit down to transcribe and analyse the recorded material, you 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.

4.2.2 Meetings

Shadowing the object being created also meant that I would have 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 which 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 solution. 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 the table 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. The Table 2 below provides a summary of the meetings I recoded and sat through.

Table 2: Summary of meetings at Peak

Serial Number	**Meetings**	**Number of Meetings**
1	Inter Departmental Meetings	19
2	Project Meetings with Alpha	11
3	Project Meeting with Theta	7
4	Engineering Departmental Meetings	15
5	Design Engineering Departmental Meetings	4
6	Manufacturing Engineering Departmental Meetings	10
7	Product Manager’s Meetings	12
	Total	**78**

4.2.3 Conversations with Informants

These conversations happened over the course of this ethnographic field study and aimed to gather “the meaningful totalities into which practitioners are immersed” (Sandberg & Tsoukas, 2011, p. 341) and factor the situational uniqueness in which the actions were taking place. The emphasis, therefore, was less on "data" and more on how ‘data’ is being constructed to aid theoretical reasoning (Alvesson & Karreman, 2007, p. 1265) in real time. By the end of the field study, I had a total of 64 recorded conversations with organisational members from various levels. The Table 3 below provides a summary of the various recorded conversations over time.

Table 3: Summary of Recorded Conversations with Informants at Peak

Serial Number	Informants	Number of 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**

4.2.4 Internal Documents and Emails

As mentioned earlier, one of the attractions of choosing to do fieldwork at Peak was the unfettered access which was required to conduct a thorough exploration of the organising and innovating processes on innovation management in practice. I was entrusted with a secure Peak ID card which allowed me entry into all the departments and the research and development (R&D) lab within Peak. 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 scheduled. 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 document I could find. This exercise compliments 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.

To sum things up, 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, 1979), which requires the researcher to probe for illuminating speculation, peripheral occurrences, capture the present in all its possibilities and incoherence, note and pursue nebulous rival yet to be validated hypothesis and might-have-beens, all of which requires a healthy measure of creativity. Unlike Tsoukas (1989, p. 556), I am convinced that such detective work is a necessary ingredient during the data gathering phase of process research and cannot be pejoratively dismissed. 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. However, I concur with Tsoukas (1989) when he insists that the sort of "synthetic reasoning" (p. 556) or what Van Maanen terms as "first order" (1979, p. 540) alone cannot serve as a sufficient condition to make plausible knowledge claims.

4.3 Data Analysis

As can be inferred from the previous sections, doing processual research on innovating involves *not the study of* the organisation but rather *a study in* the organisation. 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 focus on what Chia and MacKay call "the patterned consistency of actions" (2007, p. 224). Since the focus of the research is on the process of innovating and organising, it becomes important to concentrate on the constituting of these processes by the intertwining of micro activities as they correspond rather than on the micro-activities of individual agents per say.

The data analysis proceeded in two stages. The first stage involved data consolidation. I began the data sorting process in January 2014. The transcribing of the audio recordings started in late February 2014 as the second project I was tracking was nearing completion. For a start, I had to organise all the empirical material I had gathered during the field work into chronologically labelled data folders. There was over three hundred hours of recorded audio material and the all the audio transcripts were labelled and stored in chronological order. The tricky aspect of data analysis here is that quite often, a single file 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. By the end of the empirical material consolidation process, I had over 600 A4 size pages of data which now had to be sifted through to generate 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, as an explanation to the research question, the chronological narratives would not suffice. Doing so would require a second order analysis (Van Maanen, 1979) which facilitates both a *within case comparison* and a *cross case comparison*. Hence, the second stage of the data analysis process would have to be more analytical and further integrated with current research. That would require us to identify the temporal processes constituting the practice of organising while innovating. Here it is important to clarify what I mean by the terms organising and innovating. By organising, I mean nothing more than the act of ordering by (re)configuring existing resources, skills or organisational arrangements. Innovating on the other hand refers to the acts of executing or realising novelty. The processes of which these acts are a part, 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. These processes which constitute the 'ways of becoming' were identified. The data structure which emerged from the exercise is summarised below.

