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Punctuated Equilibrium, Process Models and Information System Development and Change: Towards a Socio-Technical Process Analysis

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Abstract
We view information system development (ISD) and change as a socio-technical change process in which technologies, human actors, organizational relationships and tasks change. We outline a punctuated socio-technical change model that recognizes both incremental and dynamic and abrupt changes during ISD and change. The model identifies events that incrementally change the information system as well as punctuate its deep structure in its evolutionary path at multiple levels. The analysis of these event sequences helps explain how and why an ISD outcome emerged. The change constructs are integrated with a socio-technical model of ISD in which configurations in work systems, building systems and the environment and their isalignments- gaps - drive ISD change. By conceiving ISD and change as a sequence of events and states, researchers can narrate explanations of ISD outcomes. Practitioners can use the odel in post mortem analyses to diagnose and learn about the effectiveness of their ISD interventions. The explanatory power of the model is demonstrated with a case study of complex ISD and change over an eight year period.

Keywords: Information System Development and Change, Socio-Technical Analysis, Change Theories, Punctuated Equilibrium, Process Models, Narrative, System Failure, Longitudinal Case Study

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Introduction

Information system development (ISD) is concerned with producing changes in an organization's technical and organizational subsystems (Swanson 1994). Information systems (IS) research has traditionally analyzed such change as a linearly progressing task where an IS is designed and implemented in an organizational context (Lyytinen 1987a, Lyytinen *et al*. 1998). IS research since it inception has sought to increase the effectiveness of this task (Keen 1981) and formulated a plethora recommendations that address the technical quality, accuracy and the precision of the system to be designed; or the efficacy and nature of the social processes - e.g. user involvement - that affect ISD outcomes in terms of their behavioral and organizational validity (Lyytinen 1987a, Markus and Robey 1983).

Despite steady progress in developing systems we still face an alarming number of failures: over 50% of systems fail (Lyytinen and Robey 1999). In particular, failures are typical for large systems where change processes become so chaotic that Drummond (1996b) refers to them as "Mad Hatter's Parties". Past IS research has focused primarily on explaining such changes by using variance theory which hides the change process, but connects causally succeeding socio-technical vector measures. When change is recognized in the IS literature - e.g. in planned models of change (Keen and Scott-Morton 1978) - it is regarded to be incremental and cumulative which can be organized into a stepwise progression. All these approaches hide the dynamics, discontinuity and complexity that characterize ISD change. They embrace no effective theory of ISD change because they do not offer a conceptual means to analyze the multi-faceted, simultaneous, complex and discontinuous change associated with ISD.

In this paper we are concerned with the following two research questions: 1) what is an appropriate theoretical model to understand ISD change as complex and discontinuous change? and 2) how such a model can be used to analyze complex ISD and change processes and explain their outcomes? To address these questions the paper *formulates a punctuated socio-technical process model (*subsequently called a *PSP model) of ISD and change* which integrates three streams of literature: socio-technical theory and models, punctuated equilibrium theories, and process theorizing. We draw upon a socio-technical model of system development (Lyytinen *et al*. 1996, 1998) as a way to understand the *content of ISD-related change*. Second, we draw upon the punctuated equilibrium change model (Gersick 1991) as a way to *understand how this change takes place*. Third, we draw upon *process theories* (Langley 1999, Pentland 1999, van de Ven *et al* 1999, Mohr 1982) to *understand how process narratives* as a conceptual lens *explain process outcomes* (Mohr 1982, Pentland 1999). To address the second question we formulate a process analysis framework using the PSP model of ISD and change and demonstrate its usefulness in explaining a complex ISD initiative which unfolded over almost a decade. We also show how the model explains better the observed process outcomes than other proposed process models.

The remainder of the paper is organized as follows. We first clarify the concept of ISD and change as an instance of socio-technical change and explain the concept of punctuated equilibrium as a means to understand how systems change. Next we explain how this model can be operationalized into a research methodology that can be applied to a case study. The next section illustrates the use of the methodology with a case study where we analyze the development of a claim processing system over the best part of a decade. The case illuminates how the PSP model offers a relatively simple, yet powerful way to account for the system change as a sequence of events in socio-technical systems at multiple levels. The paper ends with a discussion of the findings and how current topics such as success and failure and escalation theory are thereby illuminated.

Information System Development and Change as Socio-Technical Change

What is ISD change?

During ISD an organization seeks to install a change process where its information processing system is deliberately transformed. Key challenges in explaining ISD outcomes are the following: 1) what is being designed and changed during ISD? (Lyytinen 2004) and 2) how change works in such situations (Gersick 1991).

With regard to the first question, we will define an information system as an organizational system that consists of technical, organizational and semiotic elements which are *all* re-organized and expanded during ISD to serve an organizational purpose (Lyytinen 1987b). In other words, ISD creates, re-configures and re-organizes elements and their relationships within and between three realms: 1) signs and symbols deployed by the organization, 2) its social organization and work processes, and 3) its technological subsystems. One important facet of this change is the re-configuration of a new *socio-technical* work system that will execute, coordinate, and manage information-related work activities (Mumford 2003, Bergman *et al*. 2002a). In this paper we will focus mostly on ISD related change from the viewpoint of socio-technical change.

With regard to the second question most of the IS literature assumes that ISD produces changes in socio-technical (Mumford 2003), political (Keen 1981, Grover *et al*.1988), or strategic (Scott-Morton 1991) dimensions. IS scholars have assumed that the intended change will be smoothly executed as the organization adapts to it once the change has been adequately specified, designed and technically implemented (Bergman *et al*. 2002a, 2002b). Change is incremental, linear and cumulative (for a different interpretation see Parnas and Clements (1986)): it takes place gradually by shifting the foci from high level organizational issues to technical ones, and then transfusing the technology into the routine (Lyytinen 1987a). The literature varies mostly in how it narrates the sequence of tasks, which reflect variations in espoused process models such as waterfall vs. evolutionary, or iterative design (Lyytinen 1987a, Parnas 1991). Likewise, most of the organizational implementation literature (Lyytinen 1987a, Kwon and Zmud 1987) distinguishes between sequential stages (e.g. unfreezing, moving, refreezing) through which the social system gradually moves. Finally, change takes place at most on one level only - the project organization that produces these changes is not expected to change, or if it does, this will not affect the ongoing adaptation process.

If we turn our attention to empirical research of system use and failed systems, a different portrait of change is painted. Studies of system use and adaptation (Tyre and Orlikowski 1994, Lassila and Brancheau 1999, Majchrzak *et al*. 2000) characterize system use in terms of both incremental adaptation *and* leap-frogging with "lumpy" transformations which draws upon theorizing on organizational adaptation and emergent change (Halinen *et al*. 1999, Fox-Wolfgramm *et al*. 1998, Romanelli and Tushman 1994, Tushman and Romanelli 1985, Weick 1998). System use always involves small adaptations or embellishments (Weick 1998) that are caused by variation and trial and error learning. But sometimes a *gestalt* change takes place that results in radical transformations (Tyre and Orlikowski 1994). Moreover, transformative changes are not necessarily improvements (Lassila and Brancheau 1999) but they are abrupt (Tyre and

Orlikowski 1994). The *gestalt* shifts result from small cumulative changes, which at some point result in a critical specification that ignites the change; but they may result also from contextual discrepant events, or misalignments between critical elements (Lassila and Brancheau 1999, Majchrzak *et al*. 2000).

Another stream that has explored change as being both incremental and radical change is studies of systems failure (Davis *et al*. 1992, Drummond 1996a, 1996b, Keil 1995, Markus and Keil 1994, Markus 1983, Oz 1992, Lyytinen and Hirschheim 1987). Perhaps, because of the extreme nature of the studied ISD outcomes, most of these scholars view failure as an abrupt event in the development trajectory (Keil 1995, Markus and Keil 1994, Drummond 1996a, 1996b). Most of this research has not, however, explored the cause or mode of such abrupt changes, nor sought to generalize from these observations to explain system change.

Punctuated Equilibrium Paradigm

Theories of change distinguish two main paradigms (Gersick 1991, Tushman and Romanelli 1985): one of continuous incremental change where change accrues from a slow stream of small mutations and shifts; and another one of revolutionary punctuation where compact periods of metamorphic change (revolution) are followed by long periods of stability (equilibrium) and incremental adaptation. The first paradigm - incremental change - is rooted in the Darwinian mutation concept: change is continuous, incremental and cumulative. Even pervasive change like the creation of a new species is carried out through small, additive steps (Gersick 1991). In the second paradigm - that of punctuated equilibrium - a change is sometimes incremental and slow, but in other contexts rapid and abrupt (Gersick 1991). Accordingly, change is not necessarily progressive, and the systems are not malleable: they occasionally seek to prevent the change, even incremental change.

In this paper we view *ISD and change primarily from the viewpoint of the punctuated equilibrium paradigm*: ISD change will be characterized by alternations between long periods of incremental adaptation - called first order change - and brief periods of revolutionary upheaval - called second order change (Gersick 1991, Fox-Wolfgram *et al*. 1996). To use this paradigm thoroughly in investigating ISD and change a few remarks of how to characterize punctuated changes with a systemic distinction are in order[1].

The key ideas behind the punctuated change paradigm are: 1) change is not always smooth and gradual, 2) the system does not accept any type of change – small or large - under certain conditions, 3) systems do not possess teleology but inch forward to some final state (such as an accepted system, balance etc.), and 4) the system's composition and interaction principles will change radically through successive punctuations. As a result different explanatory mechanisms are needed at different times to explain observed outcomes. The punctuated equilibrium change explanation rest on four key elements (Gersick 1991; Fox-Wolfgramm *et al*. 1998):

1. Systems have *a deep structure* which refers to "the set of fundamental 'choices' a system has made of "i) the basic parts into which its units will be organized, and ii) the activity patterns and principles of interaction that will maintain its existence" (Gersick 1991 p. 14). These deep structures are

[1] Philosophically such views of change date back to Hegel and his dialectics that recognized that systems evolved through stages which had different behavioral laws (Hegel 1969). The same idea was prevalent in Marx's theory of dialectics.

stable in that they are inherited from history and they imply the path dependency of system structure and behavior (Garud and Karnoe 2001). Thus the first moves in the system's adaptation are the most fateful, and the activity patterns enabled by the current deep structure reinforce the system through feedback. (Gersick 1991 p. 16).

2. Systems go through periods of relatively stable *equilibria,* which are dependent on and determined by the system's current deep structure. As Gersick (1991 p. 16) argues: "The equilibrium period consists of maintaining and carrying out these choices" made with regard to deep structure. The periods of stability are sustained by inertia caused by routinization, cognition, motivation and obligation and the benefits of system stability (Tushman and Romanelli 1985). During equilibrium, systems undergo incremental adaptations and perturbations. Such changes can be fast paced due to the nature of the internal or external perturbations or the specific configuration of the system. Yet, all these adaptations keep the deep structure intact.
3. Systems face periods of *revolutionary changes*[2] that are characterized by the potential of and need for upheaval and reformation of the deep structure. During the revolutionary change the deep structure is dismantled leaving the system temporarily in flux until a new deep structure emerges through initial structuring. A new configuration will consist of both old elements and pivotal new pieces, but they will all operate with a different set of rules (Gersick 1991) as determined by different connections. A revolutionary change can originate either from internal changes and the misalignments between internal elements, or from novel, unexpected external changes that affect how the system adjusts to its environment. These revolutions may also fail and the system can fall back into its old regime, or escalate into continued disarray. As a result the system may start oscillating between upheavals and attempts to bring order into the chaos that in turn start a new punctuation.
4. Punctuated change involves a *multi-level structure*. Change accounts cannot be reduced to explanations at one level by examining interactions of critical elements within a single level of a well-bounded system. Such explanations are only useful in explaining first order change. In contrast, analyzing the second order change requires crossing multiple levels and understanding their complex interactions. Hence punctuated change is embedded in and affected by multiple temporal and systemic levels. Thus investigating and explaining such change requires concurrent analysis of multiple levels.

[2] Though Gersick coins these periods as revolutionary there is not necessarily anything else revolutionary other than an abrupt transition that is fast and results in qualitatively different configuration in her description. Her own study of teams (Gersick 1988) and their different team behaviors at different parts of the project implies no concept of deliberately planned revolution.

ISD and Punctuated Equilibrium

According to a punctuated change paradigm a new IS can sow the seeds for revolutionary change: it can re-configure the deep structure of work systems. Such reconfigurations involve adding new technical elements; replacing and removing or expanding organizational routine; or switching into new patterns of ideas, beliefs, skills and values that underpin and are embodied in the organizational system (Greenwood and Hinings 1993). To render such change successful the new system has to be imposed upon the organization in a metamorphic manner so that a punctuation takes place. But punctuated change theory explains that this change is difficult due to inertia caused by routinization, cognition inertia, motivation gaps and obligations (Gersick 1991, Berger and Luckman 1967). Equilibrium is maintained due to the impact of professional managers (Scott Morton, 1991), stakeholder interests (Latour, 1987), the organizational environment (Lawrence and Lorsch, 1967), or situated emergence in organizational decision-making (Suchman, 1987). If successful, the new system will continue to operate until it is changed due to new demands from the institutional (DiMaggio and Powell 1983) or competitive environment (Scott-Morton 1991), or unexpected internal changes. This continued dynamic will create a trajectory of punctuated IS adoptions. Hence ISD and change emerges as "alterations between long periods when stable infrastructures permit only incremental adaptations (normally called maintenance), and brief periods of revolutionary upheaval" (called ISD and change Gersick 1991, p. 10).

Being revolutionary, ISD and change by nature is complex, uncertain, ambiguous and hard. It is complex in that system behaviors during the transition are not deterministic and thus connecting cause and effect is fragile and remains a challenge (van de Ven *et al*. 1999). It is uncertain in that system developers face a cognitive challenge in predicting the impacts of their intervention. Often to their disappointment, their interventions remain stubbornly uncertain and the intended change does not follow as forces from the deep structure will resist. ISD is ambiguous in that the significance of the change and its motivations alter over time (Baier and March 1986, March and Olsen 1981). Finally, the change is hard due to technical complexities and the volume of the effort needed to mount the transition. Not surprisingly, many ISD change processes exhibit longevity and persistence and the expected change is never realized. Change projects can grow from modest, short-term initiatives to uncontrollable behemoths lasting for decades and that are condemned to wander, never reaching the "promised land" (Keil 1995, Drummond 1996a, 1996b, Lyytinen and Hirschheim 1987).

Due to the nature of the ISD change a separate socio-technical system - called here a building system – has to be established with sufficient powers, resources and skills to carry out the change (Lyytinen *et al* 1996). In this regard, the work or legacy system is located at the lowest layer of the systems and characterized by strong path dependencies, habitualization and cognitive inertia and high levels of complexity. The building system is expected to command and enact a set of routines - through explicitly formulated rules and regulations often engrained in tools and procedures, and tacit and embedded competencies afforded by individuals within the system (Gersick 1991) that can change and transform (i.e. trigger the punctuation in) the work system. The separation of the building system creates thus a multi-layered change across systems with their own punctuations which interact and influence each other during ISD and change.

We can now formulate the original research question 1 on p.3 in association with the punctuated change paradigm for ISD and change as follows: 1) how can we devise a model of a deep structures to explain punctuated ISD change?; 2) how can we organize accounts of ISD as a set of nested, hierarchically organized system changes and their interactions?; and 3) how can we explain these changes from the view point of process theorizing (Mohr 1982, van de Ven *et al*. 1999)?

