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The Department of Accounting, Finance and Information Systems



University College Cork

**Leveraging lessons learned in organizations
through implementing practice-based organizational
learning and performance improvement
An opportunity for context-based intelligent assistant
support (CIAS)**

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in the National University of Ireland, Cork

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2013

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Abstract

Organizations that leverage lessons learned from their experience in the practice of complex real-world activities are faced with five difficult problems. First, how to represent the learning *situation* in a recognizable way. Second, how to represent what was actually done in terms of repeatable *actions*. Third, how to assess *performance* taking account of the particular circumstances. Fourth, how to abstract *lessons learned* that are re-usable on future occasions. Fifth, how to determine whether to pursue *practice maturity* or *strategic relevance* of activities.

Practice-based organizational learning and performance improvement are investigated in a field study using the Context-based Intelligent Assistant Support (CIAS) approach. The novelty of the research resides in the simultaneous study of the different levels involved in the activity. *Route selection* in light rail infrastructure projects involves practices at both the strategic and operational levels. It is a stepping stone in that it is part managerial/political and part engineering.

A practice-based approach to activity management is enabled by a new conceptual framework that supports researchers and practitioners in applying the CIAS paradigm to *practice-based organizational learning and performance improvement*. The accompanying analytic tool-kit includes *a new method of selecting Key Performance Indicators (KPIs)*, *new methods for measuring and assessing organizational learning*, and *a new method for prioritizing organizational improvement effort*.

It is shown how *aspectual comparison of practices* represented in Contextual Graphs constitutes a new approach to the selection of KPIs that is free from causality assumptions and forms the basis of a new approach to *practice-based organizational learning and performance improvement*. Next, the evolution of practices in contextual graphs is shown to express *organizational learning* which can be interpreted in an objective and measurable way using *a practice-based organizational learning novelty typology*. Finally, it is shown how experience from lessons learned effectively leveraged leads to *practice maturity of an activity* and how the *practice maturity level* in combination with an assessment of an activity's *strategic relevance* can be used by management to prioritize improvement effort.

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Chapter 1.

Leveraging lessons learned in organizations - A real-world problem

1.1 Introduction

This dissertation investigates the role of context¹ in practice-based learning in organizations and in the improvement by organizations of their performance of complex activities. One instance of complex activities is the activity of route selection in which organizations charged with the task of public transport planning select the route for new roads or railway lines. The rich institutional, political, economic, technical and socio-cultural context of the public transport organization studied and the activity of route selection are interesting in their own right but for the thesis presented here the particular setting and activity are incidental; the subject is the role of context, as context, in the organization's learning about one of its most complex activities, and in its improvement of its performance of this activity. Learning is essentially a process of contextualization and de-contextualization (Nonaka & Takeuchi, 1995; Edmonds, 1999; Brézillon & Pomerol, 2001). Leveraging lessons learned is *a priori* amenable to context-based intelligent assistant support (CIAS) (Brézillon, 2011). This dissertation extends the CIAS paradigm to *practice-based organizational learning and performance improvement*. There is no prior research (that the author is aware of) on CIAS in *practice-based organizational learning and performance improvement* of complex activities. A challenging starting point is the real-world problem of leveraging organizational learning in long-cycle complex projects (like route selection in transport planning) where contextualization is particularly challenging for five reasons:

- Complex *activities* are hard to isolate from their *environment*
- Complex projects have both *strategic* and *operational* levels
- *Activity* and *artifact* interact recursively
- Project *stakeholders* evolve with the *institutional context*
- *Long-cycle* projects are prone to staff leaving before the organization abstracts lessons learned from their experience

¹ Here, context is defined as the elements of the environment that bear on an activity without entering directly into the description of the activity (Brézillon & Pomerol, 2001; Edmonds, 1999)

Contemporary organization researchers have different perspectives but most agree that organizations are more or less open systems and to some degree both rational and natural systems (Baum & Rowley, 1997; Scott, 1998; Quinn & Rohrbaugh, 1983). Different historical approaches have converged to this consensus (Baum & Rowley, 1997). The rational choice model emphasized successively the bureaucratic, scientific, and bounded rational aspects of decision making to explain organizational activity (Weber, 1922; Taylor, 1911; Simon 1945; March & Simon, 1958; Cyert & March, 1963); the human resources and adaptive systems views highlighted the importance of motivation and informal structure (Mayo, 1933; Barnard, 1938; Merton, 1945; Selznick, 1948; Parsons, 1960); the cybernetics movement drew attention to feedback from the environment as a means of control in systems (Rosenblueth, Wiener & Bigelow, 1943); and, the open systems theorists applied the concepts of complexity from biology to organizations (Boulding, 1956; Lawrence & Lorsch, 1967; Thompson, 1967; Weick, 1969).

Ten contemporary perspectives on organizations emerge from the historical approaches, and may be characterized as ‘well established’ (e.g., economics, ecology, institutions, power and dependence), ‘expanding rapidly’ (e.g., cognition and interpretation, networks, learning, technology), and ‘still emerging’ (e.g., complexity and computation, evolution) (Baum & Rowley, 1997). Figure 1.1 illustrates these contemporary research perspectives on inter-organizational, organizational or intra-organizational phenomena and positions them with respect to the historical approaches to systems. Researchers that view organizations as economic entities emphasize rationality, whereas researchers that see organizations as institutions, networks, ecologies, or subject to evolution emphasize the natural systems approach. The five remaining perspectives illustrated in Figure 1.1 view organizations as natural/rational-open systems and three of these are particularly relevant for this study: *cognition and interpretation*, *technology*², and *learning*.

Figure 1.1 is adapted to show the position of *practice-based organizational learning*, the core concept underpinning the work presented in this dissertation. The concept of *practice-based organizational learning and performance improvement* is placed between *technology* and *learning* because it involves both

² Technology in the wide sense of ways and means of doing

topics. The CIAS approach to *practice-based organizational learning and performance improvement* embodies *information processing* and *meaning giving* and has its research roots in the *cognition and interpretation* perspective of organization science.

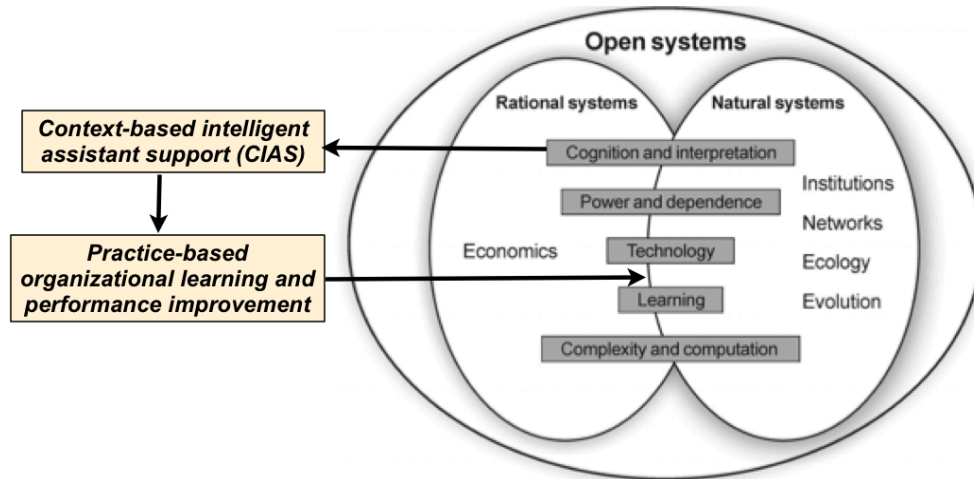


Figure 1.1 *Practice-based organizational learning and performance improvement* situated in organization science (after Baum and Rowley, 1997)

Technology involves two types of knowledge, *knowing what/that* and *knowing how/when* (Polanyi, 1966). *Practice* emphasizes the latter, it is specification of *knowing what/that* in particular circumstances. The difference is essential to this thesis and is echoed in the difference between theory and practice (Giddens, 1984), in the difference between prescribed task and effective task (LePlat & Hoc, 1983), and in the difference between procedure and practice (Brézillon, 2007).

Learning is also of two types in organizations. Organizations' learning from their own experience, referred to as *practice-based organizational learning* is the phenomenon investigated in this research. 'Transfer learning' among organizations and their subunits (Argote & Ingram, 2000) is outside the scope of this thesis. *Practice-based organizational learning* involves problems, practices and procedures. *Problems* are learning opportunities, *practices* are effective solutions in particular circumstances, and *procedures* leverage lessons learned from experience.

Cognition and interpretation are used to apprehend problems, practices, and procedures. Recognizing problems as problems involves tacit knowing, “having an intimation of the coherence of hitherto not comprehended particulars” (Polanyi, 1966). Practical knowing comes with doing (Pfeffer & Sutton, 2000). Through activity, individuals assimilate and/or accommodate new features of the environment into their models of how the world works (Piaget, 2000). Proceduralized context is the internal uniform representation of knowledge, reasoning, and context that tells an individual how to behave in a given situation (Brézillon, 2005). Its acquisition, a process referred to here as *contextualization*, is the essence of individual practical learning, and as such is a social as well as cognitive mechanism (Bandura, 2005, 1989).

The CIAS approach supports the important human process of contextualization. Humans use context to recognize situations (Edmonds, 1997) and context-based behavior may explain the evolutionary value of intelligence (Edmonds, 2012). The CIAS approach is capable of formally representing human practices without loss of the essential unity of knowledge, reasoning, and context that characterizes human activity. It has been successfully applied to both individual and organizational activities using the Contextual-Graphs representation formalism (Brézillon, 2012). This research explores the extension of the CIAS approach to practice-based organizational learning. To do this requires a better understanding of the role of context in practice-based organizational learning and improvement.

When faced with *problems* of a recognizable type, individuals explore new solutions or exploit their experience, acquired either through doing in previous similar situations or by imitating others’ “best practices”. Since no two situations are likely to be identical, *practices* are rarely re-used directly; rather they are formalized as generally applicable *procedures* by abstracting from the details of the particular circumstances in which the practice proved useful. This de-contextualization is the essence of practice-based organizational learning, a social and cognitive mechanism of sharing new knowledge. Figure 1.2 summarizes the thesis that organizational learning is a dynamic process of contextualization of problems and de-contextualization of practices. Procedures are essentially guides to future practice and must be re-interpreted in each new context.

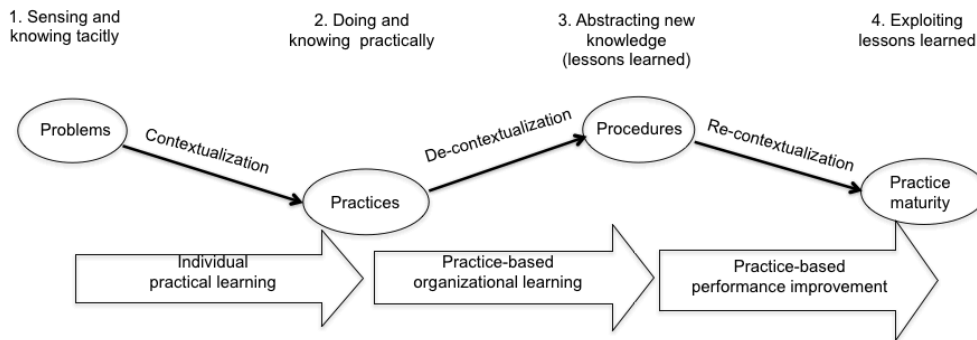


Figure 1.2 Practice-based organizational learning and performance improvement: a process of de-contextualization of practices and re-contextualization of procedures that leads to increased practice maturity

Balancing the time and effort spent devising new rules and performance programs versus enacting existing ones is a central issue of organizational learning and development (March, 1991). Figure 1.2 highlights the fact that problems and procedures are expressed at a higher level of abstraction than practices. Problem solving may be viewed as the process of rendering a solution explicit through progressive contextualization. The next step at each point in an unfolding problem-solving process depends on the current *proceduralized context*. In other words, as an activity is realized, the evolving focus of attention associates each successive action with specific values of the elements of the situation that bear on the action (the proceduralized context). The values of the relevant *contextual elements* can therefore be used to *explain* the structured sequence of actions that represents a particular practice, i.e. why one way of doing the task and not another was chosen in the given circumstances.

The idea expressed in Figure 1.2 is not that producing a new procedure constitutes organizational learning. Organizational learning occurs when new knowledge is embodied in repositories (Argote & Ingram, 2000). The new procedure must represent the de-contextualization of practical knowledge acquired in the solution of a problem in specific circumstances. *Practice-based organizational learning* is a de-contextualization of practices that are themselves contextualizations of problems. *Practice-based organizational improvement* occurs when re-contextualization of the new procedures leads to *practice maturity* of the activity. There is in this view an echo of the notion of structuration, where practices are systems of relations reproduced according to rules and resources whose continuity

and transmutation is itself governed by structuration conditions (Giddens, 1984). Representations of *problems, practices, procedures, and practice maturity* are data structures that both support, and are transformed in, *practice-based organizational learning and improvement*. Contextualization, de-contextualization and re-contextualization are the processes that transform the representations and give meaning to the processed information in its social context. Elucidating the mechanisms that explain the transformations is the purpose of this research.

Contextualization of situations involves framing at two levels: first, identification of the relatively stable features of the environment that bear on the task at a given point, the so-called contextual elements, and second, establishing the specific values of the contextual elements (Brézillon & Pomerol, 2010). The behavioral response to a situation can be qualified in three ways depending on the interpretation of the contextual elements as signals, signs, or symbols, respectively (Rasmussen 1983). Skill-based behavior is recognition-primed by the practitioner's intelligence of the situation (Adam & Pomerol, 2008). Rule-based behavior is guided by existing procedures, re-contextualized by the practitioner for the particular situation (Brézillon & Pomerol, 2001). Knowledge-based behavior is characterized by action requiring the generation of ad hoc plans (Miller, Galanter & Pribram, 1960).

This dissertation concentrates on *rule-based behavior*, where context-based intelligent assistant systems may be most useful. This utility is perhaps related to the timescale of human action (Newell, 1992); skill-based activity may require neural level explanations that are currently beyond formalization, whereas rule-based behavior spans the social, rational, and cognitive, but not the neural band, and knowledge-based activity tends to abstract away from the cognitive mechanisms that explain actual practice.

A review of results from prior research in *practice-based organizational learning and performance improvement* relevant to procedure-controlled complex activities and long-cycle projects is summarized in a conceptual framework that guided the research presented in this dissertation. Three research gaps emerge from the conceptual framework and are discussed in the next three sections. Section 1.2 evokes the problem of *selecting practice-based measures of organizational performance*, Section 1.3 evokes the problem of *measuring practice-based*

organizational learning, and Section 1.4 evokes the problem of identifying *opportunities* for a CIAS approach to *practice-based organizational learning and performance improvement*. Section 1.5 operationalizes the research in three research questions. Section 1.6 presents the structure of the remaining chapters in the dissertation.

1.2 Selecting practice-based measures of organizational performance

Assessing performance in closed systems involves measuring and evaluating activity of the system in terms of output for a given input i.e. assessing changes in the system's environment as a result of the activity (Rosenblueth, Wiener & Bigelow, 1943). Apart from the issue of unintended consequences, this is a relatively simple exercise as the relevant parameters in the environment that need to be monitored are those the system was designed to change e.g. the number of passengers transported per hour measures the performance of a transport system designed to carry x passengers per hour, as long as the system is viewed as a closed system. When systems are viewed as being open, the measurement of performance is more difficult because the system interacts with the environment in a complex manner (Le Moigne, 1999). For example, in the case of organizations charged with the realization of transport systems, interaction with the environment not only changes the external environment (the transport system realized) but it induces learning in the organization in the form of assimilation of the environment to the activity of realizing the transport system and accommodation of the activity to the environment (Piaget, 2000). The performance research literature is silent on how to select indicators of performance in organizations. While the balanced scorecard representation formalism (Kaplan & Norton, 1992) expresses the link between initiatives of the organization and measures of change in the environment, viewed from different perspectives, it does not say how the measures should be selected (Talbot 2010). The same holds for the French *tableaux de bord* approach where managers construct ad hoc performance dashboards (Bourguignon, Malleret & Norreklit, 2001).

The practical method of performance assessment, proposed here, consists in comparing, under any aspect, two practices that realized the same activity. In this case, the aspect chosen is the indicator of performance and the approach opens up all aspects of the realization to improvement through learning. This

operationalizes the claims that the purpose of performance assessment is learning (Neely & Al Najjar, 2006) and the purpose of learning is to improve (Pfeffer & Sutton, 2000). The problem of selection of indicators of performance is transposed into one of aspectual comparison of practices that realize the same activity, a task facilitated by the representation of the practices as the paths in a contextual graph of the activity realized. The *aspectual comparison of practices* in conjunction with the Contextual-Graphs representation formalism is proposed as a coherent theoretical framework for the assessment of performance as called for in the performance research literature (Talbot 2010). In Chapter 4 results are presented on the feasibility and acceptability of such an approach in the organization studied.

1.3 Measuring practice-based organizational learning

Practices can be represented as paths in a contextual graph of the activity they realize (Brézillon, 2007). The Contextual-Graphs representation formalism links situation and activity in a uniform representation of knowledge, context, and reasoning (Brézillon, Pasquier & Pomerol 2002). Context frames an activity at two levels; variable relatively stable features of the environment characterize the type of situation and the particular values of these contextual elements in the given circumstances determine the specific context (Brézillon & Pomerol, 2010). Integrity rules (reasoning about a situation) and inference rules (reasoning in a situation) constrain the values taken by the contextual elements (Brézillon & Brézillon, 2007). Activity nodes may themselves be contextual graphs representing situated activities and/or actions recursively (Brézillon, 2012). Edmonds (1999) has described the purpose of context as recognizing the elements of a situation necessary to transfer knowledge from a learning situation to other situations. Combining these ideas implies that attention, as the activity unfolds, fuses actions to the specific features of the situation in which they are performed (Hegarty, Brézillon & Adam, 2012a). The structures represented as paths in contextual graphs express practical knowledge. The evolution over time of the contextual graphs that represent the realization of an activity in an organization can be characterized using a *practice-based organizational learning novelty typology* to represent measurable practice-based organizational learning. In Chapter 4 results of the field study in the domain of transport planning are presented. These results demonstrate the feasibility and utility of contextual graphs in representing practices

and in measuring practice-based organizational learning for complex activities at both the political/strategic and the tactical/operational levels of management.

1.4 Identifying opportunities for a CIAS approach to *practice-based organizational learning and to improving organizational performance*

As organizations learn from experience, their practice of an activity matures. Practice maturity, understood as an expression of practice-based performance improvement, can be used to prioritize management effort. The *practice-based organizational learning novelty typology* together with the Contextual-Graphs representation formalism can be used to calibrate a *practice maturity model* of an activity. This application of the CIAS approach to *practice-based organizational learning and performance improvement* can be used to support activity management of complex activities at both the operational and strategic levels. In Chapter 4 results are presented on real-world opportunities for CIAS support for practice-based organizational learning and performance improvement in complex activities.

1.5 Operationalizing the research

The subject of this research is practice-based organizational learning and performance improvement in a procedure-controlled long-cycle project activity that addresses problems characterized by complexity, uncertainty, and interdependence (Scott, 2007). The purpose of the research is to extend the CIAS approach to *practice-based organizational learning and performance improvement*. More specifically, the research objective is to improve the understanding of context and operationalize its use in the subject area. This objective is operationalized in the following three research questions:

Research Question One (RQ1) asks how organizations use experience to improve performance. This question is broken down into three subsidiary questions asking how organizations represent their experience, how they abstract lessons learned from their experience, and how they leverage lessons learned from their experience.

Research Question Two (RQ2) asks what issues confront organizations leveraging lessons learned from experience. This question has two subsidiaries asking how

organizations ensure the relevance of their activities and how they ensure the effectiveness and efficiency of their ways and means of realizing their activities.

Research Question Three (RQ3) asks what opportunities exist for a CIAS approach to *practice-based organizational learning and performance improvement*. This question has two subsidiaries asking what opportunities are there for a CIAS approach to recording relevant organizational experience, and to retrieving relevant experience to improve performance in organizations.

1.6 The structure of the chapters

Figure 1.3 presents the elements of the research in a framework inspired by Hevner (2004). The elements correspond to the chapters of the dissertation.

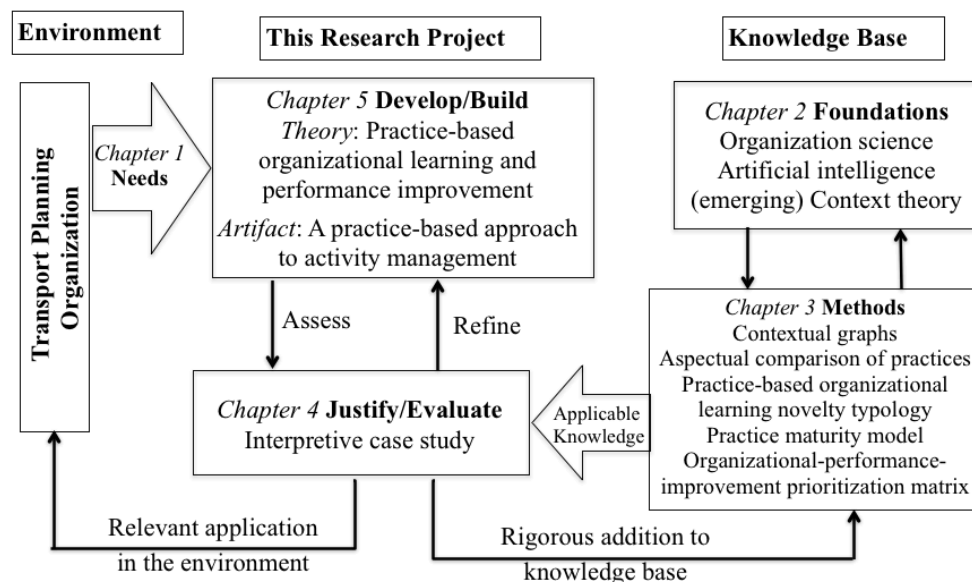


Figure 1.3 Information Systems Research Framework (*after* Hevner, 2004)

The needs of organizations that motivate the research are discussed in this first chapter and may be summarized as leveraging experience to improve performance; the scope addressed is activities for which the organization establishes formal procedures to impose rule-based behavior. Chapter 2 reviews the research literature from organization science, artificial intelligence, and the emerging discipline of context management; particular attention is paid to the

epistemological coherence of interdisciplinary concepts that appear in different semantic communities (Bannon, 1999; Whorf, 1940).