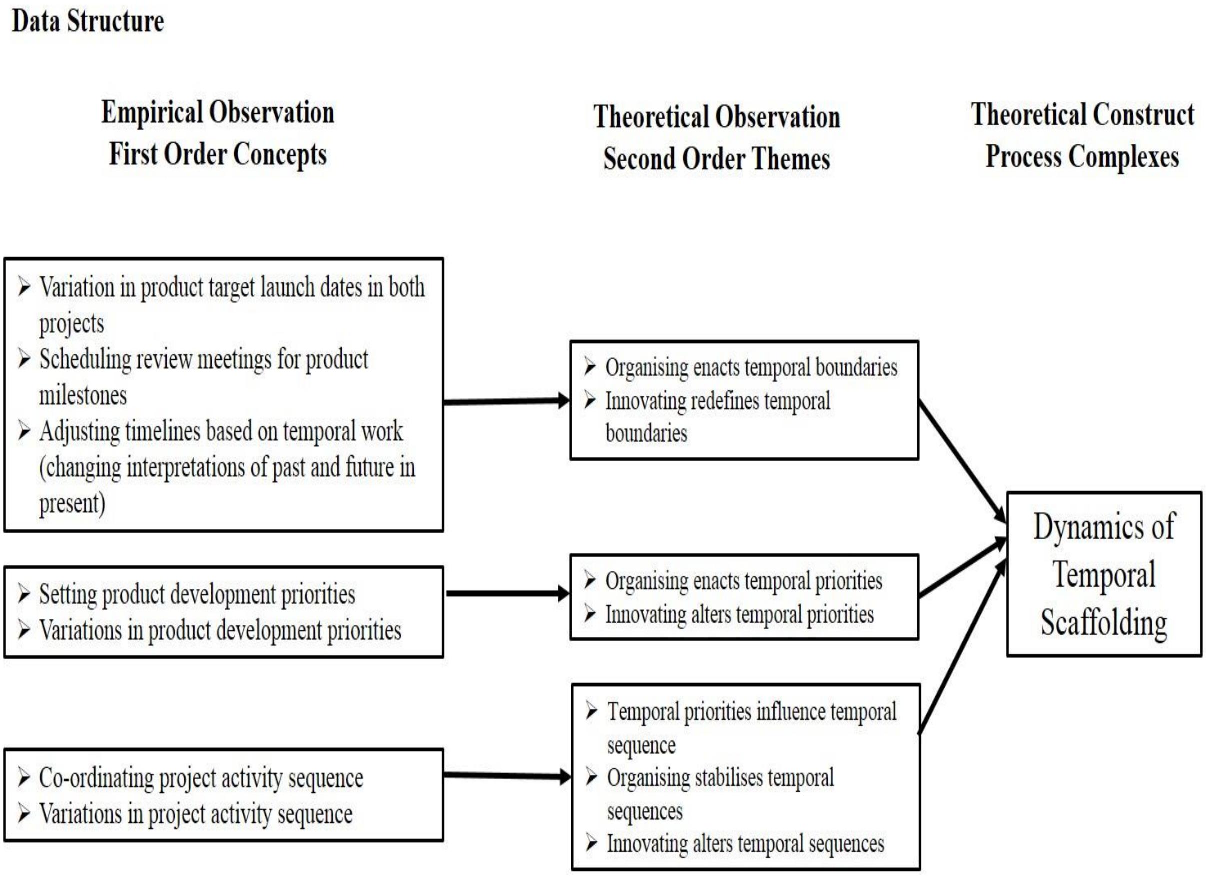

Figure 1: The Dynamics of Temporal Scaffolding

5.0 Findings

A 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. The Design Engineers meet every fortnight to discuss project development related issues. During one such meeting, 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 structures enacted while innovating. I call this dynamic which I shall define later, the dynamics of temporal scaffolding. My analysis 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 which follow, I shall unpack, explore and then integrate each of these sub-processes with examples from the two field studies.

I first provide the chronologies of the two new product development projects which I followed in real time. These narratives, with their ability to deal with multiple contextual, temporal and relational complexities of innovating, provide a distinctive integrative approach (Garud & Giuliani, 2013) to present innovation research. Because of space constraints, I shall first summarise the unfolding of the Alpha project in Table 4 below. This project was collaboration between Peak and Alpha Corporation based in Canada. The goal of course, is to ensure that the reader is sufficiently familiarised with the details from the twin studies, prior to data analysis which is undertaken in the next section.

Date	*Incident*
Early December 2012	*Peak Scientific receive an inquiry from ALPHA for an upgrade kit for their Standard ALPHA 3G generator systems*
Early December 2012	*Peak Scientific (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 Scientific.*

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*
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 components of the Panda 2.*
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	*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 the team 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*
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 AB 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*

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*
Mid November 2013	*The Validation Review and NPI review are scheduled and signed off and the product is launched.*

Table 4: List of Incidents in the Alpha Project

The unfolding of the Theta Corona project too is summarised in the Table 5 below. This was a collaboration between Peak and Theta Science Corp based in USA.

Date	Incident
Early March 2013	The Director of Engineering, Peak Scientific 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.
Mid-August 2013	Two Manufacturing Engineers are assigned to assist the Design Engineer. Assisting him on Theta Corona Nitrogen would be ME-One. ME-Two 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-Two.