How can we devise a model of a deep structure to explain punctuated ISD and change?

ISD as a punctuated change leads us to ask: what are the menus of choice (Gersick 1991 p. 16) of system change associated with ISD? The menu of choices should offer a simple, comprehensive, and adaptable set of concepts to characterize change both at the level of deep structures and their incremental variation as well as causes for both types of changes. In this paper we adopt Leavitt's open system model of organizational change with some modifications (Leavitt 1964, Kwon and Zmud 1987, Lyytinen *et al*. 1998) to conceptualize the deep structure that underpins ISD change (figure1). The main reason for using Leavitt's model is that it outlines an open system model of change that draws upon types of components that will change during ISD and their alignments, equilibria and disequilibria within and between these components and changes in the environments. It is relatively simple, and it can be adapted across a set of contexts as demanded by the idea of hierarchical organization. Finally, we can describe both incremental and deep changes with this model as will be shown below.

In Leavitt's model, the components are aligned in the sense that the chosen change dimensions and their interactions meet theoretical norms and practical needs of mutual coherence (Nadler and Tushman 1980), and thus have close affinity with Gersick's formulation of system equilibrium (Gersick 1991). Moreover, the model does not assume any teleology and views socio-technical change as a continued adaptation to internal and external changes. Finally it is an organic and open system model - again in line with Gersick's ideas of punctuated change, where environment plays a significant role.

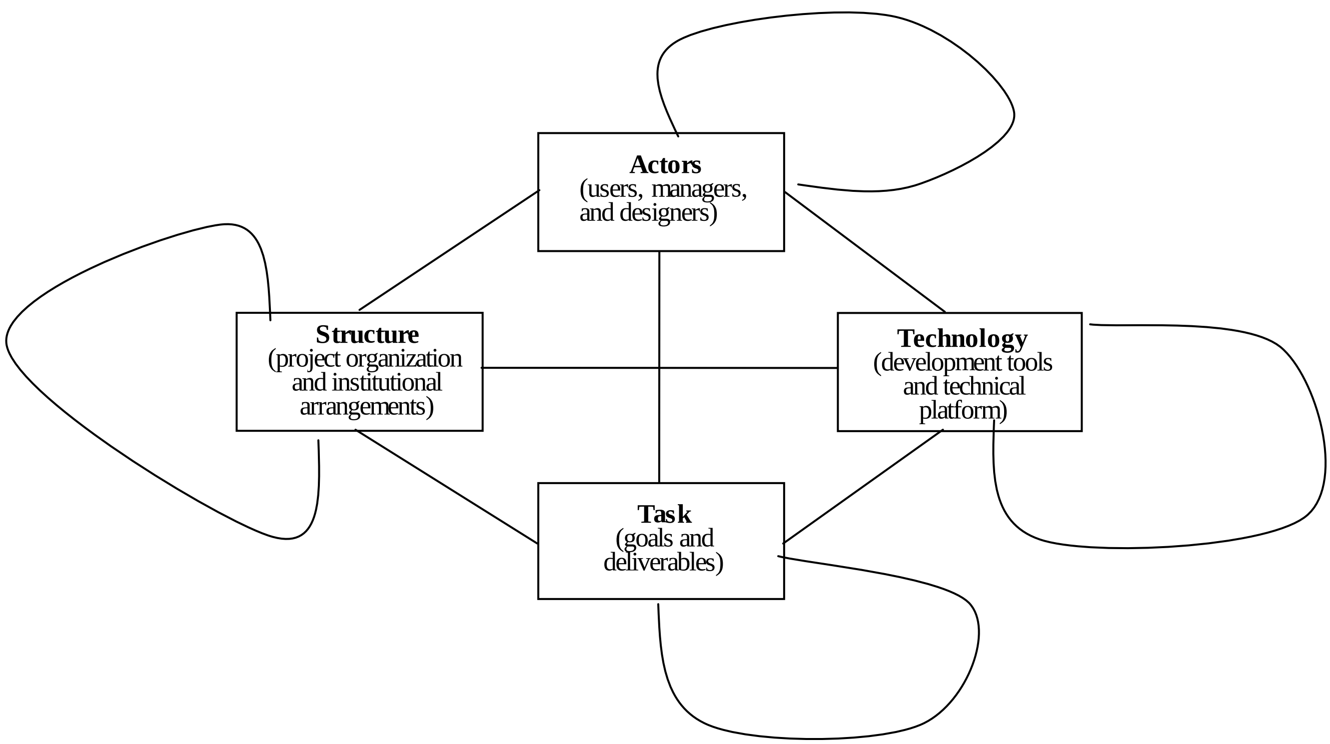

Figure 1: Socio-technical model

Socio-technical component	**Main content**	**Main properties**	**Literature**
Task	*Work (legacy) systems: Task* describes an organization's *raison d'etre* and the way in which the work gets done within the organization. *Building system:* a task is defined through project deliverables and aspired process features in that a development task dictates what developers should accomplish and how in relation to a socio-technical change *Dynamics:* Incremental: The more complex and uncertain the task, the higher the likelihood that the system will falter towards disequilibrium. Punctuation: The organization's task changes is reformed. Justification for the task is transformed or disappears.	Task size and complexity, Task uncertainty, Task ambiguity, Task specificity, Task stability, Time and performance criticality.	*General:* Leavitt 1964 *IS literature* Beath 1983, 1987; Beynon-Davis 1995; Blokdijk & Blokdijk 1987; Burns & Dennis 1985; Curtis *et al*. 1988; Lucas 1982; Lyytinen 1987a Mathiassen & Stage 1992; Nidumolu 1995; Oz 1994;; Saarinen & Vepsäläinen 1993a, 1993b; Sabherwal & Elam 1996; Salabert & Newman 1995; Turner 1992; De Zmud 1980
Actors	*Work (legacy)systems*: Actors include an organization's members and its main stakeholders who carry out or influence the work. *Building system:* represent individuals or groups of stakeholders who can set forward claims or benefit from system development. Actors include customers, managers, maintainers, developers, and users *Dynamics:* Incremental: the bigger misalignment between the actors and the other components (task, technology, structure) the bigger the likelihood that the system will falter towards disequilibrium. Punctuation: Need for radical transformation in the actor's skills, world view or values	Personal properties, Commitment and skill, Differences among stakeholders, Wrong expectations, False beliefs, Non-existent or unwilling actors, Unethical professional conduct, Personnel volatility, Politics, and opportunism.	*General:* Leavitt 1964, Perrow 1979 *IS literature:* Beynon-Davies 1995; Boehm & Ross 1989; Boland 1992; Borum & Christiansen 1993; Curtis *et al*. 1989; Ginzberg 1981; Grover *et al*. 1988; Henderson & Lee 1992; Hirschheim & Newman 1990; Keil 1995; Markus & Keil 1994; Oz 1994; Saarinen & Vepsäläinen 1993a, 1993b; Keen 1981; Wilkocks & Margetts 1994,
Structure	*Work (legacy) systems: The structure covers systems of communication, systems of authority, and systems of work flow. It includes both the normative dimension, i.e. values, norms, and general role expectations, and the behavioral dimension, i.e. the patterns of behavior as actors communicate, exercise authority, or work.* *Building system: The structure covers formal project organization and decision-making structure, work organization, its workflow and means and channels of communication. It is defined by project management frameworks, methodologies (work organization and workflow) and communication frameworks.* *Dynamics: Incremental: the bigger the misalignment between the task and structure the more likely the system will shift towards disequilibrium.* *Punctuation: Transformation or reorganization of key elements of structure: work flow, system of authority or communication structure.*	Level of formality, Level of centralization, Level and span of control, Means of control, Allocation of rights and duties, Geographical dispersion, Functional differentiation and specialization.	*General: Damanpour 1991; Leavitt 1964; Ouchi 1979; Perrow 1979* *IS literature:* *Beath 1983, 1987, Curtis et al. 1988; Davis et al. 1992; van Genuchten 1991; Lyytinen 1987a; Markus & Keil 1994, Nidumolu 1995; van Swede & van Vliet 1994; Thambain & Vilemon 1986*
Technology	*Work (legacy) systems: Technology denotes "tools—problem solving inventions like work measurement, computers, and drill presses"* *Building system: We include within technology the methods, tools, and infrastructure used to develop and implement the information system* *Dynamics: Incremental: the bigger the misalignment between actors and task due to unreliable, inefficient, non-standardized, non-compliant, or functionally limited technology the more likely the system will shift towards disequilibrium.* *Punctuation: Disruption in technological basis, discontinuation or radical shift in the technological sub-systems of the socio-technical system.*	Functional dimension (production, coordination, control, adaptability), Level of specialization, Functional scope and integration, Systemic properties (reliability, performance, ease of use).	*General: Leavitt 1964, Perrow 1979* *IS literature:* *Genuchten 1991; Lyytinen 1987a; Oz 1994; Sabherwal & Elam 1996 ; Willkocks & Margetts 1994*

Table 1. Features of socio-technical systems and their change

Originally, Leavitt's model synthesized the main contours of research concerning organizational change "as a kind of sharp caricature of underlying beliefs and prejudices about important dimensions of organizations" (Leavitt 1964 p. 55). It is also well established in IS research to trace change (Scott-Morton 1991, Yetton 1997) - especially in the IS strategy literature. The model displays virtues of a good classification: it is simple, extensive[3], and it is sufficiently well defined to be applicable. The model views an organization as a multivariate system of four interacting and aligned components - task, structure, actor, and technology (Figure 1) that builds up the technological, the social, the organizational or the strategic/ task cores of the organization. Each component can be further decomposed into subcomponents. Table 1 clarifies the nature and content of each socio-technical component and identifies the main streams of the literature in the organizational theory and the IS literatures for each component. As shown, each component can easily be translated into a well-understood aspect of ISD and change.

ISD Change as a Set of Nested Punctuated Events

The classical socio-technical model postulates that four interacting elements remain in equilibrium or seek to reach such equilibrium. Changing one component will result in compensatory or retaliatory adaptive changes in the others (Leavitt 1964 p. 55) so that the system maintains equilibrium. A change in any one component will have effects, planned or unplanned, on any other component with also second and third order effects. Due to the recursive organization of the system sub-components their interactions will also produce emergent properties for the system, or components that can propagate through the system thus establishing a hierarchical view of change.

The model observes a natural tendency in any socio-technical system to drift from its equilibrium (c.f. law of entropy) unless the system is managed to prevent that happening. Accordingly, socio-technical system literature suggests that system designers must control variations within any system process (Mumford 1983, 2003). With Leavitt's model we can thus conceive ISD change as variations in multiple, nested socio-technical systems: the work (legacy) system, the building system, and the organizational environment. ISD change results from multiple concurrent adaptations to variances in these socio-technical systems. The ISD changes are responses that seek to maintain, de-stabilize, or establish equilibria in tightly connected systems.

In explaining the change, Leavitt's original model submits to a linear change paradigm in which organizational systems incrementally change by adjusting to perturbations and the components need to be constantly adapted to keep the system in equilibrium. The perturbations are analyzed with the concept of variance that changes when misalignments or new types of alignments emerge in the system (Mumford 1983, 2003). Table 1 shows under the heading *dynamics* (column - Main content) how each socio-technical component can become a source of such misalignment which we call here a *gap*. Origins of variations can and need to be sourced to any of the system components. The way in which these variations in components propagate depends in turn on existing systemic alignments - the deep structure - of the system.

We will now expand this idea with Gersick's concept of punctuated change. In this interpretation, a misalignment can result in two types of changes (as shown in tables 1a and 1b). First, whenever any component changes, other components can incrementally adapt. It is due to the system's deep structure that such incremental alignments will normally take place. Much of

[3]For example, Kwon & Zmud (1987) augment the model with the concept of an environment.

the organizational theory summarized by Leavitt (1964) sought to explain such interactions and resulting incremental change, though the change often exhibits chaotic and emergent behaviors (van de Ven *et al*. 1999). Second, following Gersick's idea of punctuation, we propose that on some occasions where the rules of socio-technical system (its deep structure) break down the system and its sub-systems needs to be reconfigured anew through punctuation. Examples of such punctuations are listed in tables 1a and 1b. These periods of upheaval are referred to as transition states (Lassila and Brancheau 1999). When such a period is over a new deep structure emerges, the system returns to its original state, or it shifts towards increased chaos and remains in transition. This generates a new space of alignments that may be more effective in the environment.

Two types of changes in the socio-technical system originating from critical misalignments – gaps - can help narrate how ISD change exhibits both a punctuated change and incremental adaptation. It also helps detect under what conditions incremental changes or punctuated transitions emerge. Thus, we need to first analyze how incremental variations take place over time to respond to gaps, and then explore how occasionally the socio-technical system organizes itself into successive deep structures. Continued interactions between system layers also build path dependent chains of influence that shift the system either towards, or away from equilibria, where deep structure needs to be dismantled occasionally at different levels.

In theory, any gap can pose a threat to the existing equilibrium and push the ISD change towards punctuation. The punctuated model also postulates that because each component continuously changes any variation can grow cumulatively into gaps that call for radical re-organization. In addition, any attempt to remove such gap can decrease system stability due to poor understanding of the system (Cohen *et al*. 1972, van de Ven *et al.* 1999) or an actor's deficient performance. New interventions can introduce unintended second and third order effects that generate additional misalignments in other systems, which can propagate through the whole ecology of systems and lead to multiple punctuations.

How Can We Explain ISD and Change from the View Point of Process Theorizing?

We submit here to a view that ISD change cannot be explained by linear, context-independent causality as exemplified in variance research (Agar 2004, Mohr 1982, van de Ven and Huber 1990, van de Ven *et al*. 1999). As a consequence, we need to build change models that weave narratives where sequences of events explain how things evolved over time, why they evolved in the way they did across a set of systems, and why specific ISD outcomes emerged (Langley 1999). Any such account forms a process model insofar it uses a sequence of events across system levels as an explanatory mechanism for the observed ISD and change outcome. We conceive of ISD and change as a sequence of events and states which unfold sequentially and in parallel – across socio-technical systems and within systems - creating complex change dynamics. For example, poor technical design (as an event) may result in an unreliable or slow system (a technical system state in the work system), which leads to (an event) user resistance (a state in the actor element in the work system) leading to the rejection (an event) of the proposed solution (an incongruent state i.e. no workable work system solution). Many types of interventions (events) can follow any event including: introducing new organizational work flow (structural event), carrying out user training (actor event), or redesigning the user interface and the back-end data base (a technological event).

During process analysis each event is interpreted as a move in an actor's maneuvering in the building system that seeks to order and align technical and social elements (Law 1987) in the work systems and/or building system, and pits actors against other socio-technical elements. Narrated processes offer a way to make sense of how events and states relate, why events create a new state, and how the event sequences lead to observed outcomes. By anchoring process data into codified events and their orderings the resulting process model carves out mechanisms and patterns of change (Langley 1999). Such mappings abstract features of the process and generalize towards process commonalities and patterns that connect to likely ISD outcomes. At the same time they offer a faithful account of the actors' own experiences and their behavior as they relate to what was done, by whom, in what context, and why. DiMaggio (1995), and Newman and Robey (1992) both argue that process models adopt a specific form of explanation and should not be discounted as unscientific or less rigorous due to their different form. The downside of such descriptions is that they are cumbersome to build and analytically complex.