Chapter 3 justifies the ontological, epistemological, and methodological commitments made in carrying out the research project. Informed by the review of previous research, the research questions are articulated in an operational manner and the methodologies used are presented showing how the chain of evidence is maintained between the data, results, and the implications drawn for theory and practice.

The interpretive case study of the practice of route selection at Railway Procurement Agency (RPA), the organization with statutory responsibility for the procurement of light rail public transport in Dublin, included two research workshops organized on light rail route selection at RPA headquarters, more than a dozen formal face-to-face interviews with RPA strategic and operational management, and regular communications over two years with the key RPA players in transport planning. This direct contact with RPA was supplemented by analysis of organizational procedures, confidential policy and project documents including electronic archives, and public domain information on the RPA website. The results were triangulated using interviews with the government department of finance officials responsible for oversight of RPA performance, transport planning academics and practitioners outside RPA, and public domain information not generated by RPA.

The light rail transport system in Dublin is made up of two main lines, the red line and the green line, and their extension and interconnection projects. The focus of this research is on three extension projects. The Docklands extension, known as Line C1 was the first RPA extension project and was followed by the Cherrywood extension, known as Line B1 and the Citywest extension, known as Line A1. The results of the interpretive study of RPA route selection practice on each of the three projects is presented in Chapter 4 together with a cross-case comparison.

Chapter 5 concludes the dissertation with a discussion of the implications drawn from the research and highlights contributions to the theory and practice of *practice-based organizational learning and performance improvement* and to the practice of research. A section on further work shows how this work could be extended and what other research is suggested by the results.

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2. A conceptual framework for practice-based organizational learning and performance improvement

2.1 Introduction

Three rich streams of multi-disciplinary research literature are brought together, here, to create a conceptual framework for organizational learning and performance improvement. The first stream includes research on knowledge and learning in organizations from different disciplines and is recast here as the study of the phenomena of representing, transforming, and using knowledge. Table 2.1 shows the three phenomena together with the six social and cognitive mechanisms that emerge from the literature review as the principal explanatory mechanisms.

Table 2.1 Knowledge and learning in organizations	
Phenomena studied	Explanatory mechanisms
Representing knowledge	Formalization <u>and</u> interpretation
Transforming knowledge (learning)	Assimilation <u>and</u> accommodation
Using knowledge (recognition and reasoning)	Integrity rules <u>and</u> inference rules

Representing knowledge involves the mechanisms of *formalization* AND *interpretation* (Brézillon 2011d; Butler, 2006; Brézillon & Pomerol 2001; Karpatschoff, 2000; Edmonds 1999; Wilson & Sperber, 1993; Polanyi 1966; Hayek, 1945; Peirce 1877). Transforming knowledge involves the mechanisms of *assimilation* AND *accommodation* (Edmonds & Gershenson, 2012; Easterby-Smith & Lyles, 2011; King, 2009; Bandura, 2005; Edmonds 2002; Argote & Ingram, 2000; Piaget, 2000; Nonaka & Takeuchi, 1995; Lave & Wenger, 1991; March, 1991a; Senge, 1990; Schein, 1990; Fiol & Lyles, 1985; Argyris & Schön, 1978;). Using knowledge involves *integrity rules* AND *inference rules* (Pomerol & Adam, 2008; Brézillon, 2005; Pomerol, 1997; Wilson & Sperber, 1993).

The second stream includes research on contextualizing management activity in organizations and is recast here as the study of the phenomena of *situation assessment*, *problem solving*, *decision making*, and *implementing*. Table 2.2 shows the four phenomena together with the eight social and cognitive mechanisms that emerge from the review of the literature as the principal explanatory mechanisms.

Table 2.2 Contextualizing management activities	
Phenomena studied	Explanatory mechanisms
Situation assessment (sensing)	Analogy <u>and</u> enactment
Problem solving (planning)	Means-ends analysis <u>and</u> heuristics
Decision making (committing)	Reason <u>and</u> rationality
Implementing (doing)	Technology <u>and</u> practice

Situation assessment involves *analogy* AND *enactment* (Hjorland, 2007; Hofstadter, 2006; Weick, 2005; Nardi, 1996; Halton, 1992; Weick, 1988; Suchman, 1987; Granovetter, 1985; Leplat & Hoc, 1983; Pounds, 1965). Problem solving involves *means-ends analysis* AND *heuristics* (Gigerenzer & Brighton, 2009; Hatchuel & Weil, 2003; Bardram, 1997; Simon *et al.*, 1986; Allen, 1984; Wilenski, 1983; Sacerdoti, 1975; Polanyi, 1966; Miller, Galanter & Pribram 1960; Newell, Shaw & Simon, 1958). Decision making involves *reason* AND *rationality* (Elster, 2009; Adam 2008; Adam & Pomerol, 2008; Pomerol & Adam 2008; Krantz & Kunreuther, 2007; March & Olsen, 2004; Adam & Pomerol, 1998; Langley, Mintzberg, Pitcher, Posada & Saint-Macary, 1995; Eisenhardt & Zbaracki, 1992; March, 1991b; Mintzberg, Raisinghani & Thorêt, 1976). Implementing involves *technology* AND *practices* (Brézillon, 2011b; Ford & Wargo, 2007; Becker, 2003; Teece, Pisano & Shuen, 1997; Kogut & Zander, 1992; Lave & Wenger, 1991; Scott, 1998; Giddens, 1984; Nelson & Winter, 1973).

The third stream includes research on performance improvement in organizations from different disciplines and is recast here as the study of the de-contextualizing management activities of *representing practices*, and *abstracting lessons learned*, and the re-contextualizing management activity of *leveraging lessons learned*. Table 2.3 shows the three phenomena together with the six social and cognitive mechanisms that emerge from the literature review as the principal explanatory mechanisms.

Table 2.3 De-contextualizing and re-contextualizing management activities	
Phenomena studied	Explanatory mechanisms
Representing practices	State description <u>and</u> process description
Abstracting lessons learned	Measurement <u>and</u> evaluation
Leveraging lessons learned	Exploitation <u>not</u> exploration

Representing practices involves the mechanisms of *state description* AND *process description*¹ (Simon, 1996, p. 210; Dean & Sharfman 1996; Quinn & Rohrbaugh, 1983). Abstracting lessons learned involves the mechanisms of *measurement* AND *evaluation* (Grassl & Smith, 2010; Talbot, 2010; Bourguignon *et al.*, 2001; Payne & Bettman, 1999; Stevens, 1946). Leveraging lessons learned involves the mechanism of exploitation NOT exploration (Neely & Al Najjar, 2006; March, 1991a; Eccles, 1991).

¹ 'The effectiveness of the administrative process will vary with the effectiveness of the organization and the effectiveness with which its members play their parts' (Simon, 1996, p. xii)

The rest of this Chapter is organized as follows. Section 2.2 motivates the approach taken. Section 2.3 discusses the ontological, epistemological, and methodological implications of the approach. Section 2.4 presents the literature on knowledge and learning in organizations, Section 2.5 presents the literature on contextualizing management activities in organizations and Section 2.6 presents the literature on de-contextualizing and re-contextualizing management activities in organizations. Section 2.7 summarizes the literature in a conceptual framework and a number of propositions that guide research towards a theory of practice-based organizational learning and performance improvement, identifies three research gaps to be pursued, and formally states the research objective.

2.2 Motivation

Two research gaps motivate this research, one in organizational learning, the other in performance improvement. The first motivation for this research is a long-standing research gap in organizational learning, namely how to measure organizational learning as opposed to organizational adaptation (Fiol & Lyles, 1985). Progress has been made in understanding knowledge creation using the dominant socialization-externalization-combination-internalization (SECI) model (Nonaka & von Krogh, 2009) but this has not led to noteworthy results in the measurement of actual organizational learning as distinct from organizational adaptation. The realization that *knowledge* and *learning* are related as product to process suggests the problem is one of representation of the evolution of knowledge over time. Since the Contextual-Graphs representation formalism can be used to represent practical knowledge, there is *a priori* a case for using the Contextual-Graphs representation formalism as a basis for measuring practice-based organizational learning and extending context-based intelligent assistant systems (CIAS) support to organizational learning.

The idea behind CIAS support is that experience gained from practicing an activity in particular circumstances can be stored as an algorithm and reused when salient features of the environment take on the specific values encountered in the learning context (Edmonds, 1999). There is a growing research literature on real-time activity support in the form of context-based intelligent assistant systems deployed in simple situations like transport reservation systems. A situation is viewed by cognitive ergonomists as a functional system composed of actor and task (objective and constraints) (Leplat & Hoc, 1983). In the CIAS paradigm, a situation is an interpretation ('dressed in contextual elements') of the environment and circumstances that constrain an activity (Brézillon & Brézillon, 2007). Here, a

context is a specific interpretation of a situation determined by the particular values of its contextual elements and a distinction is made between simple and complex situations. In simple situations, recognizable contexts indicate the appropriate activity or action and may be represented as graphs in which activity- and/or action-nodes are linked to situation-nodes by context-arcs as shown in Figure 2.1.

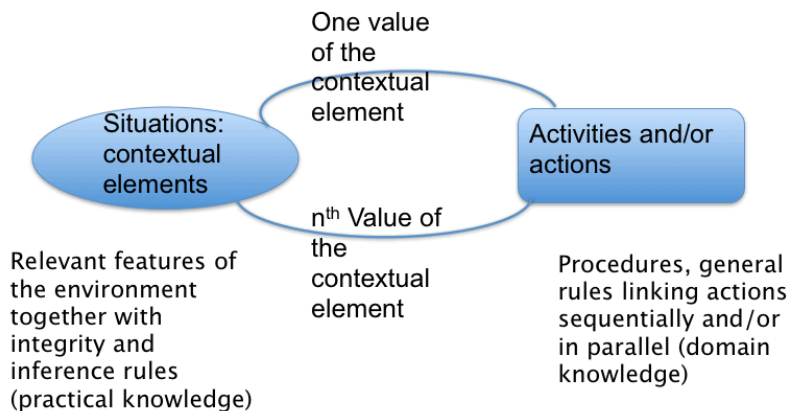


Figure 2.1 In simple situations, recognizable contexts indicate appropriate activity

The graph in Figure 2.1 represents practical knowledge acquired in a process of individual learning; for example, in the situation ‘worker about to leave home for nearby workplace’, and context ‘fine weather but rain is forecast’ two alternative activities are effective, ‘driving to work’ or ‘walking to work carrying an umbrella’. The learner’s schemata ‘grow out of one another by means of successive differentiations and integrations, and must therefore be ceaselessly accommodated to situations by trial-and-error and corrections at the same time as they are assimilating the situations to themselves’ (Piaget, 2000 p.73). In complex situations, representing context remains a challenge for researchers and practitioners because activity is comprised of actions that in turn depend on the evolving context. In complex situations CIAS support is of another order of difficulty. Just as unstructured problems called for a new approach to decision support (Gorry & Scott-Morton, 1989), complex projects call for a new approach to activity support based on a better understanding of the relationship between knowledge, reasoning, and context (Brézillon, 2012). The Contextual-Graphs approach is a candidate that is proving to be well suited to represent practical real-world activity of a certain complexity in an increasing number of domains like medical diagnosis and driver learning (Brézillon, 2011). The uniform representation

of practical knowledge, reasoning, and context that is possible using the Contextual-Graphs formalism seems to be a particularly promising approach to representing practices when it comes to complex activities in real-world projects.

The second motivation for this research is the difficult question of performance assessment. If learning leads to performance improvement, this begs the question of the dimensions on which improvement should be measured, in other words, how to select performance indicators. Prior research in performance assessment has not addressed this important question. The widely adopted Balanced Scorecard approach (Kaplan & Norton, 2001) is seen to be in need of conceptual underpinning by a theory of performance (Talbot, 2010). The Balanced Scorecard is an expression of performance results and associated means; it uses performance indicators (PIs) to specify key objectives but is silent on how to select the measures of performance. Here, the issue of performance indicators is addressed by showing how confusion between two meanings of 'objective' creates a false problem. On the one hand, where objective is the expression of a desired state of affairs it is inappropriate to speak of measuring performance against the objective; outcomes depend on events outside the control of the actor as well as actions that are under the actors control (Savage, 1954) and the best that can be done is to note the state of affairs after the performance. On the other hand, where objective expresses a commitment to a particular way of achieving the objective, two cases arise with respect to performance. If the activity is being realized for the first time then all that can be said about performance is whether the actual practice is in conformity with the plan. But if there is more than one effective way of realizing an activity, the difficult question of selection of measures of performance (PIs) can be transformed into the much simpler question of comparing the different practices that realize the activity. This suggests that extending the CIAS paradigm to measuring organizational learning may require and permit closing the research gap in performance assessment simultaneously; the two research gaps stand and fall together. This has certain ontological, epistemological, and methodological implications that are discussed in the next section.

2.3 Ontology, epistemology, and methodology

The approach taken here of addressing the organizational learning and performance improvement research gaps simultaneously implies bringing together literature from different disciplines and requires certain ontological, epistemological, and methodological precautions. Ontological coherence is ensured by modeling the performing, assessing, and learning organization as a

complex system in an active environment using the three axioms of *purposeful behavior*, *irreversible transformation*, and *recursive autonomy* (Lemoigne, 1989, p. 36). This approach ensures ontological compatibility with the cybernetic view (Rosenblueth, Wiener & Bigelow, 1943), AND the structuralist view (Piaget, 2007) AND the structuration view (Giddens, 1984).

The epistemological commitment of the research is to scientific realism (Searle, 2004, p.208; Baum & Rowley, 1997, p.23). The methodological commitment is to interpretive field study conducted and evaluated from the philosophical perspective of hermeneutics (Klein & Myers, 1999).

The embedded cognitive and social activities of performing, assessing, and learning are illustrated here as a spiral of continuous improvement in Figure 2.2. A similar idea is expressed in Brown and Duguid (1991) 'by reassessing work, learning, and innovation in the context of actual communities and actual practices, .. the connections between the three become apparent'. There is an emerging consensus in both the cognitive and social sciences that the purpose of assessing is to learn from experience (Neely & Al Najjar, 2006), and the purpose of learning is to improve performance (Pfeffer & Sutton, 2000).



Figure 2.2 The spiral of continuous improvement

In Figure 2.2 performing means doing any form of activity whether it be organized as a project (once off, in an unfamiliar situation) or a process (repeated, in familiar circumstances). Assessing performance refers to the measurement and evaluation of the change of state of the environment or the appropriateness of the activity to the situation (March & Olsen, 2004). Learning refers to new insights gained about the situation and/or activity rather than to adaptation of behavior (Fiol & Lyles, 1985).

Management activity aimed at organizational improvement finds expression in *project management*, *process management*, *performance management*, and *organizational learning and knowledge management* as shown in Figure 2.3. The overlapping circles in Figure 2.3 evoke, for complex real-world situations, the embedding of these four modes of management activity.

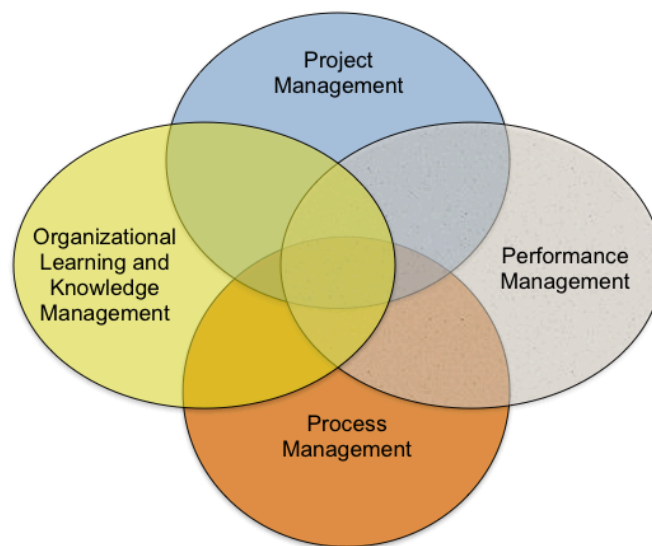


Figure 2.3 Embedded modes of management activity

Research aimed at supporting managers in their efforts to improve organizational performance is focused naturally on the objects of attention of the managers in each area: *problems*, *practices*, *procedures*, and *learning*. The correspondence between embedded modes of management activity, focus of attention and the cognitive nature of the activity is shown in Table 2.4. The distinction between *problems*, *practices*, *procedures*, and *learning* is central to this dissertation; in organizations, *learning* is about *problems*, *practices*, *procedures*, and *learning*. The

recursive aspect of learning is what renders its representation difficult and motivates a context-based approach to the representation of learning.

Table 2.4 Embedded modes of management activity, focus of attention, and cognitive nature of the activity		
Embedded modes of management activity	Focus of management attention	Nature of cognitive activity
Project Management	Problems	Contextualizing
Performance Management	Practices	De-contextualizing
Process Management	Procedures	Re-contextualizing
Organizational learning and knowledge management	Learning	Understanding

Problems are learning opportunities that motivate practice; practices are effective solutions in particular circumstances; procedures abstract lessons learned from experience and constrain future practice when applied (Pounds, 1969; Polanyi 1966; Leplat & Hoc, 1983; Brézillon 2007)

2.4 Practice-based knowledge and learning in organizations

The research literature on knowledge and learning in organizations is presented in this section articulated around the phenomena of representing, transforming and using knowledge. The emergence of these three phenomena as central to the study of organizational learning and performance improvement is due to the ontological, epistemological and methodological differences between knowledge and its representation and transformation. Frege's (1892) distinction between sense and reference opened inference to the power of computation (of truth values of propositions). Peirce's semiotics linked computations (symbol transformations) to the real world as shown in Ogden and Richard's (1927) triangle of meaning in Figure 2.4.

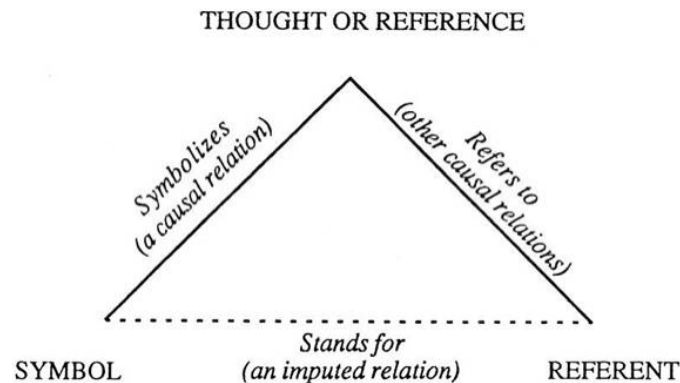


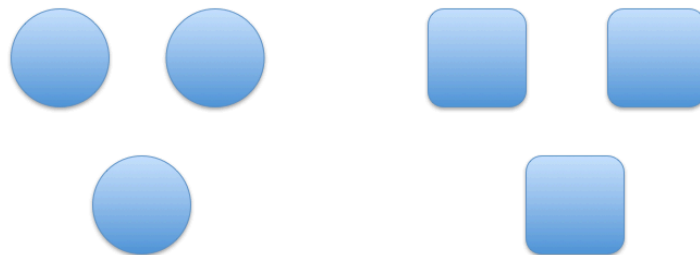
Figure 2.4 The triangle of meaning (Ogden and Richards 1927)

Formalization allowed a separation of reasoning (and its computations) from knowledge representation but at the cost of rendering implicit the context of the knowledge represented (Brézillon, 2011; Karpatschoff, 2000; Allwood, 1999; Wilson & Sperber, 1993; Austin, 1962; Grice, 1957). The literature on boundary conditions highlights the implications of this separation and the necessity for introducing interpretation rules concerning the assimilation of context and the accommodation of activity to the context (Brézillon, 2012; Piaget, 2000; Sowa, 2000; Winograd & Flores, 1986).

2.4.1 Representing practice-based knowledge in organizations

In order to assess and learn from practice it must first be evoked in an adequate representation formalism. The uniform representation of knowledge, reasoning, and context allows practitioners to develop context-based intelligent assistant systems to manage activity (Brézillon, 2012). Representation requires *formalization* AND *interpretation* (Karpatschoff, 2000). Only if communicating parties share an interpretation key can they reach a common understanding of what is meant; all communication (even inner dialogue) requires both a ‘compiler’ representation formalism that *denotes* a difference AND an ‘interpreter’ representation formalism that specifies to what the idea *refers* (Donnellan, 1966). A representation formalism is a revealer of concepts as illustrated in the example in Figure 2.5 (Brézillon, 1983). Analogy is the cognitive mechanism that abstracts a similarity under some aspect between the representations (Hofstadter, 2006; Searle 2004). Different aspects of the representation in the top half of Figure 2.5 are picked out by the alternative interpreting keys in the bottom half. The *meaning activated* in the top half is *determined* differently by the interpreting representation formalism chosen in the lower half (Allwood, 2003).

What does the form illustrated mean?



One interpretation using English words: Two faces

Alternative interpretation using roman numerals: VI=III+III

Figure 2.5 Representation reveals ideas through the mechanisms of formalization and interpretation (after Brézillon, 1983)

Different representation formalisms are not essential to the point made in Figure 2.5; the more common case is when the parties to a communication event share a single representation formalism to code and decode a message. The information processing theory of communication emphasizes the coding and decoding aspects of transmitting a message as shown in Figure 2.6 (Shannon 1949).