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

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-Two 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 Themo 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-One verifies the BOM with the model, and the orders have been placed for the Theta Corona Nitrogen metal work.
Late October 2013	ME-One 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-Two verifies the BOM with the model, and the orders have been placed for the Theta Corona Nitrogen metal work.
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-One.
Late November 2013	The prototype for the Theta Corona Nitrogen was completed by the Design Engineer who worked jointly with ME-One.
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-Two.
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-One.
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-One is pulled out of the project.
Late January 2014	The Manufacturing Engineer ME-One 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.
Late January 2014	The New Product Introduction processes are finalised for Theta Corona Air is completed by ME-Two
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-One 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-Two.
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-Two 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.

Table 5: List of Incidents Theta Corona Project

5.1 Process of Temporal Boundaries

The shifting temporal boundaries were a dominant dynamic within both the Alpha and the Theta 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. As might be recalled from the field study, 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 to smoothen 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 meaning which 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 the Alpha Panda 2 and the Theta Corona project, organising enacts and regulates temporal boundaries while innovating. Temporal boundaries, it was found, 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. Further evidence for the dynamics of temporal boundaries can be found in the illustrative quotes displayed in Table 6.

5.2 Process of Temporal Prioritising

A second dicernable sub-process, untangled from the twin field studies, 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 in the following example 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. The temporal priority normally associated with testing and design are over here reversed. Likewise, in the Theta Corona Project, after the timelines were re-enacted for the new product development project based on the membrane technology platform, the Product Manager had to assign product development priorities between the Theta Corona Nitrogen and the 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, within both field studies, set the temporal priorities to guide innovating. Innovating, as the examples discussed show, resets the temporal priorities by generating new information which triggers organising. Additional examples which provide support for the process of temporal prioritising can be found in Table 6.

5.3 Process of Temporal Sequencing

A corollary to the 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." *(Design Engineer Alpha Project)*

The Design Engineer is referring to the specific lack of control over the temporal sequence which 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. Yet another example of temporal sequencing within the Alpha Panda 2 project can be found in the following remark made by the Design Engineering Manager,

> "Rather than having a (Infinity) 1031, (Infinity) 1035 and a (Infinity) 1035 (referring to the different generator model numbers) which will discontinue months after 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, in the Theta Corona project, 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,

> "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." *(Design Engineer Theta Project).*

The delays in the development milestones are a reflection of the alterations to the temporal sequence of project development activities. Yet another instance of the importance of managing the temporal sequence while innovating is evident when a software bug was discovered while upgrading the control program on the new G-Compressor based 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 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." *(Design Engineer Theta Project).*

The remark once again highlights the blurred lines between the process of temporal sequencing and process of temporal prioritising. The lack of stability in the later 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. Additional evidence for temporal sequencing can be found in Table 6 below. .

Table 6: Data Supporting Interpretation for Dynamics of Temporal Scaffolding

Exemplar Quotes	Process Themes	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)		

"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)	Temporal Prioritising	Dynamics of Temporal Scaffolding
"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 a design engineer." (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)		

6.0 Discussion

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 these various sub-processes in greater detail. I do so by illustrating entwinement between the sub-processes using certain episodes from both the field studies.

6.1 Dynamics of Temporal Scaffolding: The Process Complex

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" *(Design Engineer Alpha Project).*

The stopping of the 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 structure while innovating. In light of the orders not coming through, this structure 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 the temporal priority. The temporal sequence emerges once the priorities are set.

However, when the temporal boundaries were shifted by Alpha due to regulatory delays (since the Panda 2 application was targeted at the medical market), we see that the 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 the original date in 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 PSA (Presuure Swing Adsoption) technology platform (two competing product platforms within Peak), we see a collapse of the temporal structure. 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.

The temporal priority, it was observed, 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 PitConn (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 statement, 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 taken from the twin field studies reveal that each of the temporal sub-process elaborated in the previous sections are in fact entwined while innovating. Further, we also see that these sub-processes require stabilising and shape innovating. Taken together, process of temporal boundaries, temporal prioritising and temporal sequencing constitute a process complex 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 Dynamics of Temporal Scaffolding: Summary Insights

This section explicates and examines the dynamics of temporal scaffolding, a key process complex which innovators have to contend with on an ongoing basis. Both the 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 (As soon as possible) 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 is 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 reveal that innovating processes were constantly destabilising the enacted temporal scaffold by generating complexity which 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, to use the Design Engineer’s words, 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 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 themes to emerge from the twin 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. Table 6, above, presents a summary of the additional examples illustrating the dynamics of temporal scaffolding. The three sub-processes are, therefore, configured to act in a countervailing manner by acts of organising to stabilise the dynamics of temporal scaffolding. This is illustrated in Figure below.