Our PSP model of ISD and change combines the concept of event sequences with the idea of punctuation. This suggests an analysis that Langley (1999) calls a visual mapping strategy of tracing process chronologies. Here investigators craft causal connections (or dependencies) between process events, their environments and outcomes and observe differences between events. In our mapping, the latter key concept - punctuation - offers a sense-making device to understand the varying nature of events, their significance, organization and scope. The former - the socio-technical model - helps identify mechanisms that generate events, and also how and why the events generate specific impacts by being organized in specific way. Together these two strategies help recognize events and states during ISD and change and offer a basis to derive process constructs for further analysis and hypothesis generation and validation.

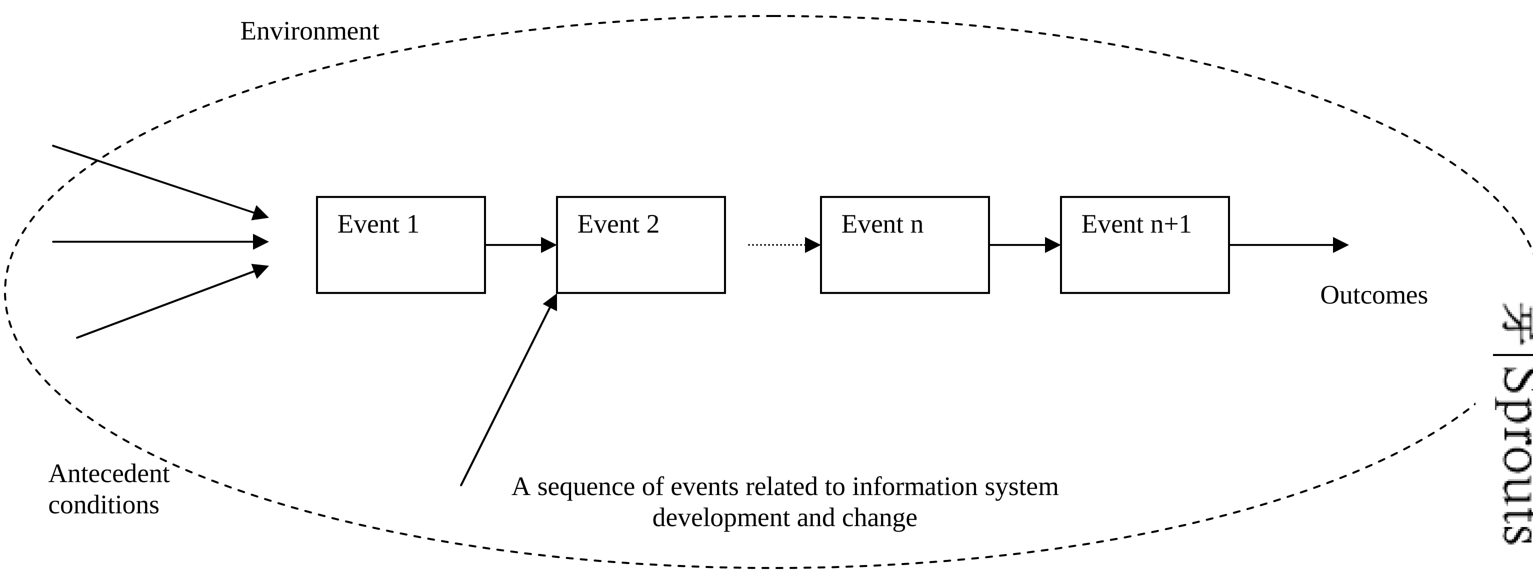

Figure 2: General process model

An essential ingredient in building process models is to identify process outcomes as *system states*- i.e. as configurations of socio-technical elements - rather than as a vector of variable values. Therefore, in the proposed model we separate different outcome sets: 1) an event leads to a socio-technical configuration in equilibrium, which can be either an incremental adaptation of generation of a new deep structure; 2) an event fails and the system retains its misalignments i.e. it is still in disequilibrium and/or has added new disequilibria. Hence, the process outcomes relates directly to the success or failure of the intended change. Yet, the archetypal sequence of events (Pentland 1999) of balance-imbalance-intervention-balance as followed in implementation and ISD methodologies (Schein 1961, Parnas and Clements 1986) is not assumed here. The simple schema for process mapping is depicted in figure 2. ISD and change data is abstracted into a set of consecutive and parallel events, which by being assembled together explain ISD outcomes. Events relate to antecedent environmental conditions (context), which form part of the necessary conditions for events. The model does not offer a dispositional explanation that identifies necessary and sufficient conditions for events to occur as represented in the likelihood of an event to occur[4], or in R^2 values of a variance model. Thus we need to recognize antecedents for any event by observing the system state and possible internal or external changes that create the event. Our main interest is to explain how antecedents played out in generating the event, and what its outcome was. Antecedents are regarded as specific relationships between the socio-technical elements prior to the event, and are seen as products of the system history. They carry over its path dependent behavior - its deep structure - whereby the system exhibits a tendency to repeat its behaviors and reproduce its structure (Cyert and March 1963; Newman and Robey 1992). Antecedents at the same system level - work system, building system - are treated as if they share a history. Such dynamic treatment of antecedents does not form part of variance models though time series can analyze interactions between two antecedent states. The focus on history helps analyze changes during ISD in terms of differences in antecedent event sequences (histories) to account for possible variance in outcomes. This historic focus adds ambiguity, and can lead to biased explanations if care is not taken to triangulate data and to expand analytical levels. To overcome these limitations we use hierarchical levels of analysis (recursivity), and multiple sources of data where actor's narratives form an important part as explained below.

Building a PSP Model of ISD and Change

We will now turn to research question 2): how to formulate a PSP model to explain specific ISD outcomes? The process analysis needs to observe events during ISD and change over an extended period (Newman and Robey 1992[5]), which occur both within the organization and its immediate environments. We differentiate between external changes in an organization's environment, and the management environment of ISD change, and focal changes that cover the work system (e.g. user resistance), and the project level i.e. adoption of new methods, tools or changes in project staffing.

A change in any focal system can occur as a result of a purposeful intervention (an attempt to implement a new system), or a non-controlled event (a project manager leaving) in

[4]. Some process models include probabilities for events to trigger other events (Langley 1999; van de Ven *et al.* 1999). In this paper we do not develop such a model.
[5] We refer here to a study that used the approach in the IS literature for the first time. Pettigrew (1990) has generally formulated a similar process-based approach (see also Langley 1999).

that it generates a socio-technical gap (Figure 3) covering all socio-technical elements shown in table 1. The major challenge is the discovery and validation of causality: how to detect those changes that truly influence the system by creating a gap from a huge stream of events that bombard such systems every day. Clearly, every interaction like a small change in software, hiring a new analyst, changing slightly the project organization, etc. cannot be considered to be of equal importance. We call state changing events that causally affect system states, *critical incidents.* Such events form critical and necessary conditions in rendering a change in the socio-technical state and creating a gap in that the change would not happen without the event.

Critical incidents can be mined from process data including interviews, reported changes in work systems, technical system documentation, examining changes in organizational charts and other documents, or by direct observation of work processes. Some relationships between event and states can be derived based on existing organizational theory (e.g. relationships between standardized technologies and hierarchical organizational form). A critical incident can be judged to be critical by analyzing the scope and depth of the impact (failure to run the system), or based on actors' reports (a quote in an interview as to why the change was for the worse thus leading to system resistance). In the similar manner we need to analyze the outcomes of such events and recognize their scope and severity as to assess their level of impact. Critical here is to distinguish between incremental and punctuated outcomes. We regard all those events which do not threaten the current system operation or significantly change their alignments as incremental while events which undermine the system or change their operation (e.g. a totally new work system, a new way to develop systems, a new strategic initiative) as punctuated. It is critical to note that intentions behind events do not make them incremental or punctuated- it the the nature of the outcome. Overall, we assume epistemic modesty in the analysis so no investigator can be expected to have omnipotent knowledge of such events and their consequences due to her/his limited cognitive capacity of deciphering causality. At most, we can expect to reach plausible explanations of events and their outcomes by carefully analyzing their impact on the current state, and how the change has have taken place.

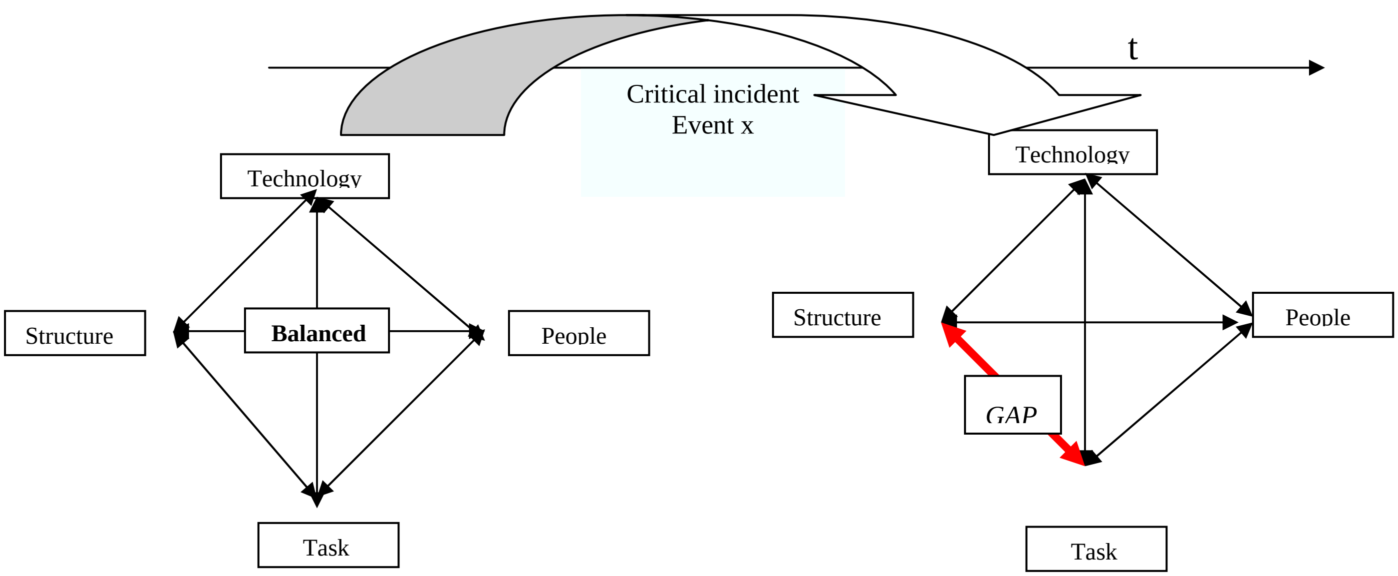

Figure 3. An event model for socio-technical analysis

To detect a critical incident each observed gap needs to be traced back to its main originating component change: either another event, or a new state of the external system. We must also explain how the gap, the outcome, emerged due to the change in antecedent states. To be faithful the analysis needs to define the scope of each event's impact in terms of socio-technical relationships affected (Figure 3).

States in our analysis are interpreted as episodes in Newman and Robey (1992) - a set of events that stand apart from other events thus signifying the end of one sequence and the beginning of another - that are separate from one another. Each state consists of a set of non-interesting events for our analysis. Thereby, each identified state corresponds to a path-dependent socio-technical state. The PSP model identifies thus relationships between socio-technical elements that persist both within and across episodes[6].

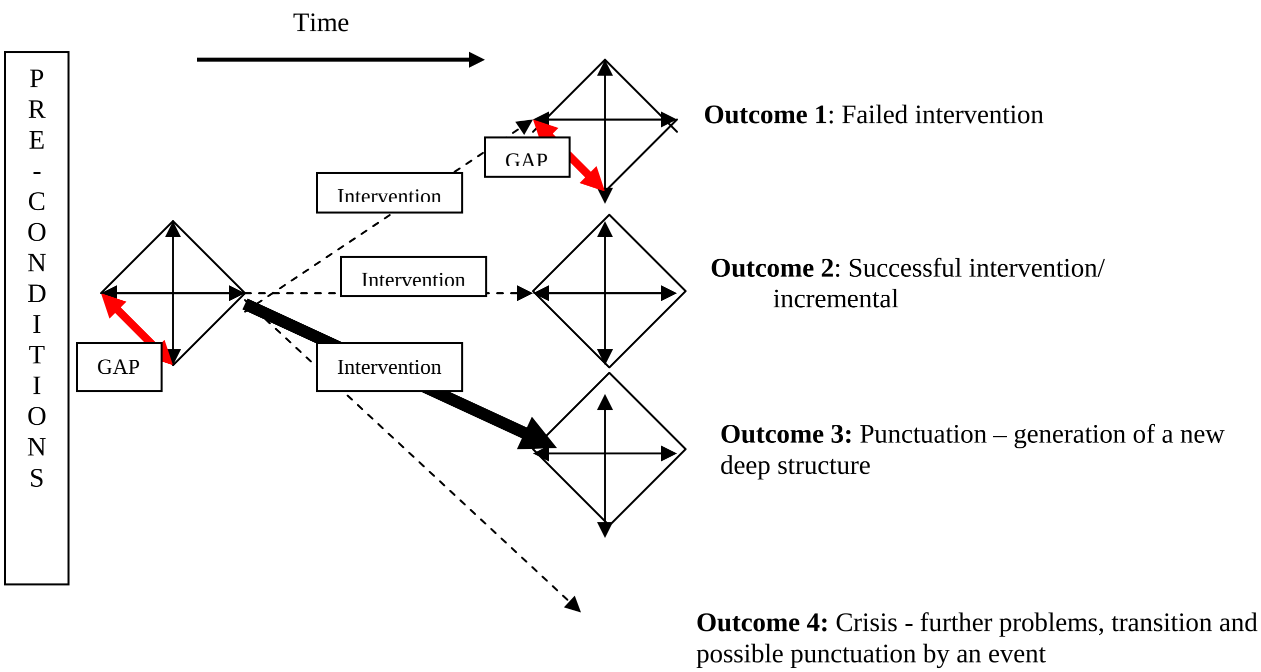

Figure 4. Four types of outcomes from events

By weaving events and states into a sequence the PSP model conveys ISD and change as a set of equilibria and disequilibria at multiple system levels separated by events, which remove, do not change or increase disequilibria. Each focal system is either in equilibrium, and the system is balanced, or it is not in equilibrium and not balanced. When it is in disequilibrium the system contains a gap, a misalignment, between one or several of its socio-technical elements. The gap may reside in the system over a long period of time, but at some point it normally calls for action – for an intervention *event* - to remove the gap or sometimes an unexpected event happens outside which removes the gap. These events will result a) in restoring a balance either by incremental change or a punctuation where a new deep structure emerges, b) in sustaining the current gap, or c) creating an additional set of gaps (figure 4). When gaps prevail despite

[6]Collaborative and critical evaluations of alternative explanations for the same set of events are therefore necessary to untangle possible biases in detecting drivers of change.

interventions or lack of such interventions or their impact is significant but in wrong direction, the system will drift to increasing disarray: it is now in transition and some events can trigger punctuations that change the rules of the system and reorganize its deep structure. Identification of such transformative events help to understand how and why focal systems during ISD process become punctuated. Because of the hierarchical organization such events can traverse across system layers. For example a building system will trigger an event in the work system to punctuate a change where a new system is adopted.

The process analysis starts normally from a point which triggers a need to engage in information system development and change as to remove a gap and punctuate the work system.. Hence, the primary socio-technical system (the work system) is expected to be imbalanced to justify an intervention. The process then follows all events in the work system, the building system and their environments that are deemed critical to understand the outcomes (states) in each of these systems. The *dureé* of the analysis covers all periods in which a major change in the organizational information processing task (work system) is either successful or rejected resulting in a stabilized socio-technical system, or in continued chaos and withdrawal of the building system (Keil 1995, Markus 1983).