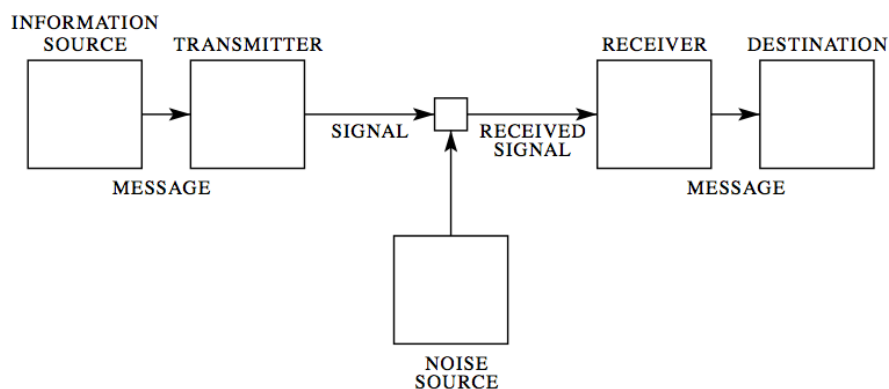


Figure 2.6 Schematic diagram of a general communication system (Shannon 1948, 2)

Shannon's model addresses formalization but is silent on interpretation. Knowledge is required to interpret data as information and researchers in knowledge-based systems note that 'a specific problem-solving episode, or case, may be viewed as data, information, or knowledge depending on its role in decision making and learning' (Aamodt & Nygard, 1995). This view of information as an interpretation of data based on knowledge is supported and extended by

researchers in semiotics for whom understanding of the code must be accompanied by an interpretation of the context (Jakobson 1956, 75). The semiotic theory of communication illustrated in Figure 2.7 schematizes the six constitutive factors in any speech event. Addresser, message, addressee, context, contact (both psychological contact and physical channel), and code each is associated with one of the six basic functions of language (Jakobson, 1960, 353).

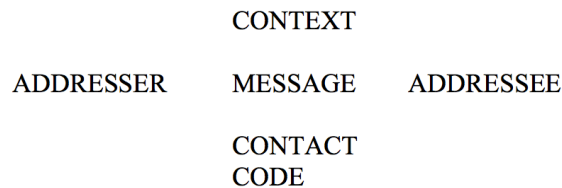


Figure 2.7 Constitutive factors in any speech event (Jakobson, 1960, 353)

Of particular interest here is the function of a code, which is meta-lingual and the function of a context, which is referential². According to this theory, a code is a system of signs that refer in a context; it bridges the view of signs as referential due to Peirce, and the view of signs as linguistic systems due to Saussure. Peirce's view already expressed in simplified form in Figure 2.4 is that 'a sign, or *representam*, is something which stands to somebody for something in some respect or capacity. It addresses somebody, that is, creates in the mind of that person an equivalent sign, or perhaps a more developed sign. That sign which it creates I call the *interpretant* of the first sign. The sign stands for something, its *object*. It stands for that object, not in all respects, but in reference to a sort of idea, which I have sometimes called the *ground* [context] of the *representam*' (Peirce, 1931-1958, 2, 228; Hjørland, 2006). In other words, context restricts the meaning of a sign, determining what is referred to. This idea is operationalized as context-sensitive meaning determination (J. Allwood, 2003) and as Gricean maxims in linguistics (Grice, 1957), and as a two-level contextualization process in the decision support systems literature (Brézillon & Pomerol, 2010). Saussure's view, illustrated in the schema in Figure 2.8, is that a sign combines a signified idea and a signifying acoustic image neither of which are delimited in advance (Saussure, 1910, 6).

² The other functions are emotive, poetic, conative, and phatic, which emphasize (are set towards) respectively the addresser, message, addressee, and contact factors.

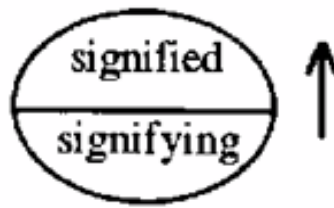


Figure 2.8 Schema of a sign (Saussure, 1910, 6)

'The signifying and signified elements contract a bond in virtue of the determinate values that are engendered by the combination of such and such acoustic signs with such and such cuts that can be made in the mass...the contours of the idea itself are what we are given by the distribution of ideas in the words of a language'. According to Saussure, language is not a nomenclature but a linguistic system of terms in which the idea of value is tacitly implied in that of term; "the value of a word can never be determined except by the contribution of coexisting terms which delimit it...what is in the word is only ever determined by the contribution of what is around it, around it syntagmatically or around it associatively' (Saussure, 1910, 6). In other words, code is a double restriction of meaning, a specification of what is meant by an idea using two structural axes as illustrated in Figure 2.9.

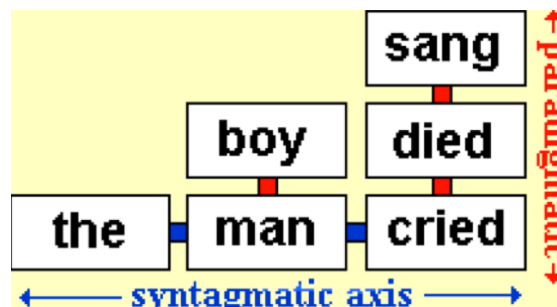


Figure 2.9 Syntagmatic and paradigmatic axes of a code (Chandler 2007, 84)

For saussurian semioticians, to use a code meaningfully requires a shared, at least partial, understanding of the rules of positioning of elements of the code (syntagmatic relations) and the possibilities of substitution of the elements of the code (associative or paradigmatic relations) (Chandler 2007, 84). For peircean semioticians it requires a common interpretation of what each sign refers to. For jakobsonian semioticians both are needed; a view that is supported by philosophers of mind who hold that 'the human mind attaches meaning to symbols' (Searle, 2004, 63); and artificial intelligence researchers who hold that there is a knowledge level above the symbol level (Newell, 1982).

Disentangling code and context is not easy in organizations and the task is a major challenge for context-based intelligent assistant support systems. The flowchart in Figure 2.10 (after Wilenski 1983) shows a model of management activity, expressed as the syntagmatic axis of an organizational code composed of situations, objectives, plans, practices, and lessons learned. The order of the terms is important for their meaning, and in the model illustrated the syntagm can be read in both directions from situations to lessons learned in the case of planning and implementing and the other way around for assessing and understanding. Planning, implementing, assessing and understanding are embedded activities occurring in each of the modes of management activity involved in organizational improvement (Figure 2.3).

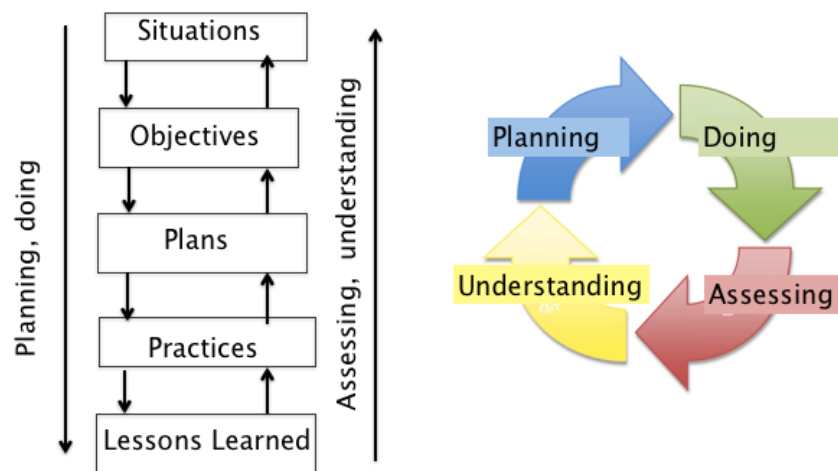


Figure 2.10 A model of management activity (after Wilenski, 1983)

Particular management practitioners and researchers may substitute their own words for any of the terms of the syntagm but the conceptual framework is essentially unchanged as long as the substitutes are chosen from a coherent paradigmatic class. The paradigmatic axis of the code is shown in Table 2.5; it includes some of the more common terms occurring in the research literature reviewed in this chapter.

Table 2.5 Paradigmatic similarity and context	
Element	Paradigmatic class
Situations	Issues, Problems (Pounds, 1969), Circumstances, Opportunities, States (of affairs), Positions (in an environment), Cases, Tasks, Contexts, Gaps (Pounds, 1969)
Objectives	Goals (Allen, 1984 p.268), Aims, Targets, Desired states (Newell & Simon, 1961), Desired outputs, Desired outcomes
Plans	Procedures, Processes, Projects, Methods, Scenarios, Scripts (Shank & Abelson, 1977), Prescribed activity (Leplat & Hoc, 1983), Sequences of actions (Fikes & Nilsson, 1971), Partial orders of actions (Sacerdoti, 1971), Complex actions (Allen, 1984, p.268), changes in situation (McCarthy, 1963), changes in state space (McDermott, 1996)
Practices	Actual ways of doing, Situated actions, Actual performances, Effective activity (Leplat & Hoc 1983), Effective solutions
Lessons learned	Experiences, Results, Findings, Evaluations, Assessments

Context supports interpretation of meaning in two ways, one meta-lingual and the other referential (Jakobson, 1960, p. 353). The first concerns the paradigmatic similarity of the type illustrated in Table 2.5. Each attribute that members of a class have in common is a ground for similarity and ‘the more an item has attributes in common with other members of the category, the more it will be considered a good and representative member of the category’ (Rosch & Mervis, 1975). This suggests that some terms are better than others as elements in the framework and the selection of a representative term from a paradigmatic class could be tested experimentally. The second way that context supports meaning derives from the syntagmatic difference between the elements as illustrated in Table 2.6.

Table 2.6 Syntagmatic differences and context				
Objects of management attention	Mode of interpretation	Interpretation		Formal description
		Qualities	Implicit knowledge	
Situations	What's going on? Expected world (Allen, 1984, p.267)	Factuality	Beliefs Preferences	Evolving states of an active system and the elements of the environment that bear on its activity
Objectives	Where do we want to go? Desired world (Allen, 1984, p.267)	Finality	Desires Commitments	Desired states of system and environment
Plans	How do we get there? Planned world (Allen, 1984, p.267)	Goodness	Constraints	Projected sequence of actions to achieve objectives
Practices	What did we actually do? (Brézillon 2011)	Maturity	Alternatives	Performance of actions in particular circumstances
Lessons learned	What did we learn? (Pfeffer & Sutton, 2000; Fiol & Lyles, 1985)	Relevance	Intentions	Emergence of new situations and/or new activities

Each of the framework elements has a different role corresponding to canonical questions that every organization addresses at different stages of its management activity of planning, implementing, assessing and understanding: What's going on? Where are we going? How do we get there? What did we actually do in particular given circumstances? What did we learn? The represented form is not sufficient to discriminate between the elements of the framework, just as it is not sufficient to discriminate between data, information, and knowledge (Aamodt & Nygard 1995). Interpretation presupposes an intention, a mode of focusing attention. This echoes the felicity conditions of a *speech act*, which depends on the facts, the utterer's knowledge of the facts, and the purpose of the utterance (Austin, 1962).

The context is the set of salient parameters, the relevant implicit knowledge used to characterize an instance of the term (Brézillon & Pomerol 1999). For example, a situation arises from consideration of the criticality of the evolution of an activity in its environment with respect to certain values. The essence of a situation is its criticality and so knowledge of the values that determine criticality is the contextual background from which every situation emerges (Endsley, 1995). In the same way, the essence of an objective is its intentionality (Searle, 2004, p.120). The essence of a plan is its effectiveness (Wilenski, 1983). The essence of a practice is the appropriateness of its actions to the specific circumstances (Brézillon, 2007). The

essence of lessons learned is their contribution to the growth of knowledge (Piaget, 2000).

Representation requires both formalization and interpretation and in order to disentangle code and context in organizations meta-lingual and referential aspects of contexts must be separated. The former is a relatively simple question of glossaries as illustrated in Table 2.5 but the latter requires a more subtle approach as referential context varies with the focus of attention as shown in Table 2.6. The solution is to address the representation of knowledge, reasoning, and context simultaneously and to use a uniform representation formalism as is discussed in the following sub-section.

2.4.1.1 Formalizing practice-based knowledge in Contextual-Graphs (CxG)

The CxG approach to representing practice specifically addresses the issue of focus of attention and is presented here together with the Generic Framework. A practice is an instantiation of a prescribed procedure in specific circumstances. Framing of decision-making involves two types of contextualization (Brézillon & Pomerol, 1999). Figure 2.12 shows contextualization at the top levels as stable, corresponding to *meaning activation* or *denotation* of the situation, whereas at the lower levels, contextualization is dynamic, corresponding to *meaning determination* or specification of the *reference* of the situation (Allwood, 2003; Donnellan, 1966).

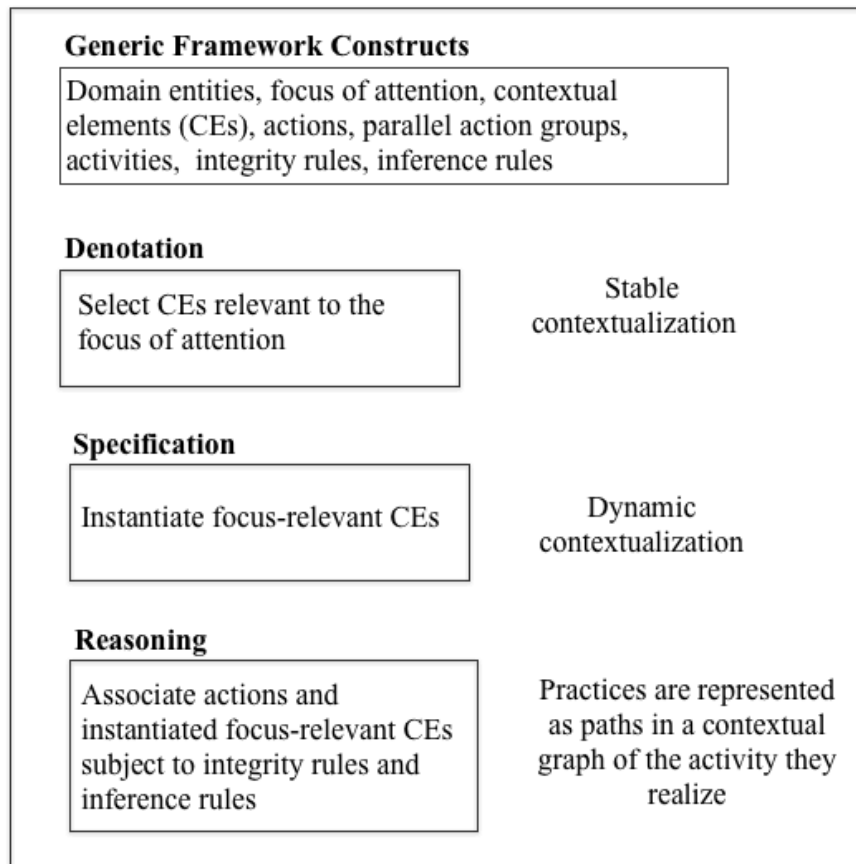


Figure 2.11 A generic framework for *representing practices* in contextual graphs (after Brézillon, 2007; Brézillon & Pomerol, 1999)

A contextual graph (CxG) can be used to represent the different ways of carrying out a generic task. Each of these ways (practices) corresponds to a path through the graph that links actions in a way that depends on the value of contextual elements that characterize the specific situation. The specific values of the contextual elements on a path explain the reasoning behind the practice.

Figure 2.12 shows an example of a contextual graph representing different *route selection* practices. Two experienced RPA transport planners participated in a research workshop that generated this graph. It is a relatively high-level representation of the route selection corresponding almost to a project network but it still contains important contextual information relating to *technology used*, *existence of prior work*, and *complexity of the topology*. Of course each of the activities illustrated in Figure 2.12 may be represented as a graph in its own right showing practices for each activity and so on recursively.

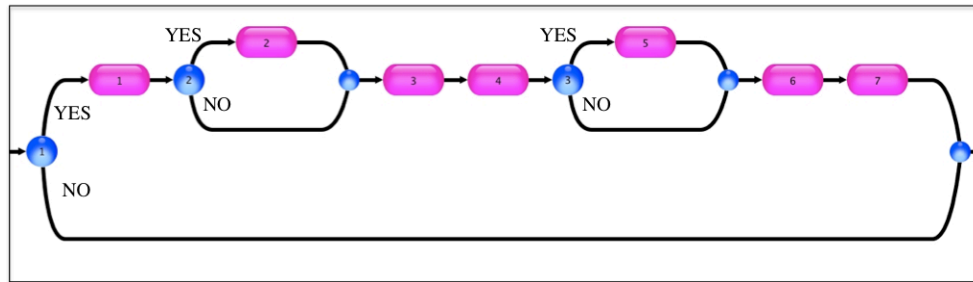


Figure 2.12 A contextual graph for route selection - the case of line L

The *contextual elements* and *activities* corresponding to Figure 2.12 are shown in Table 2.7³.

Table 2.7 Contextual elements and activities illustrated in Figure 2.12	
Contextual elements	
CE1 (circles)	Light rail technology?
CE2	Prior work exploitable?
CE3	Complex topology?
Activity	
A 1 (ovals)	Select parameters
A 2	Exploit prior (2004) work
A 3	Generate spider's web
A 4	Sift 1 workshop
A 5	Sift 2 workshop
A 6	Consult public on route options
A 7	Appraise route options (multi-criteria framework)

2.4.1.2 Interpreting practice-based knowledge

Returning to the review of the literature on *representing practice-based knowledge*, this section concludes with a discussion of the conceptual analysis shown in Table 2.8. The analysis collates and juxtaposes results in prior literature that are relevant to the phenomenon of *representing practice-based knowledge* as construed in the present thesis. The concepts presented in Table 2.8 represent a dynamic equilibrium between relevant concepts identified in the prior literature in AI, psychology, linguistics, and philosophy and those emerging as the conceptual framework that underpins the research presented in this dissertation. Prepared

³ For simplicity, the case of alternative technologies is not illustrated in Figure 2.12.

using concept-centric literature review tables⁴, as recommended by Webster & Watson (2002). Each of the sections of the literature review has its own conceptual analysis table and together they constitute the basic grammar of the research project. In all, there are ten literature review tables (Table 2.8 through Table 2.17) and each table gives rise to one row, in the form of a single 'axiomatic' statement, in the synthesis of results from prior literature in Table 2.18.

Table 2.8 first presents the concept of *representing* in four use situations of interest to the expression of *practice-based knowledge*. In this dissertation, *data* is represented as *information* in the context of *knowledge*, *human behavior* is represented as *action* in the context of *practice-based knowledge*, and *action* is represented as the *action* of a *system*. Then Table 2.8 presents the two constitutive elements of *representing*, viz., *formalizing* and *interpreting* as concepts with their own use situations.

Table 2.8 Concept-centric analysis of literature on <i>representing practice-based knowledge</i>			
Concept	Use situation	Analysis	Ref.
Representing	Data	Data signify 'material to serve' they are indications, evidence, signs, clues to and of something to be reached, they are intermediate, not ultimate, means not finalities	Dewey, J. (1929, p.29)
		Data are syntactic entities, information is interpreted data, knowledge is learned information; a specific problem solving episode, or case, may be viewed as data, information, or knowledge, depending on its role in decision making and learning from experience	Aamodt, A. and Nygard, M. (1995)
	Information	The subjective/situational understanding of information is a kind of semiotic theory (Karpatschoff, 2000); information is a difference that makes a difference (for somebody or for something or from a point of view) (Bateson)	Hjorland, B. (2007)

⁴ Literature review tables are an example of a representation formalism revealing concepts (Brézillon, 1983). They consist of rows of articles and columns of concepts. Adding a new article to the list modifies the sense of the column to which it is assigned (paradigmatic similarity) and the sense of all the other columns (syntagmatic differences). Similarly, adding a new concept column changes the attribution of the articles. The process is open to new concepts, yet converges as theoretical saturation is reached (Eisenhardt, 1991).