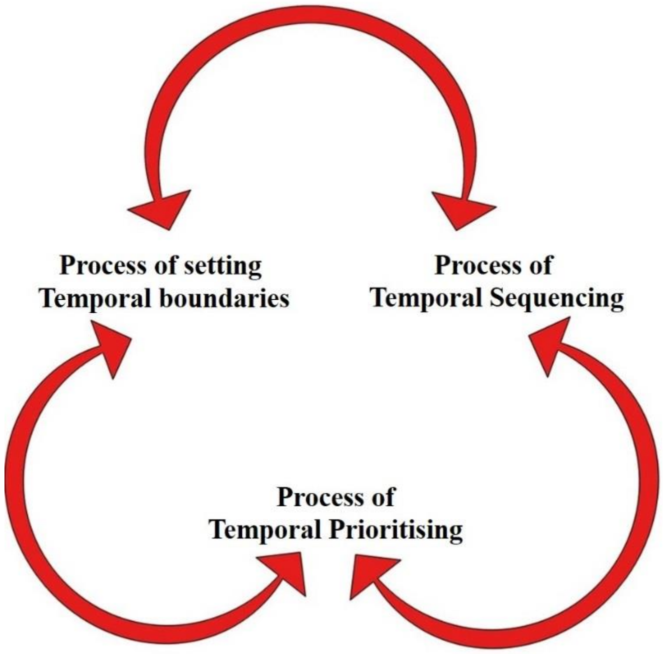

Figure 2: Dynamics of Temporal Scaffolding

6.3 Implications

By adopting a temporal perspective, I have demonstrated how organising is made spatial '*in time'* and how that spatiality is shaped with the passing of time (Hernes, 2014, p. 76). It is to this shaping of spatiality with the passing of time that I refer to as temporal scaffolding. 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 thought, I've opted for the notion of scaffolding rather than structuring. The notion of structuring is laden with a process/structure dualism. This dualism, as demonstrated in the literature review, stems from a substantialist ontology which tends to see events as discrete, isolable entities and process as something which occurs between discontinuous events. Therefore, the structure/agency duality inherent in the notion of structuring, does not adequately convey the eternal infirmities and precarious stability of the enacted temporal frames. Scaffolds, on the other hand evoke a sense of impermanence. This captures the delicate temporal stability enacted and maintained while innovating. The organisational actors derive meaning by enacting temporal scaffolds which they constantly carve out an initially undifferentiated temporal flux. Temporal scaffolding, in other words, is an effort to provisionally stabilise temporal complexity into plausible temporal frames in the present from which actors can extract cues to guide their ongoing/future actions. By explicating the sub-process and the overall dynamic, I have demonstrated how the processual framework allows us to better grasp ways in which people understand and orient their actions within the flow of time.

Evident from both these studies is that there has been a significant deviation between the desired and the actual temporal sequence of events in both projects. Process philosopher Alfred North Whitehead has coined a term ‘concrescence’ (Whitehead, [1929] 1978, p. 410), which essentially describes the capacity for things to constantly surpass themselves. Innovating here can be interpreted as a manifestation of concrescence- of that capacity to constantly surpass organising. “Inventions”, as Kubler (1962, p. 59) so perceptively pointed, “lie in this penumbra between actuality and the future, where the dim shapes of possible events are perceived. These narrow limits confine originality at any moment so that no invention overreaches the potential of its epoch. An invention may appear to meet the edge of possibility, but if it exceeds the penumbra, it remains a curious toy or it disappears into fantasy”.

The two projects underscore is the prominent role played by time and temporal scaffolding in the management of innovations. A temporal understanding of innovating, discussed here also requires us to rethink the concept of ‘events’ (Poole & Van de Ven, 2010) as the unit of analysis. Innovating is not contained in events but rather conducted through them. 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*.

7.0 Conclusion

Managing temporal complexity involves constant and effortful temporal work (Kaplan & Orlikowski, 2013), especially in innovation management where the challenges of temporal coherence is accentuated, as is evident from both the projects. The notion of temporal scaffolding elaborated here allows us to re-examine some contemporary ideas concerning the nature and influence of time on innovation management within organizations.

This paper offers four distinct contributions. First, it responds to calls within innovation process research to empirically, explore and elaborate on the temporal complexities which unfold while innovating. Second, it problematizes the ‘substantialist’ process perspective by highlighting its theoretical and empirical limitations. Third, it offers an alternate Ingoldian ‘processual’ framework which re-conceptual the process ontology into methodologically and empirically tractable terms. Finally is identifies and elaborates the ‘dynamics of temporal scaffolding’ along with its constituting sub-processes which explains how and why temporality entwines with organising and innovating as they become. In so doing, I have responded to calls from innovation scholars to explore various 'kinds of agencements' (Garud & Gehman, 2012, p. 989) and shown how actors while innovating balance stability and change to coordinate their activities in the thick of time.

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