Research Methodology for Analyzing ISD Change with Punctuated Socio-technical Model

Selection of a Research Strategy and Data set

We next illustrate the construction of a PSP model that we used to explain ISD outcomes related to a rich, longitudinal case, which we call the Hartfield case. This data set reports how a claim processing system was developed over an 8 year period. The case offers an interesting opportunity for grounding the PSP model empirically and refine its concepts - in particular the concept of interventions, gaps, critical incidents and incremental adaptations and punctuations, though it was not originally collected by using this model. Due to its richness it offers an interesting way to theoretically triangulate the rendered interpretation of the process data with other available analysis of the same data which we have conducted.

Qualitative case studies form a useful way to build and validate process models, although quantitative models such as simulation or sequence analysis are also applicable (Langley 1999, van de Ven *et al.* 1999, Sabherwal and Robey 1995). Congruent with our PSP model the research method in our study is a qualitative, longitudinal, theory-generation case study (Eisenhardt 1989) that involved interpretive methods of validating the data and findings (Pettigrew 1990; Klein and Meyers 1999; Denzin and Lincoln 2000). The main focus is in building an accurate local theory (analytical generalization) by using the process data to generate theoretical insight and to validate them. We believe that aligning the case data with the PSP model increases the analytical validity of the model as complex longitudinal case studies are useful for generating theories where little theory has been developed (Eisenhardt 1989). The process model outlined above is thus based on our careful scrutiny of several system processes to yield a rigorous but simple enough model for interpreting field data that enables the (semi) causal explanation of ISD outcomes including their generalization and testing (Yin 1994).

We emphasize that the use of one case below does not constitute an encompassing validation of the model, or a formulation of a strong predictive process theory. It is used to illustrate how by building the process models we can detect events, narrate processes and thereby accurately and plausibly explain process outcomes. We also observe how it offers insights that would remain unaccounted for in variance explanations. Larger sets of process descriptions and more rigorous theoretical constructs are needed to develop more generalized process models that would explain observed outcomes over a set of processes. This step, however, lies ahead.

Research site

The research site was a large insurance corporation located in the North East of the United States that we have called the Hartfield. The Hartfield provided both personal and commercial insurance products through a nation-wide branch network of 22 offices and several sub-offices and at the time of the case study its assets were measured in the billions of dollars. Each branch office was a profit center and local branches were given considerable autonomy in writing insurance. Home office functions were located in the city of Hartfield and their costs were charged out to the branches as an overhead cost. The case focuses on the introduction of a new claims system nationwide originally called Claim Automation Information System or CAIS. Major information systems at the Hartfield were mainly batch processing ones running on large mainframe computers located at head office. Up to the time of introducing CAIS computer support for the major insurance functions (underwriting and claims) was non-existent. They were considered craft-like activities and were heavily paper-based, a common feature of many insurance corporations. Thus the original introduction of the system could be regarded as a source of major punctuation in the existing work system.

The history of systems development at the Hartfield could be characterized by a large gulf between the branch personnel (traditionally the users of systems and the main data suppliers) and the head office IS function (the originator of most systems). This was vividly illustrated by a metaphor circulating at that time, namely, the “wall”. In this mental picture of systems development, the users are on one side of the wall while the technical people are sited on the other. Needless-to-say, the resulting systems at the Hartfield enjoyed a poor acceptance rate among users either because the quality was unacceptable or because they had become irrelevant after the months or often years required to build them. Consequently, the reputation of the IS group was poor in the eyes of the user community. For the CAIS system, the radical, user-centered approach to project management adopted was both an acknowledgement of past problems and a demonstrable discontinuity with the old way of managing projects. Further details of the research site and CAIS are provided below and in figures 6, 7 and 8 and summarized in table 3.

The second author was a visiting professor at a North East State University at the time CAIS was being developed. Through contacts in his faculty, the first meetings were arranged with a senior technical administrator at the Hartfield (James) and the Director of Claims (Eric). This led to other interviews at the Hartfield in what has been described as snowballing (Buchanan *et al*. 1994). In this way the unfolding story of the Hartfield and in particular the CAIS project was documented over an eight-year period that we label t to t+8. Twenty semi-structured interviews were conducted with personnel (both users and IS staff) in several waves of visits. Some subjects were interviewed more than once for continuity purposes. Details of the interviews, the subjects’ names (pseudonyms - as used in the case description), their job titles, the duration of the interviews, and whether a transcript was produced are given below in table 2.

Date (mm.dd.yy)	Name	Title	Duration (minutes)	Transcript Y/N
01.07.t+2	James	Senior Technical Administrator	65	Y
01.17.t+2	Eric/ -	Director Claims/ Data Processing Director (2 person interview)	75	Y
02.21.t+2	-	Field Office General Manager	75	Y
03.13.t+2	-	Supervisor, CAIS	40	N
03.20.t+2	-	Business Analyst (1), CAIS	80	Y
03.20.t+2	-	Business Analyst (2), CAIS	40	Y
04.15. t+2	Lisa	Claim System Technician (Hartfield)	35	Y
04.15. t+2	Tom	Claim System Technician (Richport)	30	Y
04.18. t+2	-	Claim Manager (Richport)	65	Y
04.18. t+2	-	Liability Claim Rep. (Richport)	20	N
04.18. t+2	-	Subrogation Salvage Specialist (R'port)	15	N
05.05. t+2	Lisa	Claim System Technician (Hartfield)	30	Y
05.05. t+2	-	CAIS Co-ordinator (Hartfield)	25	Y
05.05. t+2	-	Supervisor, Home Owners & Auto	60	Y
10.31. t+2	Lisa	Claim System Technician (Hartfield)	30	Y
08.12. t+5	James	Senior Technical Administrator	80	Y
12.08. t+5	Gary	Director, Bus. System Engineering	55	Y
12.11. t+5	Eric	Director, Claims	50	Y
12.11. t+5	Lisa	Senior Analyst, PFSD	40	Y
09.08. t+8	Gary	Director, Bus. System Engineering	65	Y

Table 2. Interview schedule

Data Collection

In conducting the interviews we followed metaphor of an interview as a drama (Goffman 1959, 1967) where the underlying model is the social encounter (Weber 1947). We paid attention to entry and exit, careful scripting of the questions using mirroring techniques (see below), the location of the interview, appearance and appropriate dress code, status and gender differences. The aim of the interview was to create texts by questioning a variety of subjects in order to tell a representative story of IS-related phenomena (events and processes) focussing on what happened, when, and why (Rubin and Rubin, 2005, Geertz, 1973). Ideally, we tried to uncover the subjects' worlds and stories in their own words (Rubin and Rubin, 2005).

We observed three validity issues arising from qualitative interviews in the context of our study which had to be addressed:

- Artificiality of the interviews – we were interrogating subjects who were often complete strangers. Moreover, we were asking subjects to state opinions under pressure. Therefore, our aim was to put the subjects at ease by letting them tell their stories as they saw fit. Yet, over time, especially with multiple visits, a relationship of trust was established (Buchanan *et al*. 1984).
- Hawthorne effects – interviewers can intrude upon the social setting and potentially interfere with subjects' behavior and opinions. Again, this was ameliorated by using multiple subjects and focusing on common events.
- Elite bias – By interviewing only people of high status it is possible to miss an understanding of the broader situation. Miles and Huberman (1984) talk about the bias introduced in qualitative research by interviewing the stars (elite) in

> an organization and overweighting data from articulate, well-informed, usually high-status informants and under-representing data from intractable, less articulate ones. Again, using a variety of subjects at different levels of the organization can compensate for this. In our study we included claims handlers, technical support staff as well as managers in our interview panel.

Our overall approach was designed to ameliorate these criticisms while encouraging subjects to talk freely about their experiences. The transcripts bear testimony to the effectiveness of this. Several of the interviewees clearly enjoyed the process. For them the interview was a kind of cathartic experience: they seemed genuinely pleased to be able to disclose their narratives in their words.

The interviews were conducted *in situ* and where possible on a one-to-one basis. The exception to this was the joint interview with the director of claims and the data processing manager. The principal subjects were James, Lisa, Gary and Eric all of whom were interviewed more than once over an extended period (see above). As in the case of other longitudinal case studies, subjects change jobs or even leave the company altogether. Lisa who was interviewed four times was originally a claim system technician. Later she was promoted to the post of a senior analyst. Promotions were also experienced by James and Gary during the data gathering phase. In James' case he left the corporation in t+6, again for a further promotion but this time to another company largely on the strength of the success of CAIS and particularly the user-centered methodology. Gary was promoted to take over James' work at the Hartfield, which by then was called Business System Engineering. Although we tried several times to re-establish contact with James after he left the Hartfield, our calls were not returned and we abandoned this attempt which we put down to subject fatigue (Buchanan *et al*. 1984).

Subjects were asked to tell their story in their words and we did not attempt to privilege one version over another. In this way we were attempting to uncover their life worlds. Questions were formulated to begin with general ones (e.g. "Can you tell me about your job?") leading to more and more focused questioning on specific events (e.g. "How did you overcome their resistance?"). In order to get the subject's life world, a mirroring technique was used where the interviewer would listen for key words used by the subject (e.g. "The users **resisted** the CAIS system.") and then reflect the words back to them for further elaboration (e.g. "What did you do when the users **resisted** the system?")[7]. In this way a researcher can avoid imposing their own life world and language on the subject. Subjects were also encouraged to focus on events especially what they felt to be critical events or incidents (Gersick 1991, Newman and Robey 1992). Thus a degree of inter-subject checking could be carried out to discover which events were important to more than one subject. We realize that the need for social approval is very strong and this may lead some subjects to alter their stories. By careful use of the above interviewing techniques we believe that a more open disclosure was encouraged and obtained.

All the subjects were tape recorded and subsequently most tape recordings were transcribed professionally. These texts became the main corpus of our data for subsequent analysis. Where it was possible and appropriate we would try to gather other documentary evidence. For example, Gary provided an internal document on the design methodology he was trying to codify for the Hartfield. In this we found reference to the metaphor the "wall" mentioned earlier and a discussion of how it was necessary to overcome this barrier. This added

[7] See Weizenbaum (1976 pp. 3-16) for a discussion of questioning in Artificial Intelligence and the software system, ELIZA.

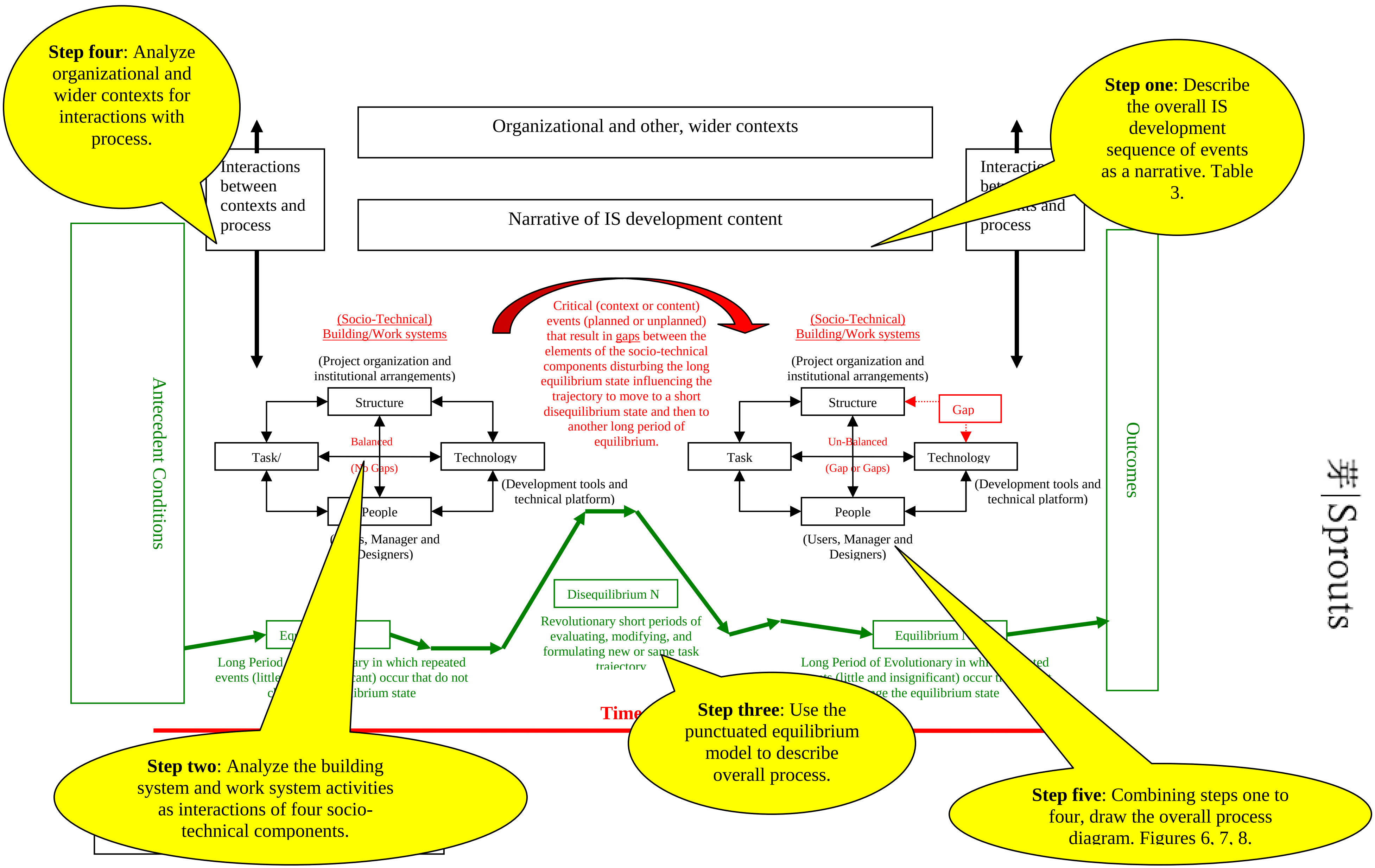

Figure 5. Data analysis steps

some measure of confirmation to statements we had previously recorded from James in which he said that systems used to be designed by the IS group "and then we'll ***throw it back over the wall*** when we've done and you (the users) see if you like it" (James, p.7, our emphasis). Additionally we would use observational techniques to supplement our data. We noticed for example that James had a well-thumbed copy of Zuboff's book, *In the Age of the Smart Machine* on his desk. When questioned about it he agreed that this had influenced his thinking on systems development.

Data Analysis

While analyzing the texts (transcripts, documents, and notes from observations) we used five indicative steps as suggested by the theoretical model outlined in the previous section. The operational steps of the data analysis are shown in Figure 5. During the first analytical step, describe the overall IS development sequence of events as a narrative, the authors reconstructed the story (narrative as instance) of the development process (Pentland 1999) and identified antecedent conditions for events and episodes from subjects' stories. This resulted in an eight page baseline story which outlined all the events and which are summarized below in table 3. Again there was no attempt to impose one view of the case. Where there were differences of opinion among subjects these were maintained in the baseline description. Both researchers read the transcripts independently looking for texts that represented critical events.