Table 2.8 Concept-centric analysis of literature on <i>representing practice-based knowledge</i>			
Concept	Use situation	Analysis	Ref.
Representing	Knowledge	The method of science is based on the hypothesis that there are Real things, whose characters are entirely independent of our opinions about them, those Reals affect our senses according to regular laws, and, though our sensations are as different as our relations to the objects, yet, by taking advantage of the laws of perception, we can ascertain by reasoning how things really and truly are, and any man if he have sufficient experience and he reason enough about it, will be led to the one True conclusion; the new conception here involved is that of Reality	Peirce, C.S. (1877)
		Representations exist at the symbol level, being systems (data structures and processes) that realize a body of knowledge at the knowledge level; representation is a symbol structure that encodes a body of knowledge	Newell, A. (1982)
		Science does not name an ontological domain; it names rather a set of methods for finding out about anything at all that admits of scientific investigation. So if we are interested in reality and truth, there is really no such thing as 'scientific reality' or 'scientific truth'. There are just the facts that we know.	Searle, J. R. (2004, p. 208)
	Action	Three basically different ways of representing constraints characterize human behavior as skill-based, rule-based and knowledge-based: signals, signs, and symbols	Rasmussen, J. (1983)
		A temporal logic is necessary to support a theory of action capable of representing 1) actions that involve non-activity; 2) actions that are not easily decomposable into sub-actions, and 3) actions that occur simultaneously and interact with many others	Allen, J. F. (1984)
		Action is not a combination of 'acts': 'acts' are constituted only by a discursive moment of attention to the durée of lived-through experience; a stratification model of the acting self involves treating the reflexive monitoring, rationalization and motivation of action as embedded sets of processes; agency refers to doing (not intention), consequences are events which are not within the scope of the agent's power to have brought about;	Giddens, A. (1984)
		Engagement in practice is characterized by the 3Rs: routines, roles, and responsibilities; a considerable amount of information that is crucial for shaping social interactions is largely implicit to participants (Bourdieu 1977); teachers are shaped by what they perceive as appropriate to the classroom as a social context; teaching can be viewed as purposeful moves in a particular social context	Ford, M. and Wargo, B. (2007)

Table 2.8 Concept-centric analysis of literature on *representing practice-based knowledge*

Concept	Use situation	Analysis	Ref.
Representing	Systems	Theoretical systems and constructs can be arranged in a hierarchy of complexity, roughly corresponding to the complexity of the "individuals" of the various empirical fields: 1) static structure:frameworks; 2) simple dynamic systems with predetermined, necessary motion: clockworks; 3) the control mechanism or cybernetic system: the thermostat; 4) "open system" or self-maintaining structure: the cell; 5) the genetic-societal level: the plant; 6) the "animal" level characterized by increased mobility, teleological behavior, and self-awareness: intervention of the "image" between the stimulus and the response ; 7) the "human" level, his image has a self-reflexive quality, he not only knows, but knows that he knows: the ability to produce, absorb, and interpret symbols, as opposed to mere signs; 8) the social systems: the unit of such systems is the "role", that part of the person which is concerned with the organization or situation in question; 9) transcendental systems: questions that have no answer	Boulding, K. E. (1956)
		A specific program plays the role that is played in classical systems of applied mathematics by a specific system of differential equations; the vagueness that has plagued the theory of higher mental processes and other parts of psychology disappear when the phenomena are described as programs	Newell, A., Shaw, J., & Simon, H. A. (1958)
		Institutionalized Organizations: Formal Structure as Myth and Ceremony; environments and environmental domains which have institutionalized a great number of rational myths generate more formal organization; organizations which incorporate institutionalized myths are more legitimate, successful, and likely to survive; organizational control efforts, especially in highly institutionalized contexts, are devoted to ritual conformity, both internally and externally	Meyer, J. W., and Rowan, B., (1977)
		The embeddedness argument stresses the role of concrete personal relations and structures (or 'networks') of such relations in generating trust and discouraging malfeasance; economic action is embedded in the structures of social relations	Granovetter, M. (1985)

Table 2.8 Concept-centric analysis of literature on <i>representing practice-based knowledge</i>			
Concept	Use situation	Analysis	Ref.
Representing	Systems	Thompson (1967) production components should be sealed off from the environment, managerial units must mediate between the more open organizational components that track environmental change and the more closed organizational units that attempt to carry on <i>routinized production activities</i> ; all organizations are simultaneously rational and natural systems, and all are both open and closed systems; since Thompson organization ecology and institutional theory do not directly challenge contingency theory but rather direct attention to 'higher' levels of analysis, the organizational population (organizations using the same form), and the organizational field (multiple types of organizations working in a common arena, e.g., mental health)	Scott, W. R. (2007)
		The context-based intelligent assistant systems (CIAS) paradigm addresses the weaknesses of expert systems of the knowledge-based systems (KBS) paradigm	Brézillon, P. (2011)
		In complex situations, greater availability of KMS leads to greater use but not to positive performance impacts ; a study of two types of KMS (unsophisticated, sophisticated) in two decision contexts (simple, complex); the universalistic view implicit in Nonaka's SECI and the contingency view regarding 'proper' KMS design	Handzic, M. and Ozlen, K. (2012)
Formalizing	Context	Formalized non-monotonic reasoning provides a formal way of saying that a bird can fly unless there is an abnormal circumstance and reasoning that only the abnormal circumstances whose existence follows from the facts being taken into account will be considered	McCarthy, J. (1987)
		"Context is what constrains a problem solving without intervening in it explicitly" at the level of the knowledge and its representation, or at the level of the reasoning mechanism, or at the level of the human-machine interaction	Brézillon P. (1996)
		Activity Theory is better suited to formalizing context in Human Computer Interaction than Situated Action Models, or Distributed Cognition	Nardi, B. (1996)
		Contexts themselves have to be learned in parallel with other facts	Edmonds, B. (1997)
		Context is what constrains <i>something</i> without intervening in it	Brézillon, P., et al. (1998)
		Context acts more on the relationships between items than on the items themselves	Brézillon P. (1998)
		Context is an abstraction of the features that are not explicitly included in the learning model but used in the recognition of its applicability	Edmonds B. (1999)

Table 2.8 Concept-centric analysis of literature on <i>representing practice-based knowledge</i>			
Concept	Use situation	Analysis	Ref.
Formalizing	Context	It is better not to distinguish context from other objects of reasoning, learning, etc., objects being in the context or not according to the circumstances	Pomerol J.-C. & Brézillon P. (2001)
		Context is tacit knowledge	Brézillon, P. & Pomerol J.-C. (2001)
		It is all too easy to trivialize context; Dey, Salber and Abowd (2001) gloss over its dynamic aspects; similar-looking contextual situations may actually differ dramatically, due perhaps to people's previous episodes of use, the state of their social interactions, their changing internal goals, and the nuances of local influences	Greenberg, S. (2001)
		Context proceduralization in decision making is <i>rational construction for action</i>	Pomerol J.-C. & Brézillon, P. (2003)
		<i>Situatedness</i> refers in its original meaning to both the ongoing or emerging circumstances of the surrounding world and the inner situation of the actor	Ciborra, C. (2006)
		Practice is the contextualization of a task	Brézillon P. (2007)
		Data, information and knowledge should all be invoked, assembled, organized, structured and situated according to the given <i>focus</i>	Fan, X., et al. (2011)
		In collaborative work, individual decision-making is based on a shared context	Tahir, H., Brézillon, J. (2012)
	Concepts	Different languages conceptualize the world differently	Whorf, B. (1940)
		Categories express <i>family resemblances</i> between members of the categories	Rosch, E. & Mervis, C. (1975)
		Representation formalisms act as revealers of concepts	Brézillon P. (1983)
		The Enterprise Ontology formalizes concepts used in management	Uschold, M., et al. (1998)
		Conceptual structures evoke logical, linguistic, and conceptual issues	Sowa, J. (2000)
Interpreting	Activity	Sense (thought expressed) and reference are semantically distinct	Frege, G. (1892)

Table 2.8 Concept-centric analysis of literature on <i>representing practice-based knowledge</i>			
Concept	Use situation	Analysis	Ref.
Interpreting	Activity	<i>Symbols</i> direct and organize, record and communicate <i>thought (or reference)</i> ; standing for and referring to are two different relations; in <i>all</i> perception, as distinguished from mere awareness, sign-situations are involved; when we speak, the symbolism we employ is caused partly by the reference we are making and partly by social and psychological factors -the purpose for which we are making the reference, the proposed effect of our symbols on other persons, and our own attitude	Ogden, C., and Richards, I. (1927)
		An utterer is held to intend to convey what is normally conveyed, we are presumed to intend the normal consequences of our actions; in cases of doubt, we tend to refer to the context	Grice, H. (1957)
		Reference depends on knowledge at the time of utterance; the felicity of an utterance depends on the facts and your knowledge of the facts and the purposes for which you were speaking; Meaning (in Frege's sense) changes with the 'illocutionary' force of a speech situation: there are families of speech acts	Austin, J.L. (1962)
		There are two kinds of awareness, focal and subsidiary; the characteristic feature of subsidiary awareness is to have a function, the function of bearing on something at the focus of our attention; we attend <i>from</i> the subsidiary particulars to their joint focus	Polanyi M. (1965)
		Referring is not the same as denoting; lack of particularity is absent from the referential use of definite descriptions precisely because the description is here merely a device for getting one's audience to pick out or think of the thing to be spoken about	Donnellan, K. (1966)
		Operational effectiveness means performing similar activities <i>better</i> than rivals perform them; strategic positioning means performing different activities from rivals' or performing similar activities <i>in different ways</i>	Porter, M. (1996)
		Signs, subject, and object may be represented as the vertices of a triangle of meaning following Ogden & Richards (1927) and activity theory (Leontief, 1978); meaning is the very quality of the intentional mediation between subject and object that is the <i>specifica differentia</i> of human activity	Karpatschhof, B. (2000)
		Word meaning (at the actual occurrence level) is produced by context sensitive operations of meaning activation and meaning determination (a structured partial activation) which combine meaning potentials (union of individually or collectively remembered uses) with each other and with contextually given information	Allwood, J. (2003)

Table 2.8 Concept-centric analysis of literature on <i>representing practice-based knowledge</i>			
Concept	Use situation	Analysis	Ref.
Interpreting	Activity	Every nominal predicate is associated with a situation variable and domain restriction proceeds through the assignment of values to the situational variable	Recanti, F. (2004)

From Table 2.8 it emerges that *formalizing* and *interpreting* are distinct concepts. *Representing practice-based knowledge* involves *formalizing and interpreting* an activity together with the elements of the environment that bear on its realization in a given situation. The latter two phenomena are separated analytically but they co-occur and co-constitute the phenomenon of *representing*. A formalization is always interpreted as a formalization by the formalizer and an interpretation is always formalized as an interpretation by the interpreter. *Formalizing* is expressed as conceptualization (codification) or contextualization depending on the *focus of attention* (Jakobson, 1960). Concepts are that *to* which an attender attends, context that *from* which an attender attends (Polanyi, 1965). The central tenet of the CIAS paradigm that guides this research is that context is always relative to an evolving focus of attention (Brézillon, 1998). *Interpreting* meaning is a social and cognitive process that guides human activity in which meaning is situated (Karpatschhof, 2000). To interpret is to find that to which the form refers and it proceeds in two steps, first activating the meaning and then determining it (Allwood, 2003).

In the CIAS approach used in the thesis to represent activity, meaning is activated by the contextual elements and determined by the values of the contextual elements instantiated as the activity is performed. The path along which the activity evolves in the specific circumstances is captured in a contextual graph. The Contextual-Graphs representation formalism separates the concepts that denote and refer to the situation from those that denote and refer to the actions that realize the activity. Contextual elements represent elements of the environment in the widest sense that bear on the activity including emotional states of the practitioner where relevant thus the heart is not missing from the CIAS approach (Ciborra, 2006).

In summary, *representing practice-based organizational knowledge* involves *formalizing and interpreting* the practice of an organizational *activity* in terms of *actions* and other *activities* that realize the given activity, together with the (*generic*) *elements of the environment that bear on the realization of the given activity in the*

given situation (contextual elements) and the *specific values* which the contextual elements take on as the activity unfolds. The transformation of such representations of *practice-based knowledge in organizations* is the topic of the next section.

2.4.2 Transforming practice-based knowledge in organizations

This section reviews the literature on *transforming practice-based knowledge*. Table 2.9 presents the concept of *transforming practice-based knowledge* under the heading *learning* in the three use situations of interest viz., *in individuals*, *in organizations*, and *in institutions*. It is claimed here that practice-based organizational learning is co-constituted by *assimilation of new situations to existing practices* and *accommodation of new practices to recognized situations*.

Table 2.9 Conceptual analysis of the literature on <i>transforming practice-based knowledge</i>			
Concept	Use situation	Analysis	Ref.
Learning	in individuals	Operational intelligence is characterized by mobile and reversible 'patterns' which are constituted by groups or groupings; innate mechanisms lack differentiation between the assimilation of objects to the subject's activity and the accommodation of the latter to possible changes in the external situation; In learning by experience accommodation to new phenomena involves a 'displacement of equilibrium' and the equilibrium that is re-established by assimilation to previous perceptual schemata shows a tendency to react in the opposite direction to that of the external change	Piaget, J. (1947)
		Intelligence is socially situated; probing and sensing, gossip, goal directed interactive learning, specific adaptations	Edmonds, B. & Dautenhahn, K. (1998)
		The Origin of Concepts; core knowledge derives from innate learning mechanisms in at least two domains: intuitive mechanics, with the concept of an object and contact causality at its core, and intuitive psychology, with the concept of an agent and intentional causality at its core.	Carey, S. (2000)

Table 2.9 Conceptual analysis of the literature on <i>transforming practice-based knowledge</i>			
Concept	Use situation	Analysis	Ref.
Learning	in individuals	To be an agent is to influence intentionally one's functioning and life circumstances; by being represented cognitively in the present, visualized futures serve as current guides and motivators of behavior; agents are not only planners and fore-thinkers, they are self-examiners of their own functioning; forethought and self-influence are part of a causal structure; personal agency operates within a broad network of socio-structural influences; in agentic transactions, people create social systems to organize, guide, and regulate human activities; the practices of social systems, in turn, impose constraints and provide resources and opportunity structures for personal development and functioning	Bandura, A. (2005)
		The social intelligence hypothesis, which posits that complex cognition and large "executive brains" evolved in response to challenges that are associated with social complexity, is well supported but recent data are inconsistent with its predictions; multiple selective agents, and non-selective constraints, must have acted to shape cognitive abilities in humans and other animals	Holekamp, K. (2006)
Learning	in individuals	Central to the dynamic systems approach to development is the postulate that development depends on experience and is therefore in large part a learning process (Thelen and Smith, 1994); 1) behavioral patterns resist change i.e. are stable (mathematically characterized as attractor states of a dynamical system), 2) behavioral change is brought about by a loss of stability, 3) representations possess stability properties as well, attractor states of dynamic fields, continuous distribution of neural activation, 4) cognitive processes emerge from instabilities of dynamic fields, 5) learning consists of changes in behavior or field dynamics that shift the behavior or environmental context in which instabilities occur	Schöner, G. (2007)
		Truth, beauty, and goodness can be reframed as principles guiding learning about transparency of methods, discrimination of experiences, and sharing of ethical dilemmas associated with roles in different polities	Gardner, H. (2011)
	in organizations	Mismatch between action strategies and consequences that feeds back to review of the action strategies is qualified as single loop learning whereas feedback to review of the governing values is qualified as double loop learning	Argyris, C. and Schön, D. A. (1978)

Table 2.9 Conceptual analysis of the literature on <i>transforming practice-based knowledge</i>			
Concept	Use situation	Analysis	Ref.
Learning	in organizations	Organizational learning means the process of improving actions through better knowledge and understanding; theories of higher level learning are rare; distinguishing OL from purely behavioral adaptation one needs to know if association development has occurred	Fiol, C.M. and Lyles M. (1985)
		Five new 'component technologies' provide the vital dimensions in building organizations that can truly learn: systems thinking, personal mastery, mental models, building shared vision, and team learning	Senge, P. (1990)
		The essence of the transactive mode is strategy making based on interaction and learning rather than the execution of a predetermined plan (Fiol and Lyles, 1985); top management is concerned with facilitating a process for transacting with key stakeholders and linking the outcomes of those processes together over time to determine strategic direction (Mintzberg, 1987); in the transactive mode style is procedural, the role of top management is to empower and enable (facilitator) and the role of organizational members is to learn and improve (participant); the Deming Prize and Malcolm Baldrige Award are granted on a firm's ability to demonstrate strong organizational learning capability fostered by transactive relationships among suppliers, customers, and employees	Hart S. L. (1992)
		The knowing doing gap, the challenge of turning knowledge about how to enhance organizational performance into actions consistent with that knowledge, how to convert knowledge into action; formal systems cannot store tacit knowledge; mission statement is one of the common means that organizations use to substitute talk for action; measure processes not just outcomes	Pfeffer and Sutton (2000)
		Learning from Organizational Experience; a four-stage model : 1) local stage of decentralized learning by individuals and work groups, 2) control stage of compliance with rules, 3) open stage of acknowledgement of doubt and motivation to learn, and 4) deep learning stage of skillful inquiry and systemic mental models; the stages differ on whether learning is primarily single-loop or double-loop, and whether learning is relatively improvised or structured	Carroll, J., et al. (2005)
		If something happens that results in a "breakdown" in understanding, social phenomena become the object of "theoretical" reasoning and acquire the ontological status of being "present-at-hand" (i.e. Vorhanden) until the "breakdown" has been repaired	Butler, T. (2006)
		Organizational Knowledge Creation Theory uses the socialization, externalization, combination, internalization (SECI) model	Nonaka, I. & von Krogh, G. (2009)

Table 2.9 Conceptual analysis of the literature on <i>transforming practice-based knowledge</i>			
Concept	Use situation	Analysis	Ref.
Learning	in institutions	KM processes (creation, acquisition, refinement, memory, transfer, sharing, utilization) directly improve organizational processes such as innovation, collaborative decision-making, and individual and collective learning	King, W. (2009)
		Institutional perspectives deemphasize the dependence of the polity on society in favor of an interdependence between relatively autonomous social and political institutions; little theoretical effort has been devoted to specifying precisely the conditions under which learning from experience leads to optimal behavior, or to relating those conditions to features of institutional structure or life	March, J. and Olsen, P. (1984)
Assimilating	situations to practice	The Magical Number Seven, Plus or Minus Two: Some Limits on our Capacity for Processing Information,	Miller, G. (1956)
		Loose and strict thinking; Experiments in thinking about observed ethnological material	Bateson, G. (1987/1972)
		Simulation is a third way of doing science in addition to deduction and induction; Agent-based modeling in the social sciences	Axelrod, R. & Tesfatsion, L. (2005)
		Contextualization is more static at the strategic level and more dynamic at the operational level	Brézillon, P. & Pomerol J.-C. (2010)
Accommodating	practice to situations	Cooperation requires a shared proceduralized context	Brézillon, P. & Pomerol J.-C. (1999)
		Contextual knowledge can be proceduralized according to the focus of the decision making	Brézillon, P. & Pomerol J.-C. (1999)
		Service co-production as collaborative decision making is founded on three inter-subjective processes: mutual learning, relationship building, and mutual adjustment	Grace, A., Finnegan, P. & Butler, T. (2012)

From Table 2.9 *assimilation* and *accommodation* emerge as the central concepts of *learning*. The mechanisms of *assimilation* and *accommodation* operate equally on all objects of attention and in particular on the objects of management attention evoked in Figure 2.10, namely *situations*, *objectives*, *plans*, *practices* and *lessons learned*. From an epistemological point of view, it is noteworthy that the psychological explanations of learning (Piaget, 1947) and the dynamical systems approach (Schöner, 2007) do not lead to different practical implications and the latter may be viewed as a physical interpretation of the former (Searle, 2004).

To summarize, transforming practice-based organizational knowledge involves *accommodating* an activity in an organization to a new situation in which it is

realized and *assimilating* the new situation to the activity. The next section presents the literature on the conditions of the felicitous use of the mechanisms of assimilation and accommodation.

2.4.3 Using practice-based knowledge in organizations

This section reviews the research literature on *using practice-based knowledge in organizations*. Table 2.10 presents the relevant concepts retained for the conceptual framework, viz., *using practice-based knowledge* in situations and about situations, *using integrity rules* to recognize situations and *using inference rules* to reason in situations.

Table 2.10 Conceptual analysis of the literature on <i>using practice-based knowledge</i>			
Concept	Use situation	Analysis	Ref.
Using knowledge	in and about situations	Stimulus and response are not distinctions of existence, but teleological distinctions; it is only when we regard the sequence of acts as if they were adapted to reach some end that it occurs to us to speak of one as stimulus and the other as response; the distinction is one of interpretation; the sensation or conscious stimulus is not a thing or existence by itself, it is that phase of a coordination requiring attention; the search for the stimulus is the search for exact conditions of action, for the state of things which decides how a beginning coordination should be completed	Dewey, J. (1896)
		The various ways in which the knowledge on which people base their plans is communicated to them is the crucial problem for any theory explaining the economic process; the answer to this question is closely related to the question of who is to do the planning; it is with respect to knowledge of the particular circumstances of time and place that practically every individual has some advantage over all others in that he possesses unique information of which beneficial use might be made, but of which use can be made only if the decisions depending on it are left to him or are made with his active cooperation; the method by which such practical as opposed to theoretical or technical) knowledge can be made as widely available as possible is precisely the problem to which we have to find an answer	Hayek, F. (1945)

Table 2.10 Conceptual analysis of the literature on <i>using practice-based knowledge</i>			
Concept	Use situation	Analysis	Ref.
Using knowledge	in and about situations	Exterior unpredictability, interior rationality and social accountability are suggested properties of free will that provide selective advantage; free will emerges by a sort of bootstrapping process in a way that is analogous to how life developed; the role that the mental evolutionary process has in separating internal and external contexts is an essential context-dependency at the root of the phenomenon of free will	Edmonds, B. (2005)
		Intentional bounded rationality and intuition (as recognition) (Simon, 1990) represent two extremes of rational behavior, which belong to the same information processing mechanism of intentional problem-solvers with limited rationality v. adaptive problem-solvers (Gigerenzer, et al. 1999) with limited awareness as regards their responses to the environment v. a theory of choice that does not ignore feelings (Kahneman, 2003)	Fiori S. (2005).
		Reasoning and recognition are inextricably linked in human decision making to language and memory	Adam, F. (2008)
Using integrity rules	about situations	Levels of culture include observable artifacts, espoused values, basic underlying assumptions	Schein, E. H. (1990),
		Understanding, explanation and contexts; contextualism should be reworked as a doctrine about appropriate forms of explanation, not requirements of understanding	Bevir, M. (2000)
		Causation is essentially a context-dependent abstraction; in order to be able to effectively learn and reason about the world using fairly definite (i.e. 'crisp') models an agent has to separate out the foreground causes from the background ones (which can be abstracted to a context)	Edmonds, B. (2002)
Using inference rules	in situations	Context determines the appropriateness of behavior in a given situation	Brézillon J. & Brézillon P. (2007)

From Table 2.10 *integrity rules* and *inference rules* emerge as the key concepts in using practice-based organizational knowledge. Practical learning involves reasoning *about* situations and reasoning *in* situations and is subject to *integrity rules* and *inference rules*. Both mechanisms operate equally on all objects of attention and in particular on *situations*, *objectives*, *plans*, *practices* and *lessons learned*, the objects of attention of management activity. The next section presents the literature on contextualizing management activity in organizations.

2.5 Contextualizing management activity in organizations

Problems are the focus of a very large body of research and the concept, which may include opportunities and crises (Mintzberg *et al.*, 1976), is variously defined by researchers:

- i. as gaps perceived by managers in their models of their organization's environment (Pounds 1969),
- ii. as incongruities calling for plans (Miller, Galanter & Pribram, 1960),
- iii. as objectives and constraints in a functional system of actor and task (LePlat & Hoc, 1983),
- iv. as an intimation of the coherence of hitherto not comprehended particulars (Polanyi, 1966),
- v. as the starting point in a decision making process (Simon, 1947),
- vi. as the output of a decision making process "*l'intelligence de la situation*" (Le Moigne, 1999),
- vii. as a challenge to find a unified description of form and function (Alexander, 1964).

There is an emerging consensus in management research that activities that deal with problems fall into four categories: *situation assessment*, *problem solving*, *decision making*, and *implementing* (Pomerol & Adam, 2008; Endsley, 1995; Weick, 1988; Pounds, 1965; Newell, Shaw & Simon, 1958) and that these activities, broadly speaking, converge on an emerging realization (Langley *et al.*, 1995) as illustrated in Figure 2.5. Here, these four management activities that contextualize problems are referred to as *contextualizing management activities*.

Situation assessment (Endsley, 1995), which includes the recognition and diagnostic-reasoning aspects of decision making (Pomerol & Adam, 2008, Pomerol 1997), is used here rather than *sense making* (Weick, 1988) or the original term *problem finding* (Pounds, 1965 and 1969) because of the central role of the concept *situation* in the context-based intelligent assistant systems (CIAS) approach. In Figure 2.4, *situation assessment* involves consideration of three 'worlds', the *expected*, *desired*, and *planned* (Allen 1984). Each 'world' is modeled as an active system in an active environment determined by the modeler's beliefs, desires, and plans about the inter-dependent evolution of both (Schöner, 2007; Nardi, 1996; Orton & Weick, 1990; Le Plat & Hoc, 1983; Leontief, 1978; von Bertalanffy, 1968; Rosenblueth, Wiener, Bigelow, 1943).

Problem solving is meant in the broadest sense of ‘making explicit a hitherto not comprehended relation between particulars’ (Polanyi, 1966) and includes the look-ahead-reasoning aspect of decision making involving scenarios and uncertainty (Pomerol & Adam, 2008; Pomerol 1997), both *objective-setting* and *planning* activities (Krantz & Kunreuther, 2007; Wilenski, 1983; Sacerdoti, 1975; Miller, Galanter & Pribram, 1960), and *situated action* (Suchman, 1987).

Decision making is used in the narrow sense of ‘the theory of choice, with its roots mainly in economics, statistics and operations research’ as opposed to ‘the theory of problem solving originally studied principally by psychologists and more recently by researchers in artificial intelligence’ (Simon, Dantzig, Hogarth, Piott, Raiffa, Schelling, Shepsle, Thaler, Tversky & Winter, 1986); it involves preferences (Pomerol & Adam, 2008; Pomerol, 1997), power (March, 1991), political decision making, and non-decision-making (Sammon, 2004).

Implementing is used in the wide sense of the ways and means of doing, including procuring and organizing the necessary resources or ‘implements’.

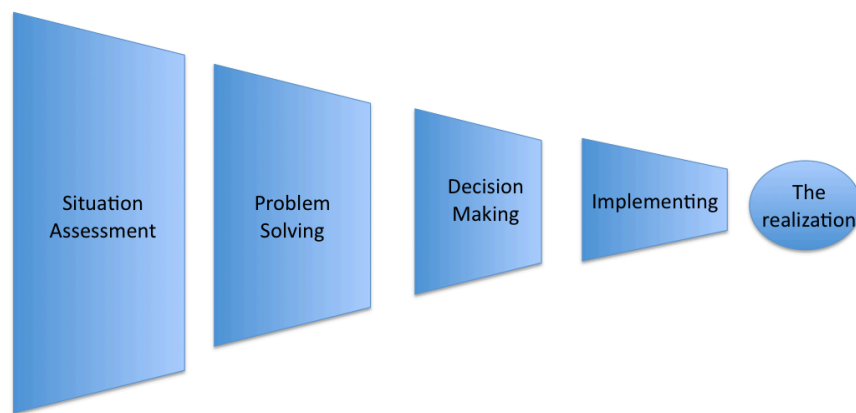


Figure 2.13 Contextualizing management activities converging on an emerging realization
(after Pounds, 1965; Langley *et al.* 1995)

The names given to the four contextualizing management activities shown in Figure 2.13 vary according to researcher, field, and period but there is consensus that the four activities are ontologically different notwithstanding any overlapping, embedding, recursive-interacting, or difficulties classifying borderline cases (Pounds, 1969, p.12).

There is also agreement among researchers that the tasks concern different levels (tactical/operational and political/strategic) in an organization with ‘operating decisions at the bottom of the hierarchy and strategic decisions on the top’ (Mintzberg *et al.*, 1976). This suggests that *practice-based organizational learning* will occur at different levels and raises the question of links between the levels. *Situation assessment*, with its emphasis on the environment, and *decision making*, with its association with power are typically reserved for top management in organizations dealing with complex situations, whereas *problem solving* and *implementing* are typically the realm of operational management. The two levels are inter-linked as the objectives set at the higher level constrain the activities at the lower level and the capabilities at the lower level constrain the higher-level objective setting activity. The literature on each of the four contextualizing management activities illustrated in Figure 2.13 is presented and discussed in the following sections.

2.5.1 Situation assessment

This section reviews the literature on *situation assessment*. Table 2.11 shows the analysis of concepts relevant to *situation assessment*, viz., *analogy*, *assessing*, and *enacting*.

Table 2.11 Conceptual analysis of the literature relevant to <i>situation assessment</i>			
Concept	Use situation	Analysis	Ref.
Situation	Analogy	Analogy is the core of cognition; perceptual attractors are long-term mental loci that are zoomed into when situations are encountered: standard lexical items, shared vicarious experiences, and unique personal memories	Hofstadter (2001)
		Analogy is central to cognition	Holyoak, K., Gentner, D. and Kokinov, B. (2001)
	Assessment	Managers use four types of models to find problems (assess the situation): trend over time, theory, benchmark compared to competitors, and vision	Pounds, W. F. (1965)
		A situation is a functional system constituted by actor and task, a task is an objective with constraints	Leplat, J. & Hoc, J. M. (1983)
		Situation awareness (SA) is a state of knowledge v. situation assessment as the process of achieving, acquiring, or maintaining SA	Endsley, M. R. (1995)

Table 2.11 Conceptual analysis of the literature relevant to <i>situation assessment</i>			
Situation	Assessment	Preference measurement is best viewed as architecture (building a set of values) rather than as archaeology (uncovering existing values); what is learned can depend on initial anchored values	Payne, J. & Bettman J. (1999)
		Dashboards designed to take account of limited attention, performance measurement, operator training, and dashboard layout issues reduce the information mediation risk implicit in the control room concept and help managers catch far more information than they normally would without assistance.	Adam, F. & Pomerol, J-C. (2002)
	Enactment	Action precedes cognition and focuses it; people enact the environments that constrain them; commitment, capacity, and expectations affect sense-making during crisis and the severity of the crisis itself; there is a delicate trade-off between dangerous action which produces understanding and safe inaction which produces confusion; the concept of enactment is a synthesis, tailored for organizational settings, of four lines of scholarship: self-fulfilling prophecies (E. E. Jones, 1986; R. A. Jones 1977; Snyder, 1984), retrospective sense-making (Staw, 1980; Weick 1979), commitment (Salancik, 1977, Staw, 1982) and social information processing (Salancik & Pfeffer, 1978); the term 'enactment' is used to preserve the central point that when people act, they bring events and structures into existence and set them in motion; the way to counteract catastrophe is to reduce tight coupling and interactive complexity	Weick, K. (1988)
		Sense-making occurs when a flow of organizational circumstances is turned into a situation that is comprehended explicitly in words (and salient categories) and that serves as a springboard into action; situations, organizations and environments are talked into existence; sense-making is about the interplay of action and interpretation rather than the influence of evaluation on choice; when action is the central focus, interpretation, not choice, is the core phenomenon (Laroche, 1995; Lant 2002, Weick, 1993); enactment theory as enactment-selection-retention-sequence builds on the application of evolutionary epistemology to social life (Campbell, 1965, 1997); it proposes that sense-making can be treated as reciprocal exchanges between actors (Enactment) and their environments (Ecological Change) that are meaningful (Selection) and preserved (Retention)	Weick, K., et al. (2005)

From Table 2.11 *analogy* and *enactment* emerge as the key concepts in situation assessment. The results presented in Table 2.11 suggest that *analogy* and *enactment* are used in organizations to determine which elements of the environment bear on an activity in the organization's expected, desired, and planned worlds. Managers recognize the similarity between new situations and

ones from their experience or they enact changes until they recognize something familiar that suggests what action to take. This has implications for research based on eliciting managers explanations of actions. Enactment implies doing something to find out what is going on, and since nobody likes to admit not knowing what is going on, care must be taken in framing questions in an unthreatening way.

2.5.2 Problem solving

This section reviews the literature on *problem solving*. Table 2.12 shows the concepts that are retained for the conceptual framework, viz., *means-ends analysis* and *heuristics*.

Table 2.12 Conceptual analysis of the literature relevant to <i>problem solving</i>			
Concept	Use Situation	Analysis	Ref.
Problem solving	Means-ends analysis	Plans fill the gap between stimulus and reflex; Image-Test-Operate approach; TOTE (test-operate-test-exit) as unit of analysis of behavior; Boulding's Image locates him in space and time and society and nature and his own history; The Image is a man's knowledge of the world; his behavior depends upon the Image; meaningful messages change the Image; Boulding and cognitive psychologists generally left an organism in the role of a spectator than of a participant in the drama of living; we can choose to describe life (the traditional approach of the scientist) or to re-enact it (the traditional approach of the artist); with computer simulation, re-enactment is emerging as a scientific alternative in its own right; description depends upon an image, re-enactment on a plan; most psychologists espouse either an S-R theory or a cognitive theory, our aim is to try again the development of a synthetic theory, we think the role of Plans is the link that will hold the two together	Miller G.A., et al. (1960)
		We know more than we can tell; the experience of seeing a problem is to have an intimation of the coherence of hitherto not comprehended particulars; attending to distal from proximal; all knowledge is of the same type as the knowledge of problem solving	Polanyi M. (1966)

Table 2.12 Conceptual analysis of the literature relevant to <i>problem solving</i>			
Concept	Use Situation	Analysis	Ref.
Problem solving	Means-ends analysis	Theory of problem solving captured in 4 propositions: 1) a few, and only a few, gross characteristics of the human information-processing system are invariant over task and problem solver, 2) these characteristics are sufficient to determine that a task environment is represented (in the information-processing system) as a problem space, and that problem solving takes place in a problem space, 3) the structure of the task environment determines the possible structures of the problem space, and 4) the structure of the problem space determines the possible programs that can be used for problem solving; "problem solving" encompasses both the activities required to construct a problem space in the face of a new task environment, and the activities required to solve a particular problem in some problem space, new or old; each knowledge state is a node in the problem space (internal representation of the problem)	Simon, H. and Newell, A. (1971)
		The structure of a plan of actions is as important for problem solving and execution monitoring as the nature of the actions themselves; "A structure for plans and behavior" is an explicit <i>clin d'œil</i> on "Plans and the structure of behavior" (Miller et al., 1960); the procedural net represents plans as as partial orderings of actions with respect to time rather than as linear sequences; the NOAH (nets of action hierarchies) system's goal is to provide a framework for storing expertise about the actions of a particular task domain, and to impart that expertise to a human in the cooperative achievement of nontrivial tasks; a procedural net is a strongly connected network of frame-like nodes, each of which may contain both procedural and declarative information, the procedural information is used to represent the domain knowledge, whereas the plan knowledge is represented declaratively in the contents of the nodes and in the structure of the net itself; the process of problem solving is a development of constraints that progressively narrow the solution space; the mechanisms underlying intelligence may be simpler than we think	Sacerdoti, E. (1975)
		Planning starts from an objective to find actions that will bring about the desired situation, understanding starts with actions to find an explanation in the form of an objective that the actions were meant to achieve	Wilenski, R. (1983),
		Planning and control are seen as countervailing processes which are simultaneously performed in a 3-Step model of Strategic Control: Strategic surveillance, premise control and implementation control	Schreyögg, G. & Steinmann (1987)
	Heuristics	Designers grope along, building their solution brick by brick without really knowing what it will look like until it is completed (Reitman, 1964; Klein, 1962; Mannheim, 1966); there is almost no attention to the design routine in the literature of administration	Mintzberg H., et al. (1976)

Table 2.12 Conceptual analysis of the literature relevant to <i>problem solving</i>			
Concept	Use Situation	Analysis	Ref.
Problem solving	Heuristics	The rules of thumb used by knowledgeable practitioners are too important to be hidden behind [Simon's] simple intelligence, design, and choice view; managers engage in problem-solving viewed as five components by Newell: specification of the problem space and its states, definition of the appropriate operators, identification and setting of goals, identification and understanding of path constraints, and specification of the relevant search control knowledge	Gorry G. A., & Scott-Morton M. S. (1989)
		A unified design theory distinguishing concepts from knowledge highlights the oddness of design when compared to problem solving approaches; C-K theory leads to a consideration of problem solving theory as a special and restricted case of design theory; design is more than 'a mapping between the function space and the attribute space'; design cannot be defined without a simultaneous knowledge expansion process	Hatchuel, A. & Weil, B. (2003)
		Heuristics are efficient cognitive processes that ignore information; the cognitive system relies on an 'adaptive toolbox'; heuristics efficiency lies in their ecological rationality, in the environmental structures to which a given heuristic is adapted; a mind that can make inferences quickly from a few observations and that exploits the fact that bias can be adaptive and can help reduce estimation error can handle uncertainty more efficiently and robustly than an unbiased mind relying on more resource-intensive and general-purpose processing strategies	Gigerenzer & Brighton (2008)

From Table 2.12 *means-ends analysis* and *heuristics* emerge as the key concepts of *problem solving*. *Means-ends analysis* and *heuristics* are used in organizations to determine which actions, taken in a given situation, would bring the expected and desired worlds of the situation assessment together. The next section presents the concepts relevant to the contextualizing management activity of decision making.

2.5.3 Decision making

This section reviews the literature on *decision making*. Table 2.13 shows the concepts retained for the conceptual framework, viz., *reason*, *rationality*, and *process*.

Table 2.13 Conceptual analysis of the literature relevant to <i>decision making</i>			
Concept	Use situation	Analysis	Ref.
Decision making	Reason and rationality	A theory of purposeful human behavior must take into account the diversity of human motivations and modes of behavior and account for the relationship and interaction between different logics in different situations; a beginning is to explore behavioral logics as complementary rather than assume a single dominant logic	March, J. and Olsen, P. (2004)
		Whereas desires bear directly on the action to be taken motivations are more fundamental attitudes that give rise to desires; three main motivations: reason, the passions, and self-interest; in any society there is a normative hierarchy of motivations; a rational agent may have an interest in the appearance of reason or the appearance of emotion; the second-order motivation may conflict with the desire that is inspired by the first-order motivation; agents have two degrees of freedom in harmonizing their motivations and desires: impartiality and social causality ; these mechanisms are subject to two constraints: consistency and imperfection ; the functions of reason and rationality in human behaviors are respectively those of tutor and councilor, the tutor teaches the prince to promote the public good in the long term, the councilor tells him how to act in order to achieve his goals	Elster, J. (2009)
	Process	Power holders within organizations decide upon courses of strategic action; this 'strategic choice' typically includes not only the establishment of structural forms but also the manipulation of environmental features and the choice of relevant performance standards (colored by prior ideology)	Child, J. (1972)
		Evaluating and choosing among different courses of action is usually called <i>decision making</i> ; the scarce resource is management attention (not information); the trend toward broadening research on decision making to include learning and adaptation is welcome	Simon H., et al. (1986)
		Strategies or technologies that improve the sharing of knowledge, information, and experience (e.g. education, data bases) are very likely to do more for exploitation than for exploration; a logic of appropriateness is implemented through a structure of organizational rules and practices; the rules evolve through experience (learning), selection (evolution), and diffusion (imitation)	March, J.G. (1991a)
		The garbage can model is empirically less robust than the other two paradigms of strategic decision making ('rationality and bounded rationality' and 'politics and power');	Eisenhardt, K. M. and Zbaracki, M.J. (1992)
		The decision rule of Case-based Decision Theory, together with the theoretical terms 'utility' and 'similarity' may be axiomatically derived from preferences, in a way which parallels the axiomatic derivations of 'utility' and 'probability', combined with the expected utility formula, in models such as Savage's (1954)	Gilboa, I. & Schmeidler D. (1994)

Table 2.13 Conceptual analysis of the literature relevant to <i>decision making</i>			
Concept	Use situation	Analysis	Ref.
Decision making	Process	The concepts 'decision', 'decision maker', and 'decision making process' are opened up: organizational decision making as convergence, driven by iteration; as insightful; as interwoven, driven by linkages	Langley, A., et al. (1995)
		AI has not paid enough attention to look-ahead reasoning whose main components are uncertainty and preferences	Pomerol J.-C. (1997)
		Collaboration and cooperation are the key to understanding interaction processes; trust-based rationalism (responsibility, benevolence, fair play, and altruism) is proposed as a third theoretical perspective to Kling's (1980) system rationalism, and segmented institutionalism;	Kumar, van Dissel, Bielli (1998)
		The concept of organizational context can be usefully viewed as a combination of cultural, structural and environmental factors, all of which are shaped by the specific circumstances that an organization is going through at a particular point in time; one way of understanding the dynamics that shape organizational context is to study the information webs of organizations; information webs are dynamically changed by the games of power played by managers in public sector companies [not uncommonly more controlled by political considerations than by market conditions (Johnson and Scholes 1997)]	Adam, F. and Pomerol, J.-C. (1998)
		Whether institutionalism has sufficient analytic power to be a worthy counterpoint to the attempt to create hegemony by the advocates of rational choice approaches to political science	Peters, B. (2000)
		The ERP vendor and ERP consultant through the direct and indirect relationships that exist between them and the implementing organization, actively demonstrate the techniques of category manipulation; the hidden art of non-decision making (Judge, 1977)	Sammon, D. and Adam, F. (2002)
		The use of Case-Based Reasoning as a method for context-sensitive applications; approach handles three important issues in context-aware applications: specifying behavior based on the context in the implementation phase, aggregating contextual data from many and diverse sources, and reasoning about context in run-times	Kofod-Petersen, A., & Mikalsen, M. (2005)
		A constructed-choice model for general decision making; Aristotle can perhaps be read as advocating situation-dependent integration of multiple goals, an idea that we pursue and elaborate in this paper; goals not utility/value; we agree with Miller, Galanter and Pribram (1960) that the plan is a fundamental structural unit in decision making; the plan/goal structure, by contrast with SEMAUT, demands a separate (context-dependent) value v_i for each goal	Krantz, D. and Kunreuther, H. (2007)

Table 2.13 Conceptual analysis of the literature relevant to <i>decision making</i>			
Concept	Use situation	Analysis	Ref.
Decision making	Process	Decision making is an almost exclusively human activity; recognition and reasoning; diagnosis, look ahead, (subjective) preferences, chosen action	Pomerol J.-C., and Adam F. (2008)
		A set of dimensions that describe decision making settings and are critical in the exploration of how regulatory context affects decision making and decision support cf. (Ostrom, 1990) approach to governance where institutions defined as "the set of working rules that are used to determine who is eligible to make decisions in some arena, what actions are allowed or constrained, what aggregation rules will be used, what procedures must be followed, what information must or must not be provided, and what payoffs will be assigned to individuals dependent on their actions...all rules contain prescriptions that forbid, permit or require some action or outcome"	Csaki, C. (2012)

From Table 2.13 *reason* and *rationality* emerge as the key concepts of *decision making*. *Reason* and *rationality* are used in organizations to chose among hypothetical plans of action in a given situation. The managers with the power and authority to make the choices are not necessarily the same as those who develop the alternative plans and are often at a higher level in the organization hierarchy. This separation of tasks has implications for research eliciting managers explanations of actions. Care must be taken to ensure coherence in the description of the situation at different levels and across time.

2.5.4 Implementing

This section reviews the literature on implementing. Table 2.14 shows the analysis of concepts relevant to *implementing*, viz., *technology* and *practices*.

Table 2.14 Conceptual analysis of the literature relevant to <i>implementing</i>			
Concept	Use situation	Analysis	Ref.
Implementing	Technology	The dynamics of firm search are complemented by the dynamics of "selection" based on superior techniques; in this work the typical role of the profitability variable is to determine a rate of change, not, as in traditional theory, the action chosen; over time the technique used by a firm may change as a result of two kinds of search process: internal (r&d, operations analysis) or imitation, the possibilities are subjected to the profitability test; the dynamics of firm search are complemented by the dynamics of 'selection'; to the extent that profitable firms expand and unprofitable ones contract, there will be a contribution to measured technical progress at the aggregate level that is not directly traceable to the individual firm search processes	Nelson & Winter (1973)
		RBV looks at firms in terms of their resources rather than in terms of their products; in analogy to entry barriers and growth-share matrices, the concepts of resource position barrier and resource-product matrices are suggested; nothing is known about the practical difficulties involved in identifying resources	Wernerfelt, B. (1984)
		Organizational knowledge, technology transfer, imitation, capabilities, learning; the transaction as the unit of analysis is an insufficient vehicle by which to examine organizational capabilities, because these capabilities are a composite of individual and social knowledge; learning has little significance in the absence of a theory of organizational knowledge; firms are a repository of capabilities, as determined by the social knowledge embedded in enduring individual relationships structured by organizing principles; a firm's functional knowledge is nested within a higher-order set of recipes that act as organizing principles	Kogut, B. & Zander, U. (1992)
		Process, positions and paths: the competitive advantage of firms is seen as resting on distinctive processes (ways of combining and coordinating), shaped by the firm's specific asset positions, and the evolution paths it has adopted or inherited; dynamic capabilities approach emphasizes the development of management capabilities, and difficult-to-imitate combinations of organizational, functional and technological skills	Teece, D., Pisano, G. & Shuen, A. (1997)
		More of our work and activities will be mediated by the new technologies; talk of "the information society" as an autonomous form is problematic	Bannon, L. (1997)
		Technology refers to "the physical combined with the intellectual or knowledge processes by which materials in some form are transformed into outputs" (Hulin & Roznowski, 1985); it constrains but does not dictate the precise configuration of machines and methods that make up a specific technical system (Weick, 1990); it is physically constructed by actors working in a given social context, and is socially constructed by actors through the different meanings they attach to it (Orlikowski, 1992)	Scott, W. R. (1998)

Table 2.14 Conceptual analysis of the literature relevant to <i>implementing</i>			
Concept	Use situation	Analysis	Ref.
Implementing	Technology	A routine is defined as a pattern of behavior that is followed repeatedly, but is subject to change if conditions change (Winter, 1964); reserve the term "skills" for the individual level and routines for the organizational level (Dosi, Nelson & Winter 2000); the role of routines in coordination and control; because the recurring elements of the routine are not in the focus and do not receive attention they economize upon limited cognitive resources; a finer distinction between the different types of recurrent activity patterns is called for;	Becker M. (2003)
		Organizational routines as a unit of analysis	Pentland & Feldman (2005)
		Understanding the Impact of Technology on Managerial Decision Making – the Case of the ERP System,	Carton, F., & Adam F. (2010)
	Practices	A more attentive reflection on the phenomenon of alignment as emerging from the field and not from the models shows the strategic relevance of practices such as 'care' (Heidegger 1962), 'cultivation' (Dahlbom and Janlert 1996) and 'hospitality'	Ciborra, C. (1997)
		The fundamental unit of analysis is the human activity which has three basic characteristics, firstly it is directed towards a material or ideal object which distinguishes one activity from another, secondly it is mediated by artifacts (tools, language, etc) and thirdly it is social within a culture; computer artifacts mediate human activity within a practice	Bardram, J. (1997)
		A body of work in CSCW emphasizes work practices and the way learning is accomplished within communities of practice; it argues that learning and action are situated (Suchman, 1987) and that work is a complexly social affair, mediated by other people and artifacts; re-conceptualize the nature of work away from an 'organizational' view focusing on training, tasks, procedures, workflow, and teams to an ' activity-oriented ' view focusing on learning, know-how, networks, conceptual understanding, work practices , judgement, and communities (of practice) (Sachs, 1995)	Bannon, L. (1999)

From Table 2.14 *technology* and *practices* emerge as the key concepts of *implementing*. *Technology* and *practices* are used in organizations to implement chosen plans of action but differ as *genus* to *species*. *Technology* is a generic way of realizing an activity whereas *practices* are adapted to the specific circumstances of a given realization. This fundamental difference has implications for research eliciting managers explanations of actions. Care must be taken to ensure coherence in the description of the situation at the generic and specific levels.