As an illustration of the first analytical step, in one interview James mentioned how the new methodology (user-centered) was breaking down the barriers to developing systems which in the past had resulted in the poor performance of systems. The following is an extract of text, which has been subsequently analyzed and used in the manuscript. In response to a comment we made about the old way of developing systems, James responded:

> "That's right 1. It's surprising that with only a couple of years, and even with a project that had difficulties, we were able to convert the organizational philosophy of developing systems into that kind of environment. 2. Things like joint application design are an absolute gimmick. 3. Having the customer be the project manager and actually having the systems people report to them is a gimmick. 4. That's just the way we set projects up. 5. And being here, it didn't seem that it was a radical change. 6. But when you step back from the organization, you say, "It's only, then - two years or three years ago - and an organization that used to be, 'We're in charge; we make all the decisions; we design it; and then we'll throw it back over the wall when we've done and you see if you like it', to having, maybe not demolished the wall, but there are some really big doors there". 7. And I don't know how you codify that sort of process in order to be able to sit down with an organization and say, "These are the five steps you need to do in order to accomplish that change"" (p.7 of transcription, interview with James, 12 August t+5).

Many of the analysis issues raised in the paper are represented in this single extract. James looks historically to the old times, '*an organization that used to be, 'We're in charge; we make all the decisions; we design it; and then we'll throw it back over the wall when we've done and you see if you like it'*, talks about the current situation, '*having, maybe not demolished the wall, but there are some really big doors there'* to the future where he will have to develop and codify the new methodology, '*I don't know how you codify that sort of process in order to be able to sit down with an organization and say, "These are the five steps you need to do in order to accomplish that change"'*. This and many other extracts were used to flesh out the narrative of the events that took place during the development of CAIS. As with any rigorous process study this also includes characterization of the starting state which required us to analyze the history of claims handling before CAIS.

As more critical incidents emerged, data from the various sources coalesced and built a specific narrative (steps two and three, figure 5) and this was then mapped onto and classified into the dynamic socio-technical punctuated equilibrium model that came out of the analysis (figures 6, 7 and 8). For example, in figure 5, evidence from James (quoted above) together with other sources were used to develop an understanding of the antecedent conditions (*'an organization that used to be…'*) as well as **crises** in B4 and B5 (see figure 7: *'…with a project that had difficulties…'*) and the new Business System Engineering methodology in B9 (see figure 7: *'These are the five steps you need to do in order to accomplish that change'*).

We did uncover contradictions or interpretative puzzles in the data. For example, when we analyzed the fragment of text above, the author seemed to contradict himself (*'Things like joint application design are an absolute gimmick'*). On the one hand he had claimed that the user-centered, joint application design was the key to success. On the other hand he says that it is a 'gimmick' or trick. It emerged from a deeper analysis of other transcripts that the users had indeed stepped down from the project leadership with the IS people assuming control, confirming the view that there was some trickery involved in having users lead the project: in this emergent picture, the users were portrayed as figureheads.

Step four was to look for evidence from the organizational and competitive environments that influenced (mutually or singly) the development or work (legacy) processes. As an example, the competitive environment was influential in the formation of the CAIS building system. Management recognized the problems of the legacy system in the light of what their competitors were achieving (e.g. the Farmers' group).

Our final analytical step (step five, figure 5) took place by constructing in a visual form the process diagrams shown (Pentland 1999). Figures 6, 7 and 8 highlight the evolutionary path of the CAIS system over almost a decade that resulted in a specific process outcome: the final but painful victory after 3 trials and 8 years of continual battle. While doing this mapping both authors together interpreted the data events, identified the gaps between components and analyzed interrelationships between events. This resulted in sorting out the events into work level events, project/process level events, project issues and organizational issues (see below). Significant relationships between the events and gaps between in the work system and the building system (project level system) were detected and identified in bold, thicker lines. Below we shall discuss the main findings of this process analysis.

Illustration of the PSP Model: The Hartfield Claims Processing System

ISD Change Process and its Drivers

We shall next probe the process narrative as illustrated in figures 6, 7 and 8 and table 3 (below) in several steps. First we will analyze the general organization of the socio-technical process associated with the CAIS change. Second, we shall analyze the critical role of the context in shaping the change. Figure 6 represents a visual diagram of the trajectory of the "CAIS project" over almost a decade in terms of events, states, gaps, and event sequences. The critical project level events are juxtaposed in the diagram with pivotal management and operational events that took place at different levels at the Hartfield (context). These events highlight the impact and evolution of the project context. The critical project level events are summarized in an event trajectory in figure 6 based on an analysis of the details of each event in figure 7. Hence, figure 7 offers clarification which details the logic of each critical event (B1[8]-B9). The type and nature of each such event (diamond) is clarified in the third row of figure 6 by offering a short description of each project event. If we relate the overall socio-technical process explanation with the specific events in the process we can show how each small diamond in the fourth row of figure 6 becomes a separate larger diamond in figure 7. Each such event description details the specific status of relationships between socio-technical elements during each identified event in the format as outlined in figure 6 to narrate the process in a special language (Pentland 1999)[9]. Similarly, the last row (encounters for the work (legacy) system) of figure 6 represents the major events (W1-W8[10]) that took place at the level of the work (legacy) system during project evolution as the result of project outcomes. These small diamonds are likewise expanded in figure 8.

The small diamonds in two bottom rows of figure 6 are connected by vertical arrows at several points. These arrows signify the interventions- events- at which the project work and the "normal" work of the claims handlers intersected and thus created co-occurring events in two socio-technical systems. For example, the B4-W4 pair connected through a vertical arrow represents a pilot of the new CAIS software at two branches of the company. The project team and the claims handlers were at this encounter brought together and shared a partially common task to make the system work. As B4 shows in figure 7, during these pilots major software and performance problems emerged which led to a project crisis at CAIS and a fallback of the CAIS from the business process. In fact, after this encounter the claim handlers continued using the pre-CAIS system until the new system was finally implemented and adopted (W8-B8) three years later! At the project level this demanded drastic decisions to be made about the continuation of the whole project (B6 at the project level) which in turn cascaded back to trigger decisions at the organizational level to revise the contracts and reconsider the implementation strategy - a punctuation in the building system. To supplement the visual maps a more conventional narrative for Building and Work processes which was used as baseline data is summarized in Table 3.

[8] We use the notation **Bx** to denote the **build** system encounters, and **Wx** to refer to **work** or legacy process level encounters (system interventions).
[9] The reader is referred to the research method section for a discussion of how these events were selected.
[10] We number these coordinating events by using the same event number as the corresponding project level event.

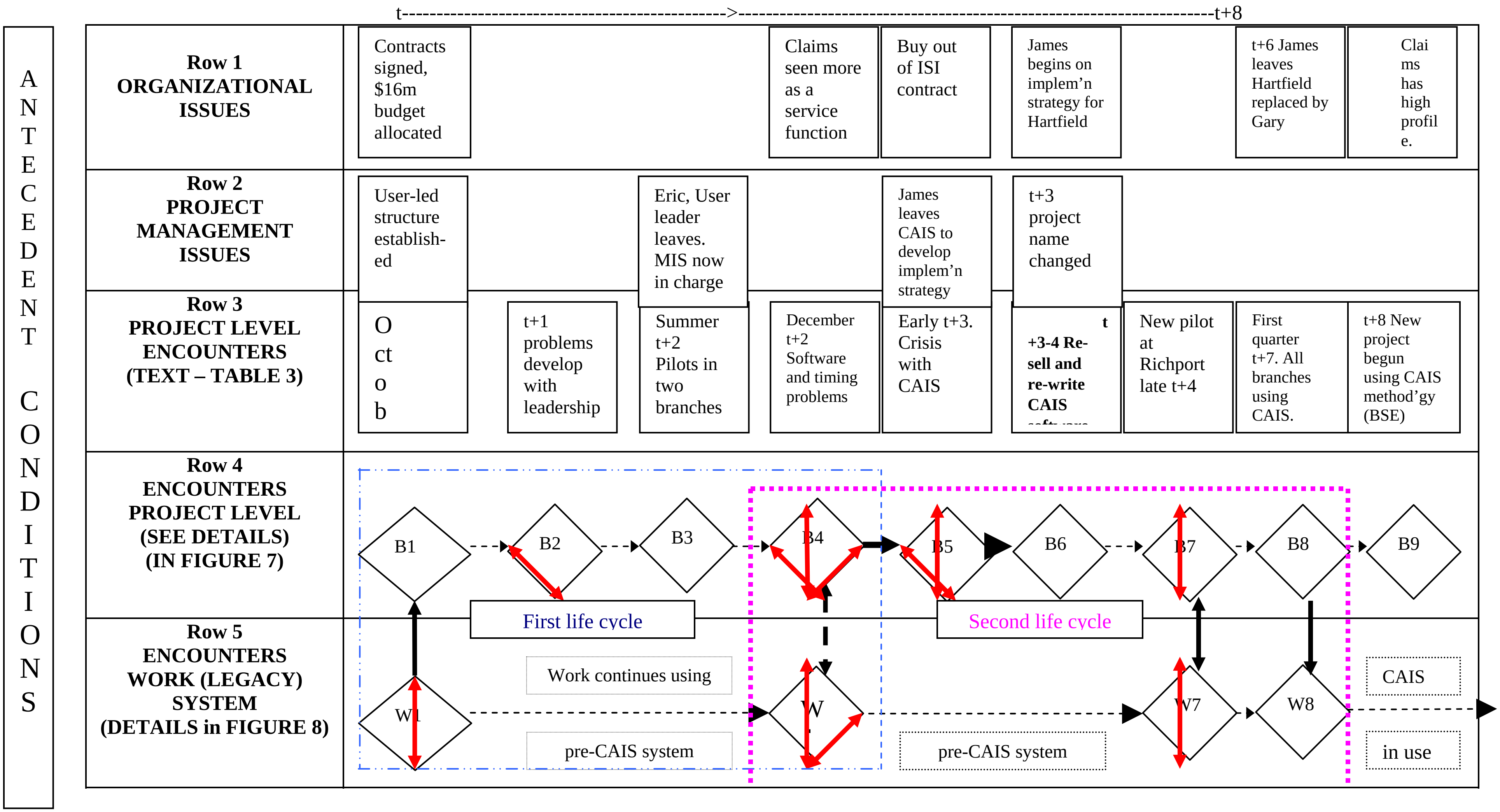

Figure 6. CAIS time line T to T+8

CAIS Building system timeline (t to t+8) (see Figure 7)	**Claims Processing: Work (legacy) system timeline (t to t+7) (See Figure 8)**
Event 1 (B1) - Proposal for CAIS (October, time t) The Hartfield is a very large insurance corporation with assets of many billions of dollars. They offer a full range of insurance products both personal and commercial through a nation-wide branch network of 22 offices and several sub-offices. Each branch office is a profit center and has considerable autonomy in writing insurance. Home office functions are based in Hartfield and their costs are charged out to branches as an overhead charge. We focuses on a system called CAIS or Claims Automation Information System. **The new system was a leading edge state of the art system using LANs at each branch, new support staff positions, user-friendly screens, and a model office that would be used in developing the system and training personnel.** The claim files would be held on the C drive of each work station. The project was predicted to save $10m costs per year for an investment of $16m. It was to be **led by the users** and ready in 2 years **(i.e. a Punctuation – a new method - in the Building System was proposed and accepted)**.	**Event 1 (W1) - Before Automation (up to year t)** Pre-automation there were many problems with the way claims were processed and records retained at the Hartfield. Files would often go missing, making claim handling a lengthy process which could lead to expensive legal claims against the Hartfield, claims they frequently lost in court. Competitors were also developing IT systems thereby reducing the cost of claims and improving customer service. **There was a large and growing gap between the technology of processing claims and what they aspired to do (Task-Technology Gap).** The new system would be a leading edge state-of-the-art system using LANs at each branch, user-friendly screens, and a model office that would be used in developing the system and training personnel. The claim files would be held on the C drive of each work station. The project was predicted to save $10m costs per year for an investment of $16m. It was to be led by the users and ready in 2 years .
Event 2 (B2)– Design and Programming (t+1) Each branch was to be given a client server networked to the claims work stations (PCs) operated by claim handlers (CHs). Claims information was to reside on the hard drives at each claim station under the control of the CHs. This was to mirror the control traditionally exercised by CHs under the manual system as it was felt that removing the files would be too much of a shock for the CHs who were "pathologically" attached to paper files. CAIS software was to be jointly developed with an outside vendor called ISI who had experience of similar systems and who wanted to market the subsequent software. As the design and programming progressed it became clear that **Eric the user leader of the project was not able to continue in his role.** He describes the experience as "traumatic" and a "searing experience" and a clear gap emerges between the technical needs of the project and its leadership. **It is no surprise when Eric steps down and Peter and James from MIS take over (Task-Structure Gap).**	
Event 3 (B3) – Pilot testing (summer, t+2) With the leadership and the project now in balance, the project continues at pace. Although there were the usual technical issues which have to be dealt with in the course of developing most major systems, the software and hardware were sufficiently ready in the summer for pilot tests to begin at Hartfield and Richport. The project team with the assistance of the claim system technicians (CSTs), Lisa at Hartfield and Tom at Richport, introduce the CAIS software at these branch offices. This description inevitably glosses over a lot of detailed preparation required for such a complex system: purchasing the hardware; preparing and cabling the building; purchasing and installing the new office furniture; training the users in the new model office; improving the users' keyboard skills as appropriate etc. etc.	

To be continued

Table 3: CAIS building and work narratives

Event 4 (B4) – Pilot tests reveal major problems (December, t+2) With the system ready for use in the two pilot branches by the claim handlers some features came to light which caused concern to the project team. Firstly, **some functions in claims such as shared losses where, for example, an auto collides with a building causing bodily and material damage, did not work. Secondly, the response time was excessive** (several minutes to fill the in-boxes). Finally, there was **a major security problem**. As designed, the system was to mirror the claim handlers (CHs) traditional pattern of control over the claim files. Each work station had the claim handler's files on the C drive. **This meant each station had to be backed up every day, a nightmare of a task for the claim system technicians (CSTs).** In summary, there were gaps between the task and the technology and the task and the people. There was also a belief that the project structure with the use of the ISI programmers was causing a problem. This was more a problem for the project team. The CHs were more favorably inclined toward CAIS even with its flaws (**Task-Technology, Task-Structure and Task-People Gaps**).	**Event 4 (W4) – Pilot tests at Hartfield and Richport (summer, t+2)** In the summer of t+2, pilot tests begun in 2 branches, Hartfield and Richport. With the system ready for use by the claim handlers some features came to light that caused concern to the project team and claims personnel. Firstly, some functions in claims such as shared losses where, for example, an auto collides with a building causing bodily and material damage were not handled by CAIS. Secondly, the response time was excessive (several minutes to fill the in-boxes). Finally, there was a major security problem. As designed, the system was to mirror the claim handlers (CHs) traditional pattern of control over the claim files. Each work station had the claim handler's files on the C drive. This meant each station had to be backed up every day, a nightmare of a task for the claim system technicians (CSTs). In summary, there were gaps between the task and the technology and the task and the people. This was more a problem for the project team. Surprisingly, the CHs were more favorably inclined toward CAIS even with its flaws (**Task-Technology, and Task-People Gaps)**.
Event 5 (B5) – Crisis with CAIS (Early t+3) Despite all its weaknesses and limitations the CHs impressions of CAIS were favorable. The CHs were even finding work-arounds. To them it was disappointing when a decision was made in early t+3 to **suspend the pilot** at Hartfield. Richport was retained as a test site while the problems were sorted out. The project team decided that there were too many design faults with CAIS to continue with the pilots. **There had to be a radical rethink of the overall system design**. At this point, if the system had followed the pattern of other Hartfield systems, the users would expect to see the project collapse at this point. However the user-centered approach adopted for CAIS meant that the project would continue. The gaps continued between the task and the technology and the task and the structure. The MIS leadership was now fully in charge of the project. James was moved to a more central role to codify and promote the design method. He was replaced by Gary as project manager. **The ISI contract was bought out** (**Task-Technology and Task-Structure Gaps**).	