2.6 De-contextualizing and re-contextualizing management activities

The research literature on *practice-based performance improvement* in organizations studies three embedded management activities, namely *representing practices*, *abstracting lessons learned*, and *leveraging lessons learned* as shown in Table 2.3. The first two are *de-contextualizing management activities*, the third is a *re-contextualizing management activity*. This section presents the literature on each of the three phenomena.

2.6.1 Representing practices and performance assessment

Performance is ambiguous with respect to *product* and *process*. On the one hand, performance *produces* a change of state. Performance as product is represented as explicit *values* of changes in the state of the active system and/or changes in the state of the system's environment but the actual practice is implicit or at least not specified uniquely⁵. This is commonly referred to as performance assessment *tout court*. In the following, this type of representation is called a *state description*⁶.

On the other hand, performance *proceeds* as a practice realizing an activity in specific circumstances. Representing the performance of a practice of an activity, *representing practices*, in the following is called a *process description*. It follows from the fact that all representation is aspectual (Searle, 2004) that the process description is also a form of *performance assessment*. When representing a practice some aspects are included and not others, those included are implicit or explicit *values* in the sense of Dewey (1929). In short, *representing practice* is *eo ipso performance assessment*.

Referring to Figure 2.13, the concept of performance may be attached both to assessment of the realization and to assessment of the realizing activity (March & Olsen, 2004). Performance of the realization interprets the change of state of the environment from which the realization emerges (the gap, the problem); performance of the realizing activity interprets the effectiveness of the organization (the structure of the objectives and constraints, the procedures, the technology) and the effectiveness of the actual ways employed by the organization's members

⁵ 'Practical activity deals with individual and unique situations which are never exactly duplicable' (Dewey, 1929, p.6)

⁶ 'Two main types of description in seeking an understanding of complex systems, viz., *state description* and *process description*' (Simon, 1996, p.210)

to deal with the constraints (the practices). The latter point echoes the classic parallel drawn between administration and play-acting “the effectiveness of the performance will depend on the effectiveness of the play and the effectiveness with which it is played” (Simon, 1996 and 1945). Table 2.15 shows the analysis of relevant concepts from the literature relevant to *representing practices and performance assessment* retained for the conceptual framework, viz., *state description* and *process description*.

Table 2.15 Conceptual analysis of the literature on <i>representing practices and performance assessment</i>			
Concept	Use situation	Analysis	Ref.
Representing practices and performance assessment	State and process description	There is a natural inclination to treat value as a measure of reality. The relation between objects as known and objects with respect to value is that between the actual and the possible; ‘the actual’ consists of given conditions, ‘the possible’ denotes ends or consequences not now existing but which the actual through its use bring into existence. the possible with respect to any given actual situation is thus an ideal for that situation	Dewey J. (1929, p. 300)
		Measurement is defined as the assignment of numerals to objects or events according to rules; the fact that numerals can be assigned under different rules leads to different kinds of scales and different kinds of measurement; scales are possible in the first place only because there is a certain isomorphism between what we can do with the aspects of objects and the properties of the numeral series; nominal, ordinal, interval, ratio scales correspond to determination of equality, greater or less, equality of intervals or distances, and equality of ratios, respectively	Stevens S. (1946)
		Organizational effectiveness is socially constructed by organizational theorists and researchers; an explicit statement of the construct in a spatial model indicates how four middle-range approaches differentiated and related in terms of three value dimensions relate to the most general paradigms in the field and clarifies the interface between Parson's and Gouldner's general theories; three competing value dimensions: 1) Focus: internal micro emphasis on the well-being and development of people in the organization v. external macro emphasis on the well-being and development of the organization itself; 2) Structure: flexibility v. control; 3) Means and Ends: emphasis on processes (e.g. planning and goal setting) v. an emphasis on final outcomes (e.g., productivity)	Quinn, R. & Rohrbaugh, J. (1983)
		The contextual graph representation formalism takes into account the dynamics of proceduralization	Brézillon P., et al. (2002)
	State description	Balanced Scorecard versus French <i>tableau de bord</i> : beyond dispute, a cultural and ideological perspective	Bourguignon A., et al. (2001)

Table 2.15 Conceptual analysis of the literature on <i>representing practices and performance assessment</i>			
Concept	Use situation	Analysis	Ref.
Representing practices and performance assessment	State description	Theories of Performance, Organizational and Service Improvement in the Public Domain lack conceptual clarity	Talbot C. (2010),
		A successful application of DSS for strategic management using a balanced scorecard with assumed causal relationships between perspectives' measures (learning and growth → internal business process → customers → financial) is assessed using Hevner et al. (2004) guidelines	Gomes, L. & Respicio, A. (2012)
	Process description	Software development process maturity model with five levels: initial, repeatable, defined, managed, optimized; process data must not be used to compare projects or individuals, its purpose is to illuminate the product being developed and to provide an informed basis for improving the process	Humphrey, W. (1987)
		Performance measurement system design: developing and testing a process-based approach	Neely, A., et al. (2000)

From Table 2.15 *state descriptions* and *process descriptions* emerge as the key concepts in representing practices and performance assessment. *State descriptions* and *process descriptions* are used in organizations to formalize and interpret different aspects of their practices. Aspectual difference has implications for research that elicits managers representation of performance. Care must be taken to ensure coherence between the two types of description of performance. The next section presents the literature on the de-contextualizing management activity of *abstracting lessons learned*.

2.6.2 Abstracting lessons learned

Practice-based organizational learning occurs when new associations between *activity* and *situation* are discovered when *assessing performance*. Practice-based organizational improvement *leverages lessons learned* abstracted from the details of the learning situation (practices) to a generic re-usable form (procedures). The literature and case studies on best practices (O'Leary, 2006) illustrates one of the forms that *procedures*, in the sense of this thesis, can take. *Lessons learned* are an important stopping place and this thesis addresses the research gap in the characterization and measurement of *lessons learned*.

Table 2.16 Conceptual analysis of the literature on <i>abstracting lessons learned</i>			
Concept	Use situation	Analysis	Ref.
Abstracting lessons learned	Measurement and evaluation	A framework for performance information	HM Treasury, et al. (2001)
		Performance measurement and evaluation definitions and relationships	Govt. Accountability Office (2005)
		Best practices (or leading practices) knowledge bases provide access to knowledge about enterprise processes that appear to define the best ways of doing things; measuring and evaluating evolution of a taxonomy of best practices is key to leveraging taxonomy in knowledge management systems	O'Leary, D. (2006)
		Guidelines on a Common Appraisal Framework for Transport Projects and Programs.	Department of Transport (2009)
		Performance-based assessment in transportation	Wachs, M. (2010)
	Measurement	A Three-Dimensional Conceptual Model of Corporate Performance,	Carroll, A. (1979)
		The Performance Measurement Manifesto	Eccles, R. (1991)
		Process matters: results using strategic decision-making effectiveness model confirmed that procedural rationality is positively correlated and political behavior is negatively correlated with DM effectiveness, where effects of environmental favorability and quality of implementation are controlled variables, environmental instability moderates positively both of the control variables impact; unit of analysis is the strategic decision	Dean, J. & Sharfman, M. (1996)
		Financial measures are lag indicators that report on the outcomes of past actions, the Balanced Scorecard approach supplements these with measures on the drivers, the lead indicators, of future financial performance; what is missing from these scorecards: no objectives or measures for <i>how</i> these balanced goals are to be achieved; the Balanced Scorecard Strategy Map is a general framework for describing and implementing strategy	Kaplan R. S. & Norton D. P. (2001)
		Definition and development of performance indicators	Finance Department, Ireland (2001)
		Process v. causal model; the application of the model to empirical research also requires a contextual variance specification of the model; use, especially informed and effective use, will continue to be an important indication of IS success for many systems; intention to use is an attitude, use a behavior	Delone, W. and McLean, E. (2003)
		Indicators European level Transport	DG Energy & Transport (2004).

Table 2.16 Conceptual analysis of the literature on <i>abstracting lessons learned</i>			
Concept	Use situation	Analysis	Ref.
Abstracting lessons learned	Measurement	A stake-holder-based, Sustainable Balanced Scorecard (SBSC) coupled with a single-measure Organizational Sustainability Performance Index v. the Triple Bottom Line (TBL) (Elkington, 1977); unlike the BSC the TBL has not been successful in penetrating organizational performance systems; SBSC is simple and could be supplemented with many pages of contextual and explanatory notes like conventional financial measures of performance (in fin. statements)	Hubbard, G. (2006)
		Performance measurement in R&D: exploring the interplay between measurement, objectives, dimensions of performance and contextual factors,	Chiesa, V., et al. (2009)
		Performance Measurement in the English Public Sector, Searching for the Golden Thread,	Michelli, P. and Neely, A. (2010)
	Evaluation	Some evidence for positive performance impact of Balanced Scorecard	Griffith, R. and Neely, A. (2006),
		Credibility/plausibility is a general criterion used to evaluate scenarios; four major determinants that are strictly interlinked: comprehensiveness, clarity, coherence, and consistency	Gambelli, D., Vairo, D. and Zanolli, R. (2010)
		Comparing operator and user costs of light rail, heavy rail and bus rapid transit over a radial public transport network,	Tirachini, A., et al. (2010)

Together the purpose of learning discussion (Pfeffer & Sutton, 2000), the nature of learning discussion (March, 1991; Fiol & Lyles, 1985) and the distinction between measurement and evaluation that emerges from Table 2.16 can be summarized in the following result: *measurement* and *evaluation* are used in organizations to abstract lessons learned from experience.

The next section presents the literature on the re-contextualizing management activity *leveraging lessons learned*.

2.6.3 Leveraging lessons learned

This section reviews the literature on the re-contextualizing management activity of *leveraging lessons learned*. Table 2.17 shows the analysis of relevant concepts.

Table 2.17 Conceptual analysis of the literature on <i>leveraging lessons learned</i>			
Concept	Use situation	Analysis	Ref.
Improving performance	Exploration and exploitation	Learning, analysis, imitation, regeneration, and technological change are major components of any effort to improve organizational performance and strengthen competitive advantage; each involves adaptation and a delicate trade-off between exploration and exploitation ; the essence of exploitation is the refinement and extension of existing competences, technologies and paradigms; its returns are positive, proximate, and predictable; the essence of exploration is experimentation with new alternatives; its returns are uncertain, distant, and often negative; individuals may adjust to an organizational code before the code can learn from them	March, J. G. (1991)
	Exploitation	Management Learning Not Management Control	Neely, A. & Al Najjar M. (2006)
		Practice reuse results from a complex phase of contextualization, decontextualization and re-contextualization	Brézillon, P. (2011)

The literature reviewed in Table 2.17 shows that *leveraging lessons learned* involves *exploitation* of lessons learned in the practice of current organizational activities (continuous improvement) not *exploration* of new activities (innovation). *Procedures* that result from the abstraction of lessons learned in the realization of the organization's activities are the object of attention of researchers in both *performance improvement* and *organizational learning*.

Exploitation of experience codified as procedures is one way of improving performance, the other is the *exploration* of new practices and activities. The former is the central subject of this thesis and gives its name to the dissertation, *leveraging lessons learned*. *Exploration* as a mode of organizational development is outside the scope of this thesis except when it results from organizations ignoring practice-based procedures (March, 1991).

The next section presents the conclusions of the literature review.

2.7 Conclusions - Towards a theory of practice-based organizational learning and performance improvement

This section concludes the literature review with a presentation of the conceptual framework, the research gaps, and a formal statement of the research objective.

2.7.1 Conceptual Framework

The review of the research literature is summarized as a conceptual framework for research in *practice-based organizational learning and performance improvement*. Tables 2.18 and 2.19 together sum up the discussion of the research literature relevant to the extension of the CIAS paradigm to organizational learning and performance assessment that was motivated by the research gaps in the theory of measuring organizational learning and the theory of representing performance. The thesis defended in this dissertation was illustrated in Figure 1.2 and is repeated here for convenience as Figure 2.14.

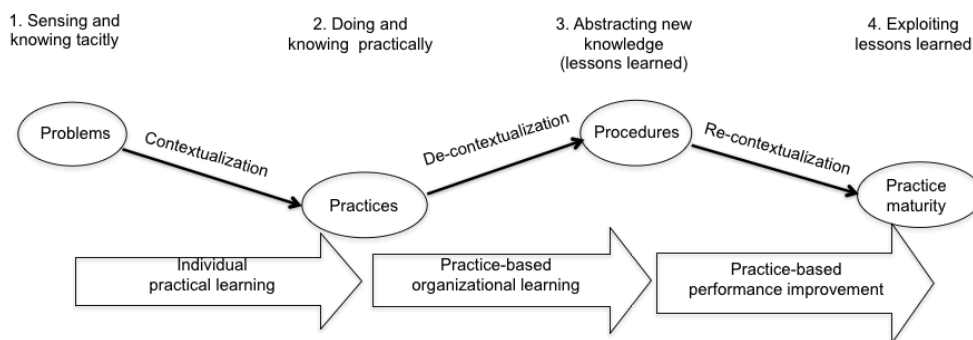


Figure 2.14 Practice-based organizational learning and performance improvement

The thesis may be stated in short form as follows:

“Practice-based organizational learning and performance improvement of an activity is a dynamic process of contextualization of problems, de-contextualization of practices, and re-contextualization of procedures leading to increased practice maturity of the activity”

The thesis may be stated in long form as follows:

“Practice-based organizational learning of an activity occurs when new associations between situation and action are discovered during performance assessment and are abstracted from the details of the discovery situation as lessons learned codified for future use. Practice-based performance improvement occurs in organizations when exploiting lessons learned from experience of realizing an activity leads to increased practice maturity.”

The thesis is supported by the results from prior research illustrated in Table 2.18

Table 2.18 Synthesis of results from prior literature		
Prior results		On
1	Representing practice-based organizational knowledge involves <i>formalizing</i> and <i>interpreting</i> an organizational activity together with the elements of the environment that bear on its realization in a given situation.	Practice-based Knowledge
2	Transforming practice-based organizational knowledge involves <i>accommodating</i> an activity in an organization to a new situation in which it is realized and <i>assimilating</i> the new situation to the activity	Practice-based Learning
3	Using practice-based organizational knowledge involves reasoning about situations and reasoning in situations and is subject to <i>integrity rules</i> and <i>inference rules</i> .	Practice-based Reasoning
4	<i>Analogy</i> and <i>enactment</i> are used in organizations to determine which elements of the environment bear on an activity in the organization's expected, desired, and planned worlds	Contextualizing management activities
5	<i>Means-ends analysis</i> and <i>heuristics</i> are used in organizations to determine which actions, taken in a given situation, would bring the expected and desired worlds together.	
6	<i>Reason</i> and <i>rationality</i> are used in organizations to chose among hypothetical plans of action in a given situation.	
7	<i>Technology</i> and <i>practices</i> are used in organizations to implement chosen plans of action	
8	<i>State descriptions</i> and <i>process descriptions</i> are used in organizations to represent different aspects of their practices	De-contextualizing management activities
9	<i>Measurement</i> and <i>evaluation</i> are used in organizations to abstract lessons learned from experience	
10	<i>Exploitation</i> of lessons learned is an alternative to <i>exploration</i> of new practices and activities used in organizations to improve performance	Re-contextualizing management activity

The synthesis of results from prior literature is presented in Table 2.18 in the form of ten propositions. Each proposition uses terms presented in the preceding conceptual analysis tables. The propositions are regrouped by theme in the last column of Table 2.18. Practice-based knowledge, learning, and reasoning are applied to management activities characterized as contextualizing problems, de-contextualizing practices, and re-contextualizing procedures as illustrated in Figure 2.14. The relationship between these high level concepts is presented in Table 2.19 as a conceptual framework to guide research and practice on *practice-based organizational learning and performance improvement*. *Practice maturity* is the central construct in the conceptual framework and thesis.

Table 2.19 Conceptual framework			
Focus of attention in management activities	Contextualizing management activities	De-contextualizing management activities	Re-contextualizing management activities
Problems Practices Procedures Practice Maturity	Situation assessment Problem solving Decision making Implementing	Representing practices Abstracting lessons learned	Leveraging lessons learned

Table 2.19 echoes the spiral of continuous improvement illustrated in Figure 2.2 and draws attention to the embedded nature of performing, assessing, and learning in management activities. Contextualizing, de-contextualizing, and re-contextualizing management activities are subject to *integrity rules* and *inference rules* governing the felicitous use of knowledge, reasoning, and context. The next section presents three research gaps, suggested by the conceptual framework, that are pursued in this thesis.

2.7.2 Research gaps

The three research gaps suggested by the conceptual framework that are pursued here are the following:

- Selecting practice-based measures of organizational performance
- Measuring practice-based organizational learning
- Identifying opportunities for a CIAS approach to practice-based organizational learning and to improving organizational performance.

The first research gap addresses one of the shortcomings in current theories of organizational performance, evoked explicitly by Talbot (2010) and previously by Neely, Gregory & Platts (2005), namely how to free performance indicator selection from assumptions of causality. The second research gap was explicitly evoked by Fiol & Lyles (1985) and represents an ongoing challenge to researchers and practitioners of organizational learning. The third research gap derives directly from the purpose of this thesis to extend the CIAS approach to organizational learning and performance improvement. The next section includes a formal statement of the research objective of the thesis.

2.7.3 Research objective

The subject of this research is *practice-based organizational learning and performance improvement* in a procedure-controlled long-cycle project activity that addresses problems characterized by complexity, uncertainty, and interdependence (Scott, 2007). The purpose of the research is to extend the CIAS paradigm to *practice-based organizational learning and performance improvement*. More specifically, the research objective is *to understand the role of context in practice-based organizational learning and performance improvement and to identify opportunities for a CIAS approach to practice-based organizational learning and to improving organizational performance*.

The research objective is further operationalized in three research questions in the next chapter.

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Chapter 3

A context-based intelligent assistant support (CIAS) approach to practice-based organizational learning and to improving organizational performance

3.1 Introduction

The exploitation of experience in organizations was presented in Chapter 1 as an important real-world problem in need of conceptual clarification and methodological support, in particular with respect to the issues of organizational learning-measurement and performance indicator-selection. The conceptual framework developed in Chapter 2, which extends the context-based intelligent assistant support (CIAS) paradigm to organizational learning and performance improvement was presented as a contribution to theory. In this thesis, *practice-based organizational learning and performance improvement* are formalized and interpreted as a cycle of contextualization of problems, de-contextualization of practices, and re-contextualization of procedures. The study of how organizations leverage their lessons learned from experience is transposed into an investigation of the aspectual characterization of organizational practices and the evolution over time of those practices. Both can be studied using contextual graphs. In this chapter, methods and tools that operationalize the thesis are developed and presented as a contribution to research practice. These methods and tools exploit the ontological distinction made in the conceptual framework between *representations of knowledge* used in organizations, the *management activities* that transform knowledge representations, and the *integrity and inference rules* that govern the contextualizing, de-contextualizing, and re-contextualizing transformations.

The rest of this chapter is organized as follows. In Section 3.2, the research objective is articulated in three research questions. Each question is sub-divided into subsidiary questions that focus on particular aspects of the main question. The research questions together with the conceptual framework developed in the previous chapter (Table 2.19) guide the location and codification of relevant data and provide the focus of attention for interpreting the observed phenomena.

Section 3.3 presents the methodology in a discussion of method, scope, unit of analysis and embedded units of analysis, research approach, data collection strategy, analytical tools and triangulation. Section 3.4 presents the actual research protocol used. Section 3.5 summarizes the research process.

3.2 Research objective and research questions

The research objective of this thesis is *to understand the role of context in practice-based organizational learning and performance improvement and to identify opportunities for a CIAS approach to practice-based organizational learning and to improving organizational performance*. This objective is operationalized by breaking it down into three main research questions and associated subsidiary research questions, as shown in Table 3.1.

Table 3.1 Research questions and subsidiary research questions			
Main Research Questions		Subsidiary Research Questions	
RQ1	How do organizations use experience to improve performance?	RQ1a	How do organizations represent their experience?
		RQ1b	How do organizations abstract lessons learned from their experience?
		RQ1c	How do organizations leverage lessons learned from experience?
RQ2	What issues confront organizations leveraging lessons learned from experience?	RQ2a	How do organizations ensure the relevance of their activities?
		RQ2b	How do organizations ensure the effectiveness and efficiency of their ways and means of realizing their activities?
RQ3	What opportunities are there for a CIAS approach to practice-based organizational learning and to improving organizational performance?	RQ3a	What opportunities are there for a CIAS approach to recording relevant organizational experience?
		RQ3b	What opportunities are there for a CIAS approach to retrieving relevant experience to improve performance in organizations?