To be continued

Table 3: CAIS building and work narratives

Event 6 (B6) – Re-sell and re-write CAIS software (t+3) The project team decided that **radical surgery** was required on CAIS (**i.e. a Punctuation to the Building System**), not just a few bandages. Because the software was written mainly by an outside vendor (ISI) who was intending to market CAIS jointly with the Hartfield, the code was generic and very difficult to modify. Consequently, it was decided by senior management and MIS to abandon this approach. Another group of programmers, internal Hartfield employees, was constituted and over the next 18 months this team rewrote the software for CAIS "from the screens backwards" All of the files previously held at the CH's work station were migrated to the file server at each branch office. More powerful PCs were bought and installed. The shared losses problem was largely solved. While the acronym "CAIS" was retained there was no longer an emphasis on staff savings, perhaps because these savings had disappeared. The new approach was to emphasize **improving services to claimants**. Thus CAIS now stood for "Claim Automation for Improved Services", the same project but with a re-engineered title. **Although not without problems, the Punctuation was Successful and the Building System was now in balance.**	
Event 7 (B7) – New pilot test at Richport (late t+4) Late in that year, the system was ready for re-testing at Richport. **There were still many problems with the new version of CAIS**. The project team logged 300 errors at Richport which were systematically removed over the next few months. The users were re-trained by the CSTs (**Task-Technology Gap**).	**Event 7 (W7) – New pilot test at Richport (late t+4)** In late t+4, the system was ready for re-testing at Richport. There were still many problems with the new version of CAIS. The project team logged 300 errors at Richport which were systematically removed over the next few months. The users were re-trained by the CSTs (**Task-Technology Gap**).
Event 8 (B8) – all branches using CAIS (First quarter, t+7) The large reprogramming effort was eventually successful resulting in nine out of 22 branch offices going live by August t+5, with a schedule of one office per month going live. All the branch offices were given CAIS by the first quarter of t+7. Videos were used for more remote branch training. CAIS was judged to be a success by MIS and the majority of users. However the financial picture contradicted this. The original cost of $16m had soared to ~$60m, the project had overrun by 5 years and the original staff savings had disappeared. The new culture of service had replaced the original efficiency criterion. There were some other benefits in training CHs and in auditing the files. Finally, the profile of claims had been raised in the Hartfield and the technology of CAIS made it easier to recruit new people as CHs **(Building System now in Balance)**.	**Event 8 (W8) – Branch Implementation of new CAIS software (First quarter, t+7)** After several years and many millions of additional dollars, the new CAIS software was ready to be rolled out for production and maintenance to the branches. The timing problem had been eliminated by redesigning the software and employing much faster PCs. The shared loss issue was sorted out for most States. The claim files were now stored centrally on the branch server which meant backups were simpler and quicker. (Interestingly, the CHs were not informed about the new arrangements for the storage of their claims files). All branches were on line by the first quarter of t+7 and by t+8 CAIS had entered the maintenance phase. The original cost estimate of $16m had ballooned to ~$60m and the project had overrun by 5 to 6 years. However the CAIS project was considered to be a great success by the project group and the majority of users. It had also raised the profile of claims as a group. The user-centered design method was to become the standard at Hartfield for new projects **(CAIS Replaces Legacy System – a Punctuation in the Work System)**.
Event 9 (B9) – New project begun using CAIS methodology (t+8) CAIS entered the maintenance phase and new releases were being rolled out to the branches. In t+6, James decided to leave the Hartfield to further develop his career. He was replaced by Gary who took over the role of codifying and marketing internally the system development method which by then was called BSE (Business Systems Engineering). In t+8 when it came to exploring how to develop and integrate the personal lines underwriting system with CAIS, it was the new approach (BSE) that was used as the design method **(CAIS Method (BSE) now Institutionalized).**	

Table 3: CAIS building and work narratives

Interactions between a Hierarchy of System Events

Row 3 of figure 6 - project level encounters - summarizes the process structure and evolution as detailed in figures 7 and 8. Table 3 reveals the interrelationships between and among different event sequences. Here, rows, organizational issues and project management issues represent incidents within the process context (Pettigrew 1990, Langley 1999, Pentland 1999). Organizational issues identify official managerial decisions and interventions about the project including decisions to initiate a project, to terminate a project or drastically change its focus and direction. Project management issues identify pivotal and uncontrollable events within or outside the project that influence the project. These can be key people leaving or entering the project, political moves to change the legitimacy of the project, or critical negotiations between or among the project stakeholders. These macro level events unfolded *simultaneously* within the organization and its environment and nearly always critically influenced the progress of the project.

The project started through a cascading set of events that were triggered by the managerial intervention that involved signing a contract (row 1) and thereafter establishing of the user-led project structure for the project (row 2). In t+2 after problems with the user leadership, the MIS group assumed leadership of the project (row 2). Increasing competition in the market place meant that there was a shift of emphasis in claims from efficiency to better service (row 1). The crisis with the software led to buying out the software contractor and developing the system in-house (row 1). At the same time, the project leader left CAIS to work on codifying the implementation strategy (a project level change). Although the acronym, CAIS was kept, the name of the project was changed 3 years later to be consistent with the new service function and obtain new legitimacy for the project intervention (row 2) (CAIS now meant Claims Automation for Improved Service). In t+6 James left the Hartfield as a career move and was replaced by Gary (row 1). Gary promoted the position of claims at the Hartfield and established the newly codified development methodology (now called BSE, business systems engineering) (row 1).

Thus, by analyzing these events at Hartfield we observe a subtle, but critical interplay between concurrent processes at multiple levels. Moreover, the events play out in both ways. At some points in time, the process of working on the project task threw up issues that had to be dealt with at a higher level. For instance, the software and timing problems in t+2 and t+3 led to a crisis at the top management level requiring intervention. The solution to buy out the ISI contract and redesign the CAIS system had major resource implications for the Hartfield but the decision was made to proceed with this new strategy. At other points, what occurs at a higher level can impact substantially the project. An example was the swift shift in the strategy for claims from cost saving to improved service as manifested in the project name change that emerged from competitive changes beyond the control of Hartfield. Overall this shows that any process analysis must carefully delineate the impact and direction of an impact at different points of time on how the project constitutes and influences its context and vice versa (Pettigrew 1990).

Interventions: Successful, Failed and Crises

As shown in figure 4 there are four alternatives outcomes of interventions: successful incremental; successful punctuation; failed; and a deepening crisis. When analyzing our event histories we can see that all emerged at different points of the process sometimes leading to deep punctuations, but not necessarily as a consequence of planned interventions. Moreover, we can observe that in most cases punctuations were outcomes of crises that emerged abruptly.[11] The start of the project was characterized by a gap between the claims task and the technology employed (see W1 in figure 8) that called for punctuation. The proposal for the project (A planned event, B1, figure 7) sought to establish a new balance between its components by **punctuating** the work system and thereby generating/punctuating a new building system. The structure of this project team was designed to make a radical break in the traditional way of running socio-technical interventions (therefore punctuation) in that the chosen leader was the claims manager. This new intervention mode was matched with contemporary cutting-edge technology (e.g. token ring and the model office) and talented project personnel such as advanced process business analysts and claim systems technicians. Hence, overall we can see an attempt to punctuate the system both at the project and at the work system level, the former immediately and the latter in an estimated 2 years time (i.e. t+2).

The project proceeded for a year (B2) when it became apparent that the user project leader (Eric) was unable to continue for various reasons - one of them being that he could not manage the inherent technical challenge and complexity of the task. The project group quickly intervened to solve this problem successfully by replacing Eric with James, a key IS person and one of the visionaries on the project (actor change). The project was able to proceed rapidly after this intervention but it did not prevent a major problem on the near horizon: the summer pilot tests at Hartfield and Richport (B3) threw up crucial problems. Large gaps emerged between the task and the technology and the task and the people (B4) as the building team tried to implement CAIS. Moreover, for the building team there was a strong belief that the structure of the team especially the use of ISI contract programmers was also causing a problem (project structure change). In summary, major problems emerged at almost every corner and relationship within the socio-technical system: the project (systems) was entering a crisis and rapidly losing its capability to remain a viable system (holding the balance between different elements of a socio-technical system). The building system was clearly in transition and ready for punctuation. Therefore drastic interventions had to be made to save the system. From our analysis it is also clear that this crisis was **not** anticipated and emerged abruptly in line with our concept of punctuated change. The team went into the pilots fully expecting a successful outcome and there was no hint of resistance. This shows the emergent and chaotic nature of processes that result from the inherent complexity (van de Ven *et al*. 1999) and the abrupt nature of the resulting punctuations.

After a few months of hesitation the project team decided that the pilots had to be cancelled (B5). The pilots revealed that no amount of tinkering would correct the problems. While this intervention was partly successful in reducing the gap between the task and the people (the claim handlers), more radical surgery was required to stop CAIS going the way many projects at the Hartfield had done in the past. Consequently, the ISI

[11] Whether crises are always associated with punctuations at the project level will not be explored here further. Orlikowski (1996) shows a case of work system punctuation which was not associated with a crisis.

programmers were removed, their contract was bought out, and the original design approach was abandoned (B6) leading to a **punctuation**. Instead, the MIS group reasserted its leadership and provided internal programmers to re-write the system "from the screens backwards". This shows a radical reorganization of the organizational routines to address the unexpected crisis - a change in the deep structure of the building system. The organization partially retreated to its historical responses when a new routine fails and changes the power bases within the system to justify different actions to solve the problem. This is an instance of **trial and error learning** that emerges as a fast response to observed relationships between action and outcome (Cyert and March 1963). Simultaneously, the project team set about regaining some of its credibility through political moves with senior managers. It sold the new approach as re-engineering and changed the project title to emphasize service rather than efficiency. This matched well with the new competitive climate in the market where the claims function in the insurance industry was increasingly seen not only as a cost item, but also as a major part of customer service. The team was successful and these interventions established the viability of the project system**.** After this the project enjoyed a period of stability for the next 18 months as the software was developed.

In t+4, a new pilot was re-commissioned at Richport using the new software. Three hundred errors were detected in the system causing a gap between the task and the technology (B7 and W7). But these flaws were systematically (i.e. **incrementally**) removed over the next few months (another technical event) until CAIS was ready to be rolled out to the branch network and implemented thereafter at the rate of one installation per month. This challenge was overcome successfully without major punctuation and the system stabilized - leading to a **punctuation** in the work system. As a result the project was completed in t+7 (B8). After this success the project team then moved on to further development work (i.e. underwriting) using the new methodology, now **institutionalized**, which was by then codified and called Business Systems Engineering (B9). Although the project was considered a success - possibly a necessary face-saving strategy - the financials told another story: the costs had ballooned from $16m to around $60m and the project was late by 5 years.

Event sequences: Life-cycles or Trial and Error Learning?

One issue in interpreting figure 6 is to engage in process theorizing: to explain why the sequence of events within the building system was organized the way it was. What was the underlying logic patterning these processes? In IS research a single generating mechanism - the life cycle (or "motor") **-** dominates process analyses (van de Ven and Poole 1995)**.** This motor chronicles ISD processes as a sequential advancement of successful problem solving that draws upon theories of bounded rationality and design of im-perceivable systems (Simon 1982, Langefors 1973, Ciborra and Lanzara 1987). This generative mechanism is so engrained in IS development studies that nearly all empirical accounts are organized as stories about problems, requirements and solutions (Hirschheim *et al*. 1995). Although *actual* process patterns do not necessarily match this ideal (Parnas and Clements 1986), and show great variance (Sabherwal and Robey 1995), there are few studies which have looked at alternative mechanisms.

The punctuated socio-technical change model offers here a more faithful account to understand the *in situ* ISD change process associated with the CAIS system. Figure 6 shows two interlocking life cycles of building these systems. These cycles are separated by a deep punctuation within the building system, where each instantiated separate methodological principles (user-led v systems led). Hence, ISD change in our case is better interpreted as an interlocked spiral of trial and error learning processes associated with two layers of the socio-technical system – the work system and the building system. Here the building layer was engaged in orchestrating a set of maneuvers to intervene until one trial wins, or the developers give up. In our case the first trial - B1 to B4 - ended in crisis. The highly-praised user-led strategy and use of contractors to diminish the influence of MIS department failed. It was abandoned during the second life cycle (B4 to B8) that emerged from the ashes of the first effort. MIS was now in charge and its own staff was given the responsibility to develop the software. This proved successful - despite the fact that MIS had failed repeatedly in the past. This success furthermore provided a platform for the MIS group to adopt and codify the successful development technology developed in CAIS to begin additional projects (B9). In some ways this was, in the long run, a greater victory for the IS group than implementing the CAIS system. This serendipity of learning was one organizational outcome that affected the Hartfield operations overall. Such serendipitous learning is not atypical in large-scale ISD: they show how specific interventions become occasions of discovery and new routine-building and thus enable further system punctuations.

Discussion

Research on ISD and IS Use Processes

The proposed model differs from past ISD process research (Newman and Robey 1992; Newman and Sabherwal 1996) that has focused solely on actors' interactions and their *conscious* reactions to other actors and resulting equilibria/ disequilibria in mutual understanding and acceptance. Our PSP model shows, in contrast, that work and project level systems need be distinguished, and at the same time co-contextualized to understand ISD change. As a result the suggested model reveals by hindsight both actors' relations to other actors (actor-related gaps) and invisible socio-technical mechanisms that operate behind actors' backs in multiple socio-technical systems through events. The model thereby adds recursivity, co-evolution and the need to propose multiple causal explanations to observed outcomes in *lieu* of focusing simply on how actors relate to one another.

Most work system related studies look at drivers of socio-technical change at the level of the work system. To this end IS scholars separate development and use through the idea of time/space disjuncture (Orlikowski 1992), and thereafter examine snapshots of changes in the latter and perceive the former as prior producer to the current system state. Consequently, several IS adoption studies (DeSanctis and Poole 1994, Majchrzak *et al*. 2000, Tyre and Orlikowski 1994, Lassila and Brancheau 1999) have examined mutual adaptation of IT and work processes using an event based approach. They frame an IS adaptation event as a cycle of misalignment between the user (actor-task) and technology. When this cycle proceeds as expected it will generate successive alignments (punctuations) between users and the technology (i.e. equilibrium Leonard-Barton 1988) in a "lumpy" pattern by changing technology or the work process i.e. structure (Tyre and

Orlikowski 1994, Orlikowski 1996, Lassila and Brancheu 1999).Their studies, however, do not analyze carefully interactions between the work system changes and the project level activity over extended periods of time, and thus ignore the history of design as affecting the use events. They also suffer from relatively *ad-hoc* classification of mechanisms that generate changes in work systems.

The idea of combining events both at the building system and work system level (i.e. a co-evolution of both systems during process analysis) is something that hitherto has been mostly noted in passing. A notable exception is Orlikowski and Hofman's (1997) study that distinguished between planned, emergent and opportunity driven changes. Their emergent changes relate to incremental change in work systems, while planned / opportunity changes cover punctuations in work systems. Therefore, both planned and opportunity driven changes imply creation of plans and thus carry the idea of a separate building system. Orlikowski and Hofman (1997) recognize also the critical role of capabilities and routines within the building system (they call it system support) in enabling planned/opportunistic change. Their analysis does not, however, offer any systematic way to describe mechanisms that generate change at multiple system levels (other than organizational learning), nor do they analyze alternative scenarios how system use could proceed after interventions.