The first research question investigates how *organizations* use experience to improve performance of an *activity*¹. Experienced organizations by definition have at least one effective way of realizing the activity considered. The first research question focuses on the manner in which practical experience is recorded and made available for future use in the organization.

¹ Activities can be *value-adding* or *supporting* in the activity-based view of the firm (Porter, 1985).

The second research question investigates issues confronting *learning organizations*² and focuses on how they select activities and how they manage performance of those activities. In other words, how organizations ensure they are doing the right things and how they ensure they are doing those things right.

The third research question applies to responsible organizations i.e. to organizations that already ensure the relevance and robustness of their practices. It looks at opportunities for a CIAS approach to practice-based organizational learning and to improving organizational performance. It focuses on the use of CIAS to record relevant experience and to retrieve experience in context to improve future performance.

Together the three research questions articulate a CIAS approach to investigating the role of context in the complex embedded phenomena of practice-based organizational learning and performance improvement. To answer the research questions, relevant data must be located and interpreted in the context of the activity which generates it and to which it refers. How this is done for each research question is explained in the following sub-sections.

3.2.1 Research question one (RQ1): How do organizations use experience to improve performance?

The first research question investigates how organizations use experience to improve performance. It proposes a three-part investigation of organizational learning and performance improvement, asking how organizations represent their experience, how they abstract lessons from that experience, and how they leverage lessons learned in future activity. The review of prior results in the research literature anticipated the tripartite articulation of this first research question, noting how the focus of management attention in real-world situations evolves from performing, to assessing, to learning, and on to performing again, in a spiral of continuous improvement. De-contextualizing *practices* in the form of *procedures* that improve performance when confronted with similar *problems* in the future is the essence of practice-based organizational learning and performance improvement. Each of the parts of the first main research question is presented and briefly discussed in the rest of this section.

² *Learning organizations* are purposefully self-reflective (Senge, 1990)

RQ1a: How do organizations represent their experience?

The first subsidiary research question investigates how organizations represent their experience. Experience fuses activity and situation in an organization's practices, in other words practice expresses the experience of organizations in realizing their activities (Hegarty, Brézillon & Adam, 2012a). Realizing an activity brings together knowledge, reasoning, and context in a practice and is represented as a path in a contextual graph using the framework illustrated in Figure 2.11.

There are two difficulties in representing practice, one associated with representing situations, the other with representing activity. The difficulty with representing situations is in *denoting* the elements of the environment perceived as bearing on the activity and *referring* to them with specific values (Brézillon & Pomerol, 2010; Allwood, 2003; Donnellan, 1966). The difficulty in representing activity, whether expected, desired, planned, actual, or past, as shown in Table 2.6, lies in determining the boundary of the active system. Activity separates the world into an inner and outer environment as shown in Figure 3.1 and elements of both environments are used to situate action. This broad view of what a *situation* is echoes the original phenomenological meaning where 'situatedness refers to both the ongoing or emerging circumstances of the surrounding world and the inner situation of the actor' (Ciborra & Willcocks, 2006). The psychological dimension of the situation is captured using the activity theory distinction of *activity*, *action*, and *operation* depending on the focus of attention (Leplat & Hoc, 1983; Leontiev, 1978). The temporality of the situation is expressed in the mode of interpretation of the past, present, and future ways of being-in-the-world, i.e. in terms of practice background 'what we bring to the situation', objects in the foreground, 'what shows up', and plans opening up possibilities 'what we make of the situation' (Riemer & Johnston, 2012; Allen, 1984).

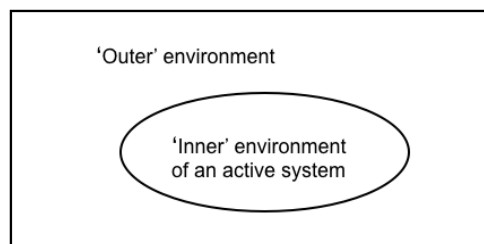


Figure 3.1 Inner and outer environments of an active system

Practice in organizations is embodied in the realization of an activity. Four contextualizing management activities convert a problem, perceived as a gap between the desired and expected worlds, into a realization that closes the gap in specific circumstances (Figure 2.13). To represent practice is to de-contextualize the experience, leaving aside some aspects in favor of others.

The context-based intelligent assistant support (CIAS) approach, followed here, attaches importance only to those elements of the situation that bear on the action as the activity unfolds. The CIAS paradigm suggests an approach to the collection of data summarized in the slogan ‘ask about practice not about procedures’. This approach is implemented using the Contextual-Graphs representation formalism, and is very effective in collecting data on the practice of complex activities. The paths in a contextual graph directly represent different ways of realizing an activity; they represent practices and express the experience of the organization in the particular circumstances that prevailed at the time of the action.

Furthermore, since every practice realizes an activity, selecting performance indicators for an activity is transposed into investigating aspectual characterization of organizational practices that realize the activity. Because, the realization of the activity is itself an aspect of the practice, it expresses performance *as product*, just as the path of the practice in a contextual graph is an expression of performance *as process*. In this way, the Contextual-Graphs representation formalism, is a comprehensive tool for expressing performance without recourse to assumptions about causality. Once the question of representing experience has been investigated, the question of abstracting lessons learned follows on its heels.

RQ1b: How do organizations abstract lessons learned from experience?

The second subsidiary to the first research question (RQ1b) investigates how organizations abstract lessons learned from experience. This is equivalent to measuring practice-based organizational learning of an activity and is transposable into an investigation of the evolution of organizational practices that realize the activity. Again, the Contextual-Graphs representation formalism is employed. Once the question of abstracting lessons learned has been investigated the question of leveraging lessons learned follows on its heels.

RQ1c: How do organizations leverage lessons learned from experience?

The third subsidiary of the first research question (RQ1c) investigates how organizations leverage lessons learned from experience. The review of the literature highlighted the dilemma faced by organizations when exploitation of experience is juxtaposed with exploration of alternative approaches. This thesis considers only exploitation. An inspection of the evolution over time of the practices that realize an activity reveals the activity maturity of the organization and is a measure of the organization's effectiveness at leveraging lessons learned.

This third subsidiary to the first research question completes the questionnaire on the investigation of how organizations use experience to improve performance. It opens the way to the second research question, which investigates the issues that confront organizations leveraging lessons learned from experience.

3.2.2 RQ2: What issues confront organizations leveraging lessons learned from experience?

The second research question asks what issues confront organizations leveraging lessons learned from experience. It changes the point of view from one of an actor within the organization to that of an observer of the organization (an internal or external auditor) and implicitly evokes a standard that exists independently of the current practice of representing, assessing and improving performance and learning. The literature review showed how a standard opens a gap between output and outcome and introduces two types of uncertainty; the first uncertainty relates to the acceptability of the standard for practice and the second to the vulnerability of practices in achieving the standard. The research question is broken into two subsidiary parts; the first investigates how organizations ensure the acceptability of objectives; the second investigates how organizations manage risk. Each of the subsidiary research questions is operationalized in the following sub-sections.

RQ2a: How do organizations ensure the relevance of their activities?

The question of relevance of activities or acceptability of objectives is approached indirectly from the angle of sustainability and growth to avoid a philosophical discussion. The first subsidiary of the second research question (RQ2a) thus asks what actions organizations take to ensure the relevance of their mission and the

appropriateness of their risk appetite. By investigating feedback actions at the level of objectives, the topic is situated in the mode of 'organizational learning and knowledge management' (Figure 2.3). Direction and governance are high-level activities that generate data important for situation assessment. Mission and exposure to risk are the starting point for the investigation of the management of vulnerability of practices, the topic of the next section.

RQ2b: How do organizations ensure the effectiveness and efficiency of their ways and means of realizing their activities?

The second subsidiary of the second research question (RQ2b) addresses the issue of vulnerability of practices and asks what events organizations identify and manage when representing, assessing, and improving their performance and learning. To answer the question, data is collected on how organizations identify risks and opportunities and manage them. The essence of enterprise risk management is control, both strategic and operational; it is the third mode of management activity involved in organizational improvement (Figure 2.3).

The second research question investigates risks to practices and throws light on areas that might benefit from context-based intelligent assistant systems support. Opportunities to support organizational learning and performance improvement are the subject of the next research question.

3.2.3 Research Question Three (RQ3): What opportunities are there for a CIAS approach to organizational learning and to improving organizational performance?

The third research question investigates opportunities to support organizational learning and improvement under two rubrics; the first investigates support for real-time practical knowledge acquisition and the second investigates CIAS support for access to existing information systems.

RQ3a: What opportunities are there for a CIAS approach to recording relevant organizational experience?

The first subsidiary of the third research question (RQ3a) investigates the contextualization of information systems involved in practical knowledge acquisition and asks what opportunities are there for CIAS support for real-time concurrent capture of situation and activity data. The thesis shows how situation and activity data are fused by the evolving focus of attention so it makes sense to capture the

data concurrently as the focus of attention evolves. The ease with which this can be done depends on the degree of formalization of the activity and the extent to which the activity outputs are already consigned to information systems and is a matter of investigation. Once the question of contextualizing existing information systems as an experience base is answered, the issue of access and exploitation follows.

RQ3b: What opportunities are there for a CIAS approach to retrieving relevant experience to improve organizational performance?

The second subsidiary of the third research question (RQ3b) investigates access to contextualized information systems that store the organization's practical knowledge and asks what opportunities are there for CIAS support for reporting actions situated in their context. Such reporting can be at the operations level in which case it serves practical learning for newcomers to the organization or novices to the activity. When the level of reporting is top management and governance instances then it serves the purpose of explanation of decisions taken and transparency.

3.3 Methodology

This section includes a discussion of research method, scope, unit of analysis and embedded units of analysis, research approach, data collection strategy, analytic tools, and triangulation.

3.3.1 Research method

The method used is the interpretive case study (Klein & Myers, 1999). The case study method is well suited to the study of complex phenomena, here *organizational learning and performance improvement* of the route selection activity in a large organization charged with light rail infrastructure procurement.

What is novel about the approach here as compared with prior research using contextual graphs (Brézillon, 2011) is that both the political/strategic level and the tactical/operational level are involved in the route selection activity. The political/strategic aspects of the situation in which route selection decisions are made are more open to interpretation than the tactical/operational aspects in which practice is constrained largely by technology. In the case investigated, RPA described its

performance at the political/strategic level in narrative form (cf. memos to the Board reproduced in Appendices 1, 2 and 3) and RPA management's interpretation of the situation must in turn be interpreted by the researcher without going beyond the data that was available at the time i.e. bearing in mind that 'there is the class of descriptions of any event under which the event cannot be witnessed' (Danto, 1962). In other words, the method of research used is to collect and represent data that was available to the practitioners as the activity of route selection unfolded using different representation formalisms that do not alter the interpretation of the situation.

Because RPA used an informal method of representing its performance and the thesis is framed in terms of a formal representation using contextual graphs it was necessary to find a bridge between the two representation formalisms to ensure that the transposition of the narrative into contextual graphs did not introduce research bias. The common language between researcher and practitioner used was a tabular intermediary transposition table that on the one hand formally separates 'situation', 'RPA actions', 'performance assessments' and 'lessons learned' in a manner compatible with contextual graphs and the conceptual framework developed in Chapter 2 and on the other hand is intuitively understandable by the RPA management involved in the production of the source documents who were then able to validate the transposition of the data.

Alternative methods of analysis of the rich data set that suggest themselves include narrative networks (Bearman & Stovel, 2000) and taxonomy evolution (O'Leary, 2006) but these are beyond the scope of this thesis which explicitly focusses on the CIAS approach.

3.3.2 Scope

The scope of the study is the practice of complex mission-critical activities in procedure-controlled long-cycle projects of experienced organizations. Here, the particular activity selected is *route selection* activity in light rail infrastructure projects. Route selection is a stepping stone in that it is part engineering and part managerial/political.

3.3.3 Unit of analysis and embedded units of analysis

The primary unit of analysis is the organization. The embedded units of analysis are the activity and the practice of light rail route selection at RPA. Both are presented in this section.

Unit of analysis

Here, the organization selected is the Railway Procurement Agency (RPA) in Dublin, an organization experienced in the practice of light rail route selection. Three issues influenced the selection of RPA for the thesis. First, because the study calls for a complex activity, it makes sense to select an activity that is familiar to the researcher to facilitate communication with practitioners. Second, because performance assessment is a sensitive issue, it makes sense to pick an organization whose objectives are publicly stated and whose output is objectively measurable. Third, since the organization should be willing to grant the researcher access for the duration of the thesis to people involved in the activity and to the actual data generated. Public transport planning is a complex activity that fits the bill on all three counts; it is familiar to the researcher who studied the subject as an undergraduate, its output is objectively measurable infrastructure and it is carried out by organizations that are accessible to researchers. A short list of transport planning organizations was drawn up before finally selecting the Railway Procurement Agency (RPA) in Dublin for the case study.

The organization, known as the Railway Procurement Agency (RPA), is an Independent Statutory Body, established in 2001 by order of the Irish minister of transport following the passing of the Transport (Railway Infrastructure) Act, 2001. Its mandate is to provide a light-rail transport system for the capital city. Specifically its brief is to:

- Secure the provision of, or to provide, such light railway and metro infrastructure as may be determined from time to time by the Minister for Transport
- Monitor and publish regular reports on the safety of the light railway and metro infrastructure
- Enter into agreements with other persons in order to secure the provision of such railway infrastructure whether by means of a concession, joint venture, public private partnership or any other means
- Acquire and facilitate the development of land adjacent to any railway works subject to an application for a railway order where such acquisition and development contributes to the economic viability of the said railway works

To deliver on its statutory mandate, RPA implements a corporate strategy guided by the core principles, vision and master goal shown in Table 3.2

Table 3.2 Railway Procurement Agency core principles, vision and master goal	
Core principles	Focus on the Customer Experience Safety and Sustainability Integrity and Transparency Cost effectiveness and Innovation
Vision	Get people in Irish cities out of cars and on to public transport
Master goal	To increase the use of public transport by putting in place an integrated network of high quality transport infrastructure and services in a cost effective way

The Railway Procurement Agency's Board makes decisions relating to the agency's activities in light rail. The Board comprises of the Chairman, Agency CEO, four external members and one elected employee representative member. The Chief Executive Officer is responsible for the day-to-day running of the agency in attaining its objectives. Activities in light rail are achieved through Corporate Services, Finance, Design & Construction and Project Services. An Internal Audit function also reports directly to the Chief Executive Officer. Of particular interest to the researcher were Corporate Services responsible for Information Technology and RPA Design & Construction responsible for Transport Planning.

RPA is experienced in the activity of route selection. It delivered the first two lines in the Dublin light rail system on time and within budget to wide public acclaim and the system has been operating without any serious accident and without requiring a public subsidy since opening to passengers in 2004.

RPA is a research-friendly organization and entered a confidentiality agreement with the two universities responsible for supervising the thesis. The confidentiality agreement reassured the organization's top management that commercially sensitive data would be redacted out of published documents and at the same time provided the researcher privileged access to data and people in the organization throughout the duration of the thesis. This proved critical to the success of the research project.

Embedded units of analysis

The embedded units of analysis are the activity and the practice of light rail route selection at RPA. Light rail public transport systems can be characterized as rail-based systems with a passenger carrying capacity greater than buses and less than metros. They are economically viable in medium density urban areas. Light rail vehicles are powered by electricity, usually drawn from overhead lines, and are viewed as environmentally friendly, modern transport systems that can contribute to urban form. To provide a high level of service, light rail systems are generally segregated from other traffic in a dedicated road space. Unlike metros that are generally underground or over-ground, light rail infrastructure is generally at grade level, which means that the construction of a new light rail line has a bigger impact on the surrounding city space than a metro. The selection of a route is a complex activity with political, economic, socio-cultural and technological aspects.

Public transport projects emerge as part of a wider political arbitrage embracing sustainable urban development and other claims on the public purse. Once a project has sufficient political support, it is integrated in a formal development plan and an existing or specially created agency is charged with its implementation. The modern history³ of light rail in Dublin started with renewed political interest in railways in the 1990s at the start of the Irish economic boom known as the 'Celtic tiger'. The Irish national railway agency, Coras Iompair Éireann (CIÉ), which on its inception in 1944 had been vested with the historic Dublin United Tramways Company (DUTC), was charged by the government in 1994 with elaborating a plan to implement the Dublin Transport Initiative (DTI) of the same year. The DTI was a comprehensive land use and transport plan for the Greater Dublin Area (GDA) and foresaw a three-line light rail transit (LRT) system linking Tallaght, Ballymun and Cabinteely to the City Centre. The LRT system was branded LUAS and the CIÉ Light Rail Project Office set about implementing the plan for the first phase of Luas in line with a Government decision of May 1998. In December 2001, the Transport (Railway Infrastructure) Act 2001 established RPA as an independent statutory agency responsible for the procurement of railway infrastructure systems and RPA subsumed the role of the former CIÉ Light Rail Project Office. The first RPA board meeting was held in January 2002.

³ Dublin had a tramway system from the 1870's but it gave way to the rise of cars and buses in the early 20th century and the last tram exited service in 1949 (Wikipedia, 25dec2012; Ferris, 2009).

The 2001 legislation required light rail systems to receive permission to build and operate in the form of a Railway Order. An application for a railway order by RPA is preceded by a consultation of the public on alternative route options. Since Railway Orders provide for compulsory purchase of land or buildings if this is determined to be in the public interest, the procedure ensures against abuse of private property rights. Applications by the RPA must show precisely the route to be taken by the line and any encroachment on private property must be justified. This formal transparency of the output of the route selection activity greatly facilitates the research project.

Once the permission to build and operate is received, eventually with conditions imposed, RPA procures the system following EU regulations for public procurement. The nature of RPA contracts means the tendering procedure used by RPA is normally the Negotiated Procedure, which is indicated for complex projects when the overall price cannot be determined in advance. RPA advertises and negotiates the terms of the contract in a process that normally involves the submission of formal tenders by at least three candidates. A concessionaire carries out daily operations; at the time of publication, Veolia operates the system for RPA. The ultimate criteria in the evaluation of the route selection activity are the extent to which the line as built actually attracts passengers in daily operation and contributes to the RPA master goal in Table 3.2.

Practice of route selection is expressed in specific infrastructure projects. Here, data to answer the research questions is collected on three different RPA projects in route selection. The projects selected for investigation are the extensions line C1, line B1 and line A1 to the Dublin light rail public transport system illustrated in Figure 3.2. Known as LUAS, Dublin's light-rail system consists of two principal lines, the Luas Red Line and the Luas Green Line. They will be connected in 2017 when the northbound extension of the Green Line opens but since the interconnection project has not yet been built it is excluded from the scope of the thesis. The Luas Green Line, opened for passengers 30 June 2004, originally ran Stephen's Green to Sandyford. The Luas Red Line, opened 28 September 2004, originally ran from Tallaght to Connolly with 17 stops. The eastward extension of the Red line, known internally as project C1, passes through the Docklands to the Point adding four additional stops and opened to passengers 8 December 2009. The southward Cherrywood extension of the Green line to Bride's Glen known

internally as project B1, opened for passengers 16 October 2010 with 9 additional stops. The westward extension of the Red line through Citywest to Saggart, known internally as project A1, added five additional stops and opened to passengers 2 July 2011. The three cases of route selection will be discussed in the order in which the extension projects were delivered; first C1 (Docklands), then B1 (Cherrywood) and finally A1 (Citywest).



Figure 3.2 Luas, Dublin's light rail public transport system showing the three extension projects investigated in the case study (map © RPA)

The approach to research is specifically adapted to the study of practice as discussed in the next section.

3.3.4 Research approach

The CIAS approach used in this research project is characterized here as practice-based, inter-disciplinary, and human-centered. Each of these aspects is discussed in this section.

Practice-based

The practice-based approach is first and foremost research anchored in experience as can be summed up in the following quotation:

"Instead of assuming hidden causes or transcendental principles behind everything we see or do, we are to redefine the concepts of abstract thoughts as constructs, or functions, or complexes, or patterns, or arrangements, of the things that we do actually see or do. All concepts that cannot be defined in terms of the elements of actual experience are meaningless" (Cohen, 1935).

The focus of the research is on the actual practice of organizational learning and performance improvement as the embodiment of experience. Just as an activity is embedded in other activities as shown in Figure 2.2, practice is embedded in other practices. The practice of learning route selection is embedded in the practice of the seven management activities of the conceptual framework (Table 2.19) that contextualize, de-contextualize and re-contextualize the practical knowledge of route selection. These management activities are practiced at different levels in the organization, which is modeled as an active system Figure 3.1, and as a complex system in Figure 3.3.

RPA is modeled, using the open systems approach, as a complex of an operating system AND an information system AND a decision-making system, as shown in Figure 3.3. The decision-making system is, in turn, a complex of a goal-setting system AND a design system AND a selection system. It is connected to the operating system by the organization's information system (Lemoigne, 1999).

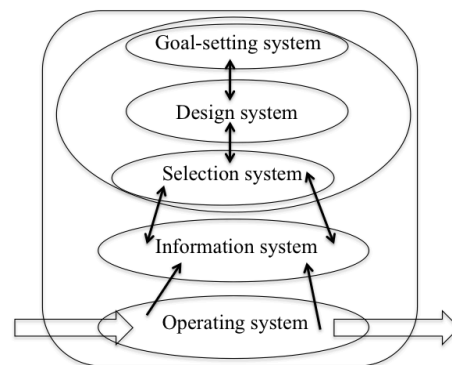


Figure 3.3 A complex systems model of an organization (Lemoigne, 1999, p.64)

The first research question addresses the operating system, the second research question addresses the decision-making system and the third research question addresses the information system that links the other two. The representation of a

practice⁴ implies the existence of a practitioner at the operations level, at the decision-making level and at the information systems level.

RPA is modeled as a complex system that is active in its environment (Figure 3.1). Its activity is modeled using the Contextual-Graphs representation formalism. A contextual graph represents an activity in terms of practices that realize the activity. A practice is represented in a contextual graph as a path that traces the evolution of the focus of attention as the activity unfolds. The path is a directed sequence of actions and activities connected to contextual elements whose values specify the situation pertaining at the moment of the action or activity. Thus, the focus of attention fuses situation and unfolding activity.

Activity is an abstraction that corresponds to purpose or task. The task modeled in the contextual graph is realized by actions that are implemented in operations that are outside the focus of attention of the practitioner at the moment of realizing the action. The implements of action, the practitioner's resources, do not appear in the contextual graph unless they determine the choice of action at some point as the activity unfolds, in which case they constitute a contextual element. The quality of activity, action, or operation is not inherent in an object but depends on the focus of attention. This distinction between activity, action, and operation echoes the activity theory of psychology. What is shared between the CIAS approach and activity theory is the discriminating role of the focus of attention.

Insofar as a practice is a realization of activity the practice-based approach is compatible with different activity-based approaches in psychology, economics and information systems (Leontief, 1978; Porter, 1985; Nardi, 1996a and 1996b).

Interdisciplinary

The interdisciplinary approach is evidenced in the broad literature review and the attention paid to the coherence of epistemological and ontological commitments inspired by results from different disciplines. The approach is inclusive in the sense that the model of the organization as a complex system in Figure 3.3 is an instance of the model of an active system in Figure 3.1 which in turn is an instance of a

⁴ In the Contextual-Graphs representation formalism a practice is represented as a path in the graph of an activity that may include other activities that in turn can be represented as other contextual graphs, recursively. Activity is embedded in activity recursively

general system model defined as *the representation of an active phenomenon perceived identifiable by its projects in an active environment in which it functions and transforms itself purposefully* (Le Moigne, 1999, p.40).

An example of the inclusive interdisciplinary approach is the slogan *activity as the meaning not the context of action*. The sense given to *activity* in the activity nodes of the Contextual-Graphs representation formalism (Brézillon, 2012) is fully compatible with the sense given to the term in Activity Theory (Nardi, 1996). CIAS approach does not represent *operations* in the sense of Activity Theory unless they enter the focus of attention as actions. It is suggested that formalizing the concept of 'operation' in the same sense as in *Activity Theory* would enrich the CIAS paradigm by facilitating a formal definition of the terms *action* and *activity*. The formal alignment of the three terms would facilitate collaboration between researchers in the CIAS community and those in the Activity Theory community. The research presented here has benefited from engagement with Activity Theory and its deep roots in cognitive psychology. It is suggested that IS researchers using the Activity Theory paradigm and who refer to activity as the context of action could similarly benefit from the conceptual clarity that the CIAS community brings to the difficult topic of context. The slogan 'activity as the meaning not the context of action' tries to capture the common ground.

Human-centered

The human-centered approach finds expression in the human-first approach to technology evidenced by the use of CIAS as a support for people in the organization and not an automated approach that requires people to adapt to the technology (Bannon, 1997). People learn in organizations how to improve the performance of the activities people realize through organizations. Organizations do not learn without people.

3.3.5 Data collection strategy

As shown in the previous chapter, managers formalize and interpret data in and about a situation as meaningful problems, practices, and procedures using codes and context that are difficult to disentangle (Section 2.4.1). The data structures that represent problems, practices and procedures emerge from seven management activities that focus on and transform those very data structures as was shown in

the conceptual framework (Table 2.19). The role of context in organizational learning and performance improvement is brought into the research focus of attention by qualifying the seven transforming management activities in the manner shown in the conceptual framework: *situation assessment*, *problem solving*, *decision making* and *implementing* are qualified as contextualizing management activities, *representing practices* and *abstracting lessons learned* are qualified as de-contextualizing management activities and *leveraging lessons learned* is qualified as a re-contextualizing management activity (Table 2.19).

Since the activities unfold at different points in a project's life and have different data intensity, it makes sense to organize data collection around them. The activities, used as sources of data to investigate how organizations use experience to improve performance are summarized in Table 3.3 together with the corresponding management formalizing and interpreting codes.

Table 3.3 Locating and organizing data to investigate how organizations use experience to improve performance		
Data source activity	Management codes used in <i>practice-based organizational learning and performance improvement</i>	
	Formalizing code	Interpreting code
Situation assessment	Situations	Beliefs, preferences
Problem solving	Plans	Objectives
Decision making	Decisions	Commitments
Implementing	Actions	Constraints
Representing practices	Performance reports	Alternatives
Abstracting lessons learned	Lessons learned	Intentions
Leveraging lessons learned	Practice maturity	Relevance

Table 3.3 facilitates the location and organization of data relevant to organizational learning and performance improvement. It also serves as a glossary of terms for use in interviews and trans-coding the specific terminology of the organization being studied. The terms in Table 3.3 are used in the usual management research acceptance and are not bound to any particular representation formalism or management theory.

At RPA, the management activities of problem solving and implementing are associated with the operations level and are represented in an operations-level contextual graph of route selection. The contextual elements (represented by CE nodes) denote the situation and the values of the contextual elements (represented by CE branches) refer to the specific situation. Actions⁵ appear directly in the graph (represented by action nodes) structured by the practice (represented by the path linking actions and contextual elements) that realizes the activity (represented by the entire graph). The practice represented in the graph is an instantiation of the plan to achieve the objectives that the activity expresses. To construct an *operations level route selection CxG* involves collecting route selection *problem solving* and *implementing actions* and the *elements of the situation* that bore on the actions together with the *values of those elements* in the particular circumstances.

Similarly, in the case of RPA, the management activities of *situation assessment* and *decision making* are represented in a strategic-level contextual graph of route selection. The two graphs are linked by nature as the strategic level determines the objectives for the operations level and the operations level elaborates the possible plans subject to decisions at the strategic level. Linking the operations and strategic levels via the information system requires finding new practices at the information systems level that can exploit the CIAS support opportunities for recording and retrieving experience that are the subject of investigation in this thesis.

Data collection included semi-structured interviews with 17 informants and two route selection research workshops with 3 RPA senior management participants and 2 RPA transport planning experts. The main data sources are listed in Table 3.4.

⁵ Actions that are not serial are represented in parallel action groups and activities within an activity are represented by activity nodes in the graph. Activity nodes can be expanded into contextual graphs that contain other activities recursively

Table 3.4 Main data sources	
Source	Informants
EU Commission DG Move, Brussels	1
Irish Govt. Department of finance, Dublin	1
Irish Govt. Department of transport, Dublin	2
RPA Senior Management : CEO + directors, Dublin	3
RPA Transport planning (TP), Dublin	4
RPA Information systems, Dublin	2
Transport planning academics (TCD Dublin, UCC Cork)	2
non-RPA Transport planning practitioners (RATP and STIF, Paris)	4
CxG Route Selection Research Workshop N° 1 (Management + transport planners)	3+2
CxG Route Selection Research Workshop N° 2 (Transport planners only)	2

All interviews were individual face-to-face and were followed up with email and telephone complementary discussions. In the case of the principle informants (RPA director of operations and RPA head of transport planning) multiple interviews were accompanied by extensive tele-communication over a period of two years. All interviews were semi-structured, combining open and closed questions; the structure coming from the research questions, the tools used and the specific questions suggested by the review of relevant documents. Informants were encouraged to use their own words, which were clarified with respect to the constructs in the conceptual framework.

The contextual graphs workshops took place at RPA headquarters on the same day. The first workshop included the RPA CEO, Director of Operations, Director of Communications, Head of Transport Planning Department and a project manager who was the previous Head of Transport Planning Department. The workshop was recorded and a transcript sent to the participants for review and comments. During the CxG workshop the Contextual-Graphs representation formalism was used to present the CIAS approach to RPA management. The participants found the approach to be intuitive and had no difficulty with the researcher using the CxG software to elicit RPA practice of the route selection activity at senior management level. This ‘ask about practice not about procedures’ approach to research proved very engaging for RPA management and the data collected was very rich and relevant to the thesis.

The second route selection research workshop followed immediately on the first and focused on more technical issues with the transport planners who compared

their individual practices of route selection. This was again supported by the CxG software. A partially prepared route selection contextual graph⁶ was developed with the participants who could immediately visualize and comment on the differences in their respective approaches to route selection. The head of transport planning found the CxG representation formalism particularly interesting and worth pursuing in his department on future projects. This again confirms the value of the ‘ask about practice not about procedures’ approach to research and the ‘live’ use of contextual graphs in the eliciting process.

3.3.6 Analytic methods

The data collected was analyzed using contextual graphs and four new methods, developed as part of the thesis. The base data was transformed into contextual graphs using transposition tables and analyzed using the new methods, namely the *aspectual comparison of practices*, a *practice-based learning novelty typology*, a *practice maturity model* and an *organization-performance-improvement matrix*. Each of these analytic methods is presented in the following sub-sections.

3.3.6.1 Transforming narrative into contextual graphs

Transposition tables were used to maintain the chain of evidence and ensure that the RPA narrative in the Board memos was faithfully reproduced in the contextual graphs. This is illustrated below using data from the Line C1 Board Memo (Appendix 1, p. 8 of 17, items 14 and 15):

Base data (item 14): “ A contract was awarded to ABC for utility diversions in May 2007 for X euros under the FIDIC red book which is based on a design by the client and is a re-measurable form of contract.”

Base data (item 15): “ It is highly unlikely that it is possible to transfer all the risk associated with diversions to contractors or if it were possible that value for money would be achieved”

The base data cited above is presented in the transposition table below (Table 3.5).

⁶ As preparation for the workshop, the researcher had taken an RPA light rail route selection report for a new line then under study by the head of transport planning and transcribed it into the Contextual-Graphs representation formalism using the CxG software

Table 3.5 Transposition table from narrative form (Appendix 1) to contextual graph (Figure 3.4)				
N°	Situations	RPA Actions	Performance assessments	Lessons Learned
14	Separate utilities diversion contract?	"A FIDIC red book re-measurable form of contract for utilities diversion was settled for €x	"This is a significant increase over the tendered sum of €y million"	"Contracts for the diversion of utilities should have a large risk figure attached to them allowing for the form of contract used"
15	Type of utilities diversion contract?	"FIDIC red book re-measurable"	"It is highly unlikely that it is possible to transfer all the risk associated with utility diversions to contractors"	"A form of contract that incentivizes efficient working between client and contractor and recognizes the risks involved might be a better approach for utility diversions"

The data in Table 3.5 which relates to the ‘utilities risk contingency’ is transposed into a contextual graph in Figure 3.4 below: N° 14 situation becomes CE₁₄, n° 15 situation becomes CE₁₅, and n° 14 RPA action is shown as A₁₄. For simplicity only one action is highlighted. The path in the graph through this action represents RPA actual practice in the case of Line C1. It is this actual practice of the activity of contracting for utilities diversion services that is measured and evaluated in the column “performance assessment”.

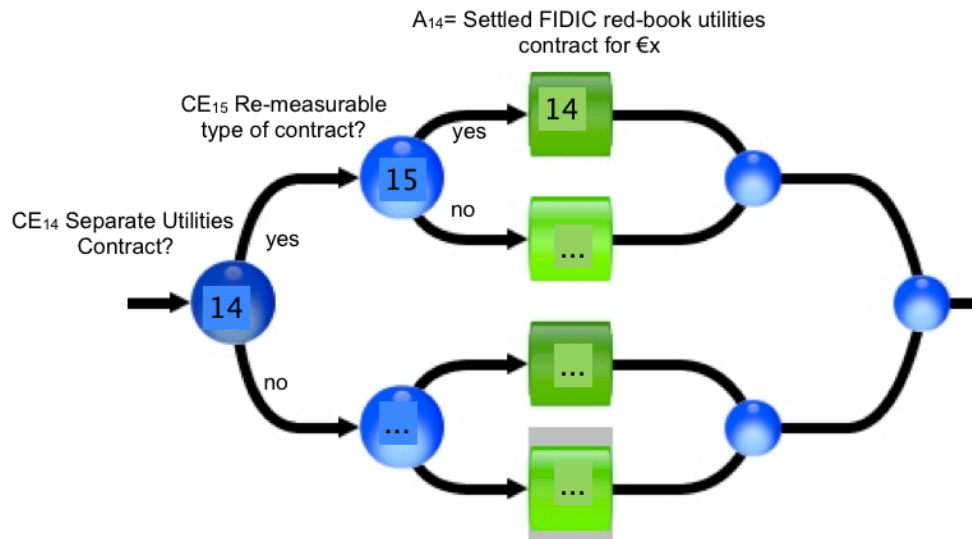


Figure 3.4 Example of a contextual graph (cf. Table 3.5)

The lessons learned in the last column of Table 3.5 are abstractions from the actual practice in the case of Line C1 that refer to the contextual elements (contracts for utilities diversion) but no longer refer to the specific values of the contextual elements (FIDIC red book type of contract) that pertained as the activity unfolded. This process of abstracting from a value of a contextual element (FIDIC type of contract) to the contextual element itself (contract *tout court*) is called *de-contextualization* in the thesis (Figure 2.14). It opens the way for improving performance through *re-contextualization* where the contextual element recognized on a future occasion takes on a different value and therefore calls for a different response.

The transposition tables were used in discussion with RPA management to ensure that the contextual graphs faithfully represented the Board memos. Once the situation data is captured in contextual graphs it is possible to compare two practices under any aspect as discussed in the next sub-section.

3.3.6.2 A new method of selecting Key Performance Indicators (KPIs)

Contextual graphs represent practices in the context of the activity they realize. It makes sense therefore to compare two practices that realize the same activity. This comparison can be under any aspect and is called *aspectual comparison of practices*. This use of contextual graphs provides a tool to support the emergence of indicators of performance that do not use causality assumptions (Searle, 2004).

3.3.6.3 A new method of measuring organizational learning

Organizational learning of an activity can be characterized in terms of the evolution over time of the contextual graph that represents the realization of the activity (Hegarty, Brézillon, Adam, 2012). As an activity is unfolding, learning is tacit until a breakdown propels a concept into the focus of attention (Leontief, 1978; Polanyi, 1966); the new concept is accommodated as a parameter of the activity, enriching the theoretical model of the activity or assimilated as a characteristic of the learning situation, enriching the practical model of the situation (Piaget, 2000; Edmonds, 1999). Practice-based organizational learning concerns the assimilation of new elements of the environment denoting the learning situation or new values of elements of the environment referring to specific situations. In the Contextual-Graphs representation formalism novelty appears over time as new contextual elements or new instances of already known contextual elements.

New Situation	Assimilation of a new situation to an existing practice	Assimilation of a new situation to a new practice and accommodation of the new practice to the new situation
Recognized Situation	Confirmation that an existing practice continues to be appropriate in a recognized situation	Accommodation of a new practice to a recognized situation
	Existing Practice	New Practice

Figure 3.5 A practice-based organizational learning novelty typology

Figure 3.5 shows four learning novelty types depending on whether the situation and/or of the practice is new. The appearance of new contextual elements or new instances of existing contextual elements in a contextual graph expresses assimilation whereas the appearance of new actions or activities signals accommodation. Recording the evolution over time of contextual graphs supports the characterization of practice-based organizational learning by type. When there is no history in the form of contextual graphs then people familiar with the history must be asked whether the situation and/or practice is new. Figure 3.5 is presented as a contribution to theory and practice (O'Raghallaigh, Sammon & Murphy; 2010). It extends the CIAS paradigm to organizational learning and the difficult problem of measuring learning. Together with the Contextual-Graphs representation formalism it provides a tool for objectively carrying out the measurement.

3.3.6.4 A new method of assessing organizational learning

Organizations develop practices over time. Initially there is just one practice, later new ways of realizing the activity are discovered and the number of practices increases. This can be observed in a densification of the contextual graphs used to measure the learning as shown in the previous section. As time goes on best practices displace less effective ones in the process of continuous improvement. And as the activity matures further optimization leads to the one best way. *Practice maturity* is the reflection and measure of activity maturity. The *practice maturity model* expresses this idea schematically in Figure 3.6.

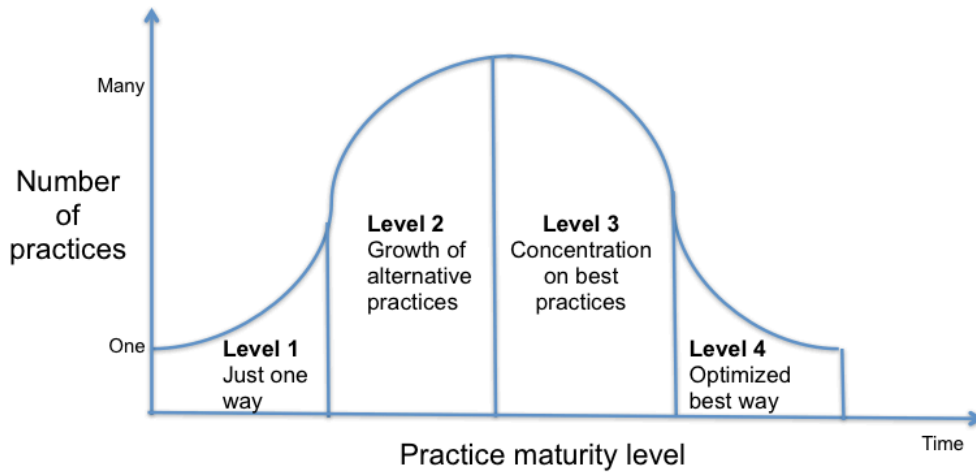


Figure 3.6 A practice maturity model

Insofar as the phases of maturity are measured by observing the evolution in contextual graphs, the practice maturity model represents an extension of the CIAS paradigm to activity management. The characterization of activities by practice maturity level is a new method of assessing organizational learning.

3.3.6.5 An organizational-performance-improvement prioritization matrix

The *practice maturity level* of an activity can be used to guide management improvement effort in combination with an assessment of the *strategic relevance* of the activity. While the formal characterization of *strategic relevance* is beyond the scope of this thesis, an *organizational-performance-improvement matrix*, illustrated in Figure 3.7, is proposed as a new tool to support the prioritization of activity improvement efforts in the spirit of the Importance-Performance matrix (Slack, 1994). Activities with high strategic relevance and low practice maturity are high priority for maturing the practice through exploitation of experience as shown in Figure 3.7. Route selection at RPA falls into this category.

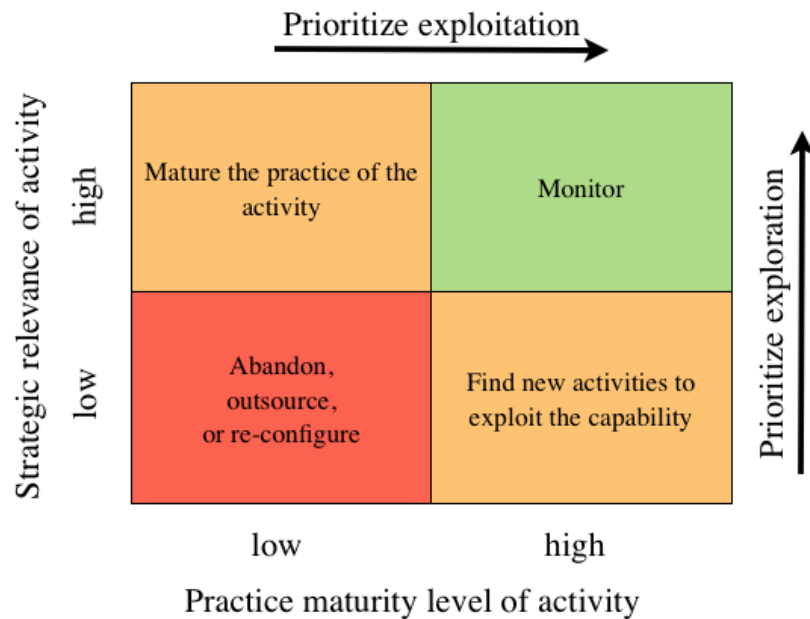


Figure 3.7 An organizational-performance-improvement prioritization matrix

3.3.7 Triangulation

Interviews and public domain information were used to cross-validate results from the study at RPA. Triangulation interviews with transport planning officials in the European commission and Irish government departments, with transport planning academics from Trinity College Dublin (TCD) and University College Cork (UCC), and with transport planning practitioners at STIF (Greater Paris region transport planning authority) and RATP (Paris public transport provider) listed in Table 3.6 provided data on light rail route selection policy, theory, and practice that was used to cross-validate results from RPA.

There is also a large body of public domain information on the RPA and its projects. Archived press and television reports covering the extension projects from initial planning, through construction to current operation proved useful in checking results from RPA. These included legislation setting up RPA, public transport policy documents for Dublin and its region, and transcripts of the public hearings carried out as part of the planning approval process (railway order) for each of the three extension projects.

3.4 Research protocol

The research protocol shows how the data identified as necessary to answer the research questions is collected, analyzed and presented, guided by the methodology. The procedure followed is outlined in Table 3.6.

Table 3.6 Research Protocol	
Item	Action
1	Select an experienced organization with procedure-controlled long-cycle projects
2	Select a mission-critical complex project activity
3	Select actual projects that involved practice of the activity
4	For each project, collect data on the activity in the strategic-decision-making, operating, and information systems
5	Analyze the data using contextual graphs, <i>the method of aspectual comparison of practices</i> , <i>the practice-based organizational learning novelty typology</i> , <i>the practice maturity model</i> , and <i>the relevance-maturity matrix</i> with the objective of closing the gaps identified in prior research i.e. selecting practice-based measures of organizational performance, measuring practice-based organizational learning, and identifying opportunities for a CIAS approach to practice-based organizational learning and to improving organizational performance
6	Present the results to the organization's strategic management for validation
7	Triangulate with expert opinion and public domain information
8	Interpret implications and contributions to theory and practice
9	Identify opportunities for further research

3.5 Summarizing the research process

The research process consisted in collecting, analyzing and presenting practice-based data on organizational learning and performance improvement using the conceptual framework developed from the literature in Chapter 2, and the methodology and analytic tools presented in this chapter. Focusing on a mission-critical complex activity, light rail route selection, for the Railway Procurement Agency in Dublin, data was collected on the organization's actual practice of route selection, and on its practice of representing and using its experience to improve its performance of route selection in future. The data were analyzed using contextual graphs and four new tools developed for this thesis, *viz., a method of aspectual comparison of practices using contextual graphs, a practice-based organizational learning novelty typology, a practice maturity model, and a organizational-performance-improvement prioritization matrix.*

Chapter 4 presents results on *practice-based organizational learning and performance improvement* in the case of route selection at RPA and identifies opportunities for a CIAS approach to practice-based learning at RPA