Research on Socio-Technical Change and Punctuated Equilibrium

Recently, Alter (2005) has proposed a socio-technical approach to examine ISD as an integral part of work system change. His work focuses on how to model IS as part of a work system and how to conceptualize ISD change as a kind of socio-technical change. These methods offer a richer and more complex vocabulary to analyze ISD change as part of work systems, but do not offer similar richness in analyzing dynamics of ISD and change processes at multiple levels nor do they use similar socio-technical concepts symmetrically to analyze ISD change processes. However, we find that the ontological model in itself is a promising way to conceptualize ISD changes, and one research challenge in future would be to integrate Alter's model with our dynamic change model.

Some IT strategy studies have also used socio-technical thinking to explore IT/ IS strategy change. They argue that emergent strategy results from complex interactions between socio-technical elements during strategy formulation and execution (Yetton 1997) and propose that such interactions do not match with the idea of aligning technology to task (strategy), or structure (Scott-Morton 1991). These models are high level representations of organizational transformation as enabled by IT/ IS, and do not offer the detail of event histories required to explain strategy outcomes. Nor do they assume the concept of punctuations in explaining the change. In contrast, Sabherwal *et al*. (2001) used a punctuated equilibrium model to analyze strategic alignment in three organizations. They recognized both incremental events and transformative events that define to what extent different dimensions of IT-Strategy alignment change and how strategy/IT alignment is achieved both through internal and environmental changes. The dimensions of the alignment are not similar but are quite close to our socio-technical model as they cover strategy (task) and business structure (structure) in addition to IS strategy (recursive task of IS function) and IS structure (technology). Their findings are surprisingly similar: long periods of non-alignment (disequilibria), reluctance for punctuation unless there is a deep crisis, the inevitability of punctuations, and actors' limited cognitive capability to choose effective designs. Our study differs mostly from this study in its careful delineation of changes at project level, and careful delineation of process traces and events at multiple levels.

Research on ISD Outcomes: Failed and Successful Systems

We claim that the proposed model offers a better way to build local, accurate theories of ISD process outcomes. We also feel that over time process investigators can generalize such theories across sets of processes and contexts. In this sense the model offers a better way to explain outcomes of complex and discontinuous ISD change than prevailing variance models. In the Hartfield case many of the strong predictors for IS success were present: top management support, user participation and professional requirements management and project management approach. Yet the system failed miserably due to path dependency, unexpected environmental events, and technical failures. The success or risk factors alone cannot help us explain how and why the outcome emerged unless a causal mechanism is laid over the process to explain why it happened. We do not think, however, that factor models are not needed - they only offer a limited and highly sanitized glimpse of tendencies that are likely to affect process outcomes. We feel also that our model expands significantly other process models which have either focused on user interactions or task sequences but did not offer a more encompassing theory of discontinuous system change.

Overall our process study provides rich insights into the **patterning** effects of success and failure i.e. how historical patterns of behavior that develop and that are reinforced by repetition (c.f. Robey and Newman, 1996) influence outcomes. History does repeat itself and organizations do get mired in patterns of failure (Lyytinen and Robey 1999). In this regard it is vital that the historical context of the current project is explicated by researchers and heeded by decision makers. At the Hartfield we saw a miserable history of systems development, and its legacy systems were not well thought of. What resulted was an invidious cycle of project work, which would, other things being equal, render a failed outcome almost certain. Any organization can enter a cycle of failure, rejection and further change which, without any decisive action, will be reproduced in any new project. But in the Hartfield the actors **did** act decisively and punctuated the historical patterning. They still came close to failure but at least they created the conditions for future success. Patterning also shows how a failed project outcome becomes the antecedent condition for any new building effort thus compounding other problems. This has parallels with other human activities including competitive sport e.g. soccer or horse-racing or criminal trials, where we use historical analyses to predict present performance. Likewise, in ISD change, an organization will have IS "form", or has made "irrevocable" commitments to technologies such as ERP systems, which together may render ISD change ineffective without a decisive, punctuated intervention.

Furthermore, our analysis provides insights into the complexity of assessing success and failure and, in particular, into deciding between escalation and de-escalation (Keil and Robey, 1999). By linking history, process and context we can trace the trajectory of a project and show how its process is strongly related to past outcomes and the associated rhetoric of success. CAIS was delivered five years late and four times over budget, but was still believed by all the managers we spoke to be a success! This indicates that escalation, or the continued commitment of resources to a failing project, and the counter demand to de-escalate appears to offer somewhat simplistic explanations from a process perspective (c.f. Drummond 2005). The CAIS system was essential to Hartfield's future, and to abandon it prematurely would be to compound their problems. The time and budget overruns might have been escalating, but the need for the system remained. There was no escalation or de-escalation of their need: they could not just jettison the project and the system.

Finally, we offer tentative insights which may be valuable to stakeholders undertaking large-scale ISD change including senior management, user managers and other users, etc. From the senior manager's perspective, it is hardly surprising to learn that a large project's budget and length is often wildly underestimated! In our case, both budget and time quickly escalated out of control. However, what is not so obvious is to recognize the importance of historical, antecedent conditions. It is pointless to begin a large, complex IS project if the company has a habit of failure in previous efforts unless negative patterns can be punctuated by deliberate interventions. This also suggests that large projects should rarely be attempted using a *big-bang* approach but by dividing them into smaller, more manageable sub-projects. Ambitious, lengthy projects are inherently risky as they become increasingly subject to internal and external vicissitudes, drift and punctuations as time flows. Senior managers could also be circumspect as to how much change their organization can accept. Indeed, the evidence here suggests they need to think of large-scale ISD change as speculative, risky and experimental. And while this applies in particular to large, bespoke systems, as in this case, "off-the-shelf" commoditized solutions such as ERP systems are not immune from such problems. The literature is replete with stories of failures in both domains (Beynon-Davies 1995, Eglizeau *et al.* 1986, Mitev, 1996, Drummond 1996a). For managers and users, our model teaches that interactions with the project can be time-consuming and stressful. It is too easy to get embroiled in complex software, hardware and organizational issues: good managers should protect their staff from too much uncertainty and allocate sufficient resources to enable this. At the Hartfield we saw claims staff heroically struggling to cope with change, uncertainty and failure. However, on the positive side we also saw considerable resources targeted at the claims personnel to ameliorate this problem (e.g. the model office, business analysts and CSTs).

From the IS personnel side the process perspective helps see how early decisions cause an escalation that later require "band aids". The choice of the project leadership and to build CAIS jointly with an outside software house (ISI) falls into this category. This does not mean that James had alternatives, but it seems wise to invest time and resources in these crucial early decisions. Also, during managing the project critical issues will emerge some within the control of project leaders while other, external effects will arise that are beyond their control. So reactive and proactive stances are often needed, and these were both observed in CAIS. The process perspective also reveals the possibility of **creating** change through initiating critical events (punctuations). The project manager would do well to recognize when a project is lurching towards failure or getting mired in a dispute and try to unfreeze the process (Schein, 1961).

Agency and Indeterminacy of Process Theories

If we analyze interactions between past events and the actions adopted by the project team we can observe that most problems during the CAIS process were unanticipated, sudden and abrupt. The gaps emerged mysteriously as major crises. At the same time the team could not learn from past events, or similar patterns with other systems (Lyytinen and Robey 1999). This blindness to the situation can be due to the inherent difficulty of teams to make sense (Weick 1995): the processes were either so rare, or so chaotic that there was little to learn from. It is no surprise that most longitudinal studies of project failure (Keil 1995, Drummond 1996a) show actors' limited learning. Due to their blindness, projects drift (Ciborra *et al.* 1999): the teams react to gaps with delays by orchestrating *ad hoc* interventions that enact established superstitious organizational routines. Later, some interventions became successful, but teams could not foresee this beforehand either. They remained blind to the path that could carry the process from its current state to the expected final state.

This finding delineates the criticality of how actors' epistemic/interpreted realities affect what events are observed and what responses they receive. Sometimes responses enjoyed periods of success separated by inevitable and unexpected struggles against crisis. These crises, often abrupt, were mostly neither of the actors' own making nor under their control. Totally unexpected events within the environment intervened at several points to render human plans and heroic efforts fruitless. For example, when the competitive climate changed, efficiency, the backbone and justification of the first generation of CAIS, became a background issue, whilst customer service emerged to the fore. This is an exemplar of the complexity of large IS projects - they contain or are associated with elements that randomly intervene: the new competitive climate, the coming and going of senior managers, new technologies, etc. can all conspire to make even well-planned projects fail or drift. Therefore our model does not expect deterministic outcomes from process situations: events are highly ambiguous and agents' responses are not deterministic. The model seeks to explicate a narrative which embodies the context and history of events for related socio-technical systems, and which traverses through specific junctures - called gaps - in which the narrative can follow several trajectories.

Consider the narrative that played out at the Hartfield. At one point - **B4** - the project was on the verge of being cancelled and a major punctuation was needed. The cancellation would have had negative implications for actors' careers as well as for their radical development methodology. James and the others, however, were able to devise a set of interventions by leaning on their past experience. This led to abandoning the old-new, technological approach in favor of a new-old MIS-led project. It was re-sold to management as a new approach with improved customer service. The acronym CAIS and all the symbols of CAIS (pens, letterhead, t-shirts, etc.) could be retained while the name's content was re-engineered: service was now the important *modus operandi*, and who could argue against improved customer service? Here we can see the significant role of symbols and ambiguity in keeping the process going (Baier and March 1986). We can also see how actor's wits influence the trajectory and the outcomes - they made the same thing assume different meanings - and sometimes names - in order to adapt to changing contexts and new challenges. Their solution remains stable while the problem that justifies it drifted: the logic and politics around the solution are changed to overcome the resistance within the socio-technical system.

The analysis also raises another question: under what conditions can sequences of events that actors follow create path dependency and produce deep structures through forging strongly positive feedback loops (Garud and Karnoe 2001, Van de Ven *et al*.1999)? Such trajectories are observed with escalating commitment (Keil 1995, Drummond 1996a, 1996b) and CAIS exhibited escalated commitment, too: it was financially in the red all the time and it should have been killed off by rational analysis after **B5**. Yet the Hartfield did not do so, as it had created a path dependent response to the identified gap. The key issue for Hartfield was not to complete CAIS in time or budget, but to reconfigure its claims handling and remove the gap observed in **W1**. This gap was recurrent (March and Olsen 1976) and drove the management to path dependent responses: it ran one project after another with diverse solutions, problems formulations, and rationalities i.e. new punctuations at the project level until the gap was removed from the going concern at t+7.

Could the management have avoided this type of process of events i.e. was the outcome indeterminate during the process? Yes, had they been more proactive, smarter and luckier. Could they have done things differently after the failure of sequence **B1-B5**? Possibly, but with huge organizational costs: the problems with claims processing, the gap observed in W1, did not disappear, and the path that had been opened remained lucrative. In this situation, the only solution was to establish a new coalition and punctuate the building system with a new set of maneuvers as evidenced in the sequence **B6-B9** - which at the end emerged victorious. At the same time the new success with old tricks revealed and reinforced general management as capable actors. Our main point from this is the following: project level (psychological) analyses of escalating commitment can be useful in understanding how path dependency in cognition and action is maintained i.e. how and why management cognition fails. The problem of escalation in the Harfield, however, runs deeper: it related to the contextual justification and managerial reading of the logic of the socio-technical change[12]. The main issue here is what type of learning leads to a conclusion that this choice is plausible and desirable i.e. what would it have taken to remove the gap in the claim processing from managerial prerogatives? Hence, a socio-technical analysis shows how managers and systems interact: what types of theories are called to justify their interventions, and what evidence is available to falsify such theories and how do actors in the end make choices that render the process indeterminate.

Philosophical and Theoretical Grounding

In the punctuated socio-technical model the events are seen to be generated by underlying socio-technical components and their alignments. In this regard its ontological and philosophical stance is close to critical realism[13] (Dobson 2001, Mingers 2004a, 2004b). In critical realism, as promoted by Bhaskar (1978, 1979), socio-technical systems

[12] The analyses in Keil (1995) and Drummond (1996a) are similar. The change happened when reading of the situation changed as a result of financial crisis, change of top management and new competitive demands, which required reformulating in a new way. Drummond's careful discussion of how London Stock Exchange manager Rawlins made, through clever politicking, the need for Taurus to go away is here illuminating.

[13] We are indebted to an anonymous reviewer for pointing this out.

act in the real domain of mechanisms that generate events in the empirical domain, some which will be recorded and interpreted by actors and investigators (epistemic domain)[14]. The concepts of system hierarchy and open systems and actor's limited and voluntary behavior is in line with critical realism's view of social reality as open ended and too complex for prediction. The idea of using simplified models to understand in hindsight *why* certain outcomes emerged is in line with critical realism's idea of social theory as seeking to improve the explanatory power of our imaginations: i.e. what has happened and why. The idea of generalized pattern matching across different event sequences, in turn, seeks to identify tendencies in how complex processes could unfold.

Some readers[15] may feel uneasy about the use of functionalist explanations associated with concepts of gap and punctuated equilibrium. In recent complexity discourse they have become passé (see Agar 2004, Axelrod and Cohen 2000, van de Ven *et al.* 1999) as changes are seen to happen continually and the system never rests in equilibrium. For example, using an IS changes parts of the organization all the time. Complexity theory distinguishes the frequency and magnitude of these changes which, if represented in a log scale – the so called power law - would show that small changes are frequent, while punctuated changes are rare. Such construct also offers a guideline to establish metrics to recognize punctuations at different system levels. Such an interpretation fits nicely with our model, and suggests useful avenues for further research. First, we need to introduce metrics for analyzing socio-technical gaps to understand their power law, and how close the system is to the punctuation. In area of project management these would fit with some ideas of project level risks (Lyytinen *et al*. 1998). Second, the idea of recursivity and co-evolution implies that higher level changes are less frequent and more drastic but interact in significant ways with lower level changes. Therefore we need to better examine the interactions of across system hierarchies in understanding complex ISD change. At the same time we must see how small changes at one level can trigger larger changes at a higher level - as suggested by complexity theory and argued by Ciborra and Lanzara (1987) in their concept of *bricolage*.

Validity and Limitations

We acknowledge that case studies of this nature are highly resource intensive. However, other researchers should consider following a similar research paradigm as there is a clear dearth in this area. Such studies will derive rich data and profound theoretical understandings. They offer plausible descriptions and explanations of ISD phenomena and offer greater transparency to such processes (Klein and Myers, 1999). In an exploratory study like ours, a single case is acceptable, but we can hardly claim that the study represents a typical IS project in the insurance industry let alone system projects in general. We felt, however, that an in-depth exploratory study gives us better freedom to develop the PSP model and illustrate its plausibility. In fact the development of the fundamental categories and the analysis of the data with those categories went through several cycles of refinement, expansion and validation before the data and the model were well aligned with one another (Eisenhardt 1989). Hence the generalizability across other populations is not expected, though our findings are in line with findings from

[14] In this sense the model overcomes well known problems of knowledge contingency and necessity and human causation.
[15] We are indebted to an anonymous reviewer for pointing this out.

longitudinal studies of system development efforts (Keil 1995, Drummond 1996b). The analytical generalizability - from samples to theoretical concepts - is high as the model develops with a relatively small number of concepts a compelling analytical framework to examine ISD change that is applicable to any type of ISD process. It is also well grounded in theories of organizations, and their change. Hence, its theoretical generalizability is superior to existing life-cycle based ISD change models.

One criticism which can be leveled against our case is its dependence on a relatively old data set. We acknowledge that our data set derives from over a decade ago, but we do not believe that this is a handicap. First, good longitudinal data sets are difficult to obtain as they require recurrent visits to the organizations over time – a process which cannot be achieved by typical 18 month to 2-year PhD empirical studies. Therefore, we used a data set which was available, and met with our requirements for describing extensively ISD and change associated with a large system. We believe that the depth and richness of our data analysis outweighs any questions concerning the age. Second, we do not believe that ISD process data differ significantly from current systems. Underlying technologies have changed drastically (like ERP and CRM), but all other elements - and events - have remained the same in terms of complexity and behavioral implications. We have used the same model to analyze design and implementation of two large ERP systems in Saudi-Arabia between1995-2004 and obtained similar insights (Al-Muharfi *et al.* 2004). In fact, the main difference is that some of the interactions between the technology and other elements were intensified while technology has become pervasive. Another difference is that the pace of change and more complex interactions due to fast intervention cycles. What is clear from our study that IS researchers need more extensive longitudinal data sets if we are to unravel the complexity and dynamics of ISD change. Therefore, we encourage all researchers to become more willing to study longitudinal ISD changes *in situ*, over a significant *dureé*.

Conclusions

In this paper we are concerned with the following research questions: 1) what is an appropriate theoretical model to understand ISD change as complex and discontinuous change? and 2) how such a model can be used to analyze complex ISD and change processes and explain their outcomes? To address research question 1) we formulated our PSP model drawing upon theories of socio-technical change, punctuated equilibrium and process theories. The model depicts a subtle interplay between technologies, actors, organizational relationships and tasks at multiple levels as a main driver in ISD change - both incremental and discontinuous. The model views ISD and change in the context of a hierarchy of socio-technical systems where ISD is treated as a punctuated adaptive process of stability maintenance and disruption. Any socio-technical system within this ecology has the potential to generate unsustainable differences (gaps) that trigger interventions into the focal system that lead occasionally to punctuations in the system structure. The model is co-evolutionary in the sense that it distinguishes multiple separate, but interacting streams of socio-technical activities – the work system, the project level, and the surrounding organizational level. One of the advantages of the model, when used *in situ*, would be to tease out alternative theories of socio-technical change being used and thus induce learning among actors as to what extent they agree or disagree with *the* current doctrine of socio-technical change.

To address the second question we formulated a process analytical framework and demonstrated its usefulness in explaining a complex ISD and change outcome which unfolded over almost a decade. We also show how the model explains better the observed process outcomes than other proposed process models. The value of the case study is first in demonstrating how to operationalize the model to explain process outcomes, and secondly in formulating a local and accurate process theory that explains the observed outcome and the process organization.

In future we plan to apply the socio-technical model in investigating additional case histories to establish a better understanding of punctuations and event sequences. We expect these analyses to formulate explanations as to why certain sequences lead to specific outcomes, or why specific interventions lead either to success or deepening crisis. We expect to observe patterns in sequences that lead to divergent process outcomes: crisis, chronic intervention, and successful punctuated change. We also expect to see common patterns that emerge from analyzing several cases.

We believe that the model can offer a fruitful vocabulary to frame and anticipate experiences and to learn from past situations so as to understand how ISD processes unfold and how causes and effects relate. In this regard the socio-technical process model offers one type of "kernel theory' (Markus *et al*. 2003) to formulate prescriptive system development methodologies**.** Currently, there is little or no methodological research on the dynamics of development processes that utilizes socio-technical ideas of punctuated change. In the methodology framework we can use punctuated equilibrium to recognize periods when crises are likely to occur from periods of stability either at the work system, or the building system level. This will help identify better risky development trajectories (Lyytinen *et al.* 1998) and formulate process and decision meta-models **(**Jarke *et al.*2004) for the development processes. Accordingly, socio-technical methodologies could be conceived as theory driven guidelines to conduct experiments within socio-technical systems where designers apply trial and error learning. Alternative theories may be appropriate at different times (Newman and Noble 1990) for accounting for these experiments. By doing this, methodologies could help derive more generalizable explanations as to why specific sequences and contexts lead to specific outcomes, or why specific interventions lead either to success or further escalation.

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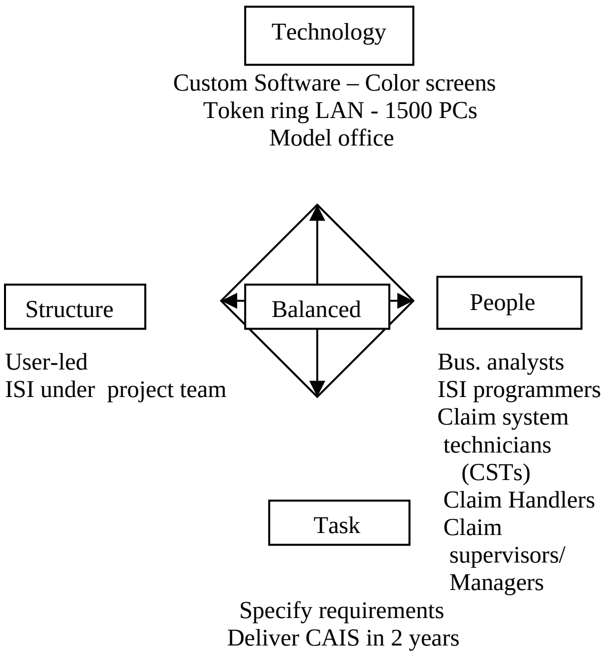
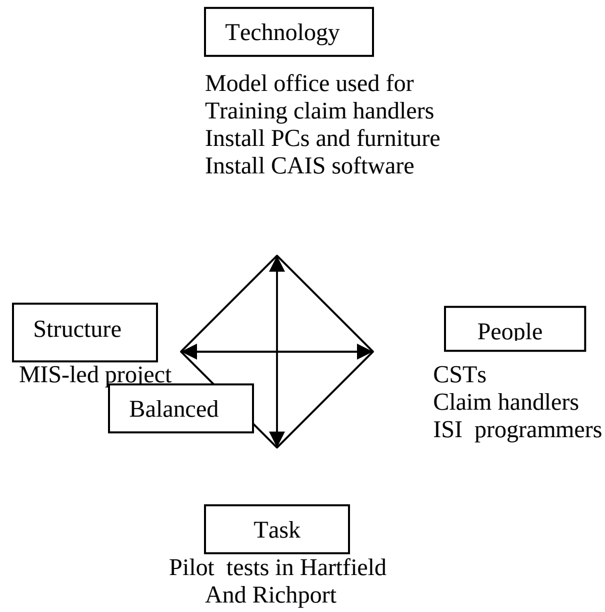
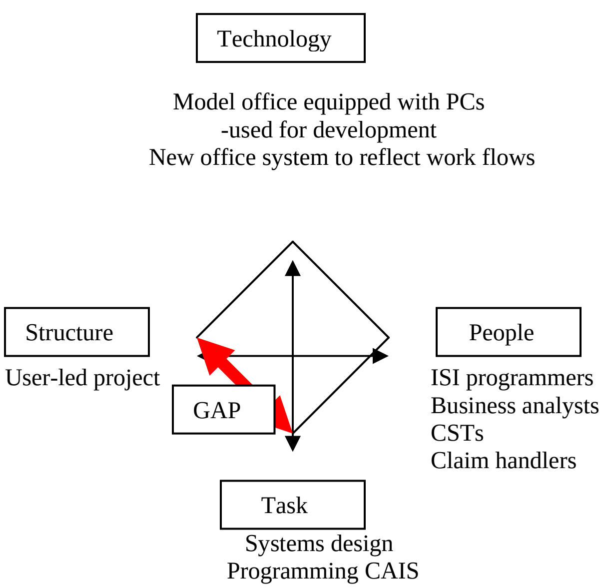
Appendix A
CAIS Building System Timeline (t to t+8)



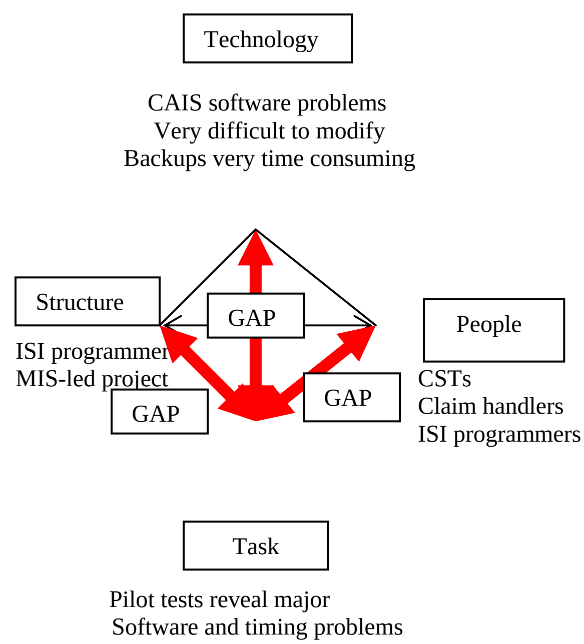
Encounter B1 - Proposal for CAIS (October, time t)



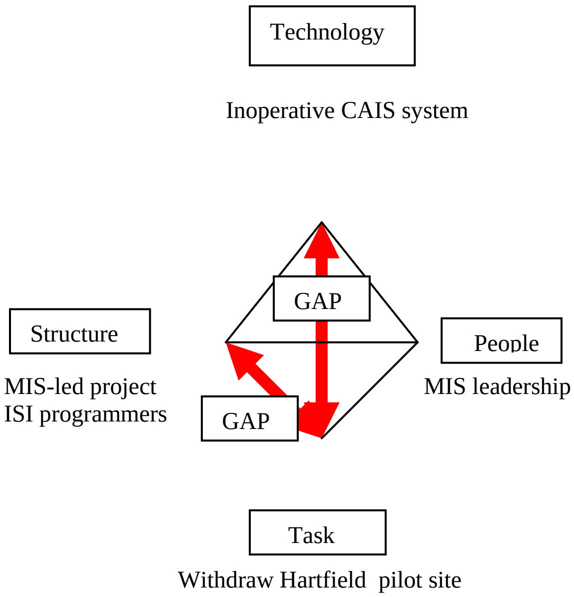
Encounter B3– Pilot testing (Summer, t+2)



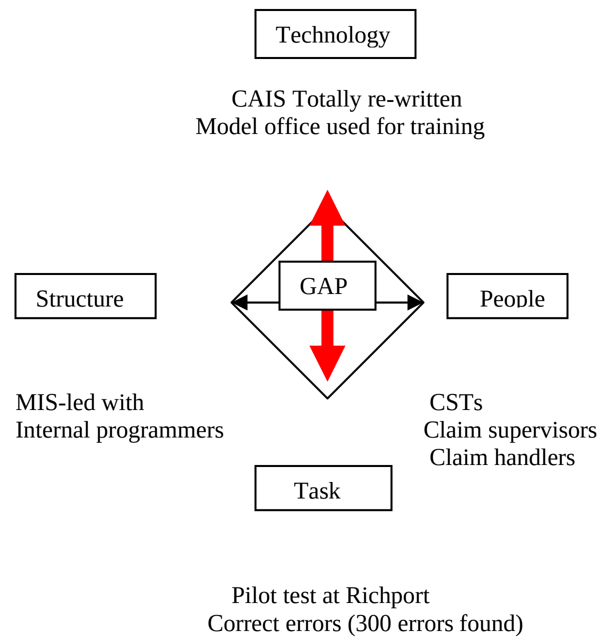
Encounter B2 – Design and Programming (t+1)



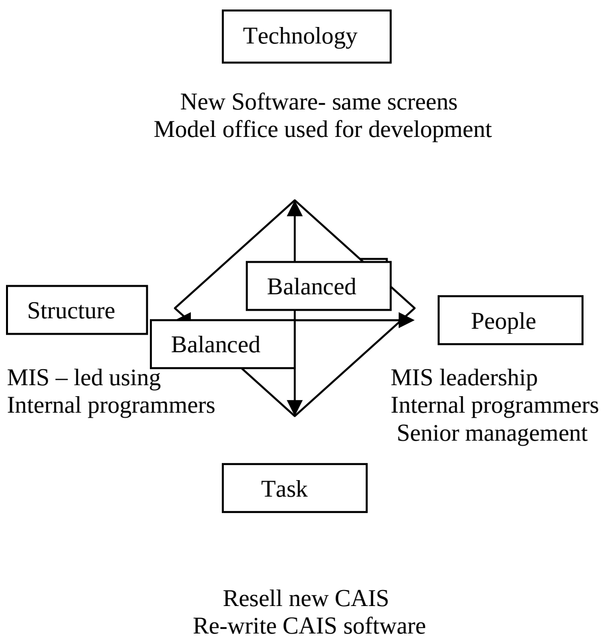
Encounter B4 – Pilot tests reveal major problems (December, t+2)



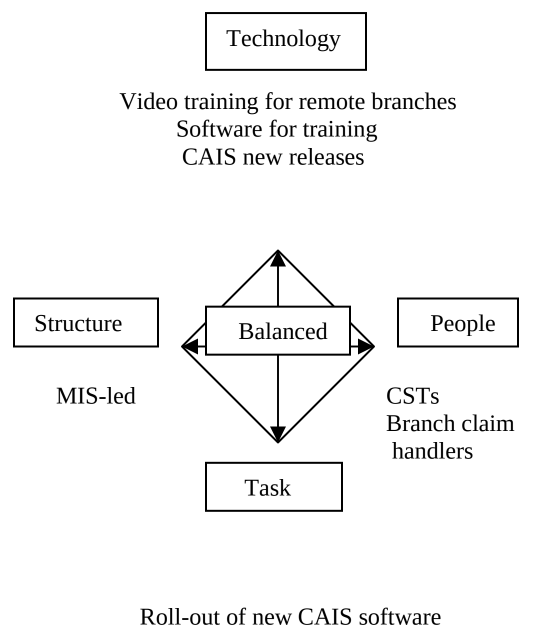
Encounter B5 – Crisis with CAIS (Early t+3)



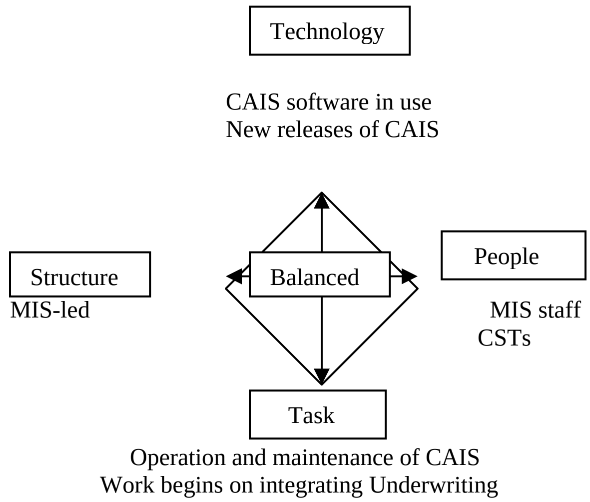
Encounter B7 – New pilot test at Richport (late t+4)



Encounter B6 – Re-sell and re-write CAIS software (t+3)



Encounter B8 – all branches using CAIS (First quarter, t+7)



Encounter B9 – New project begun using CAIS methodology – BSE (t+8)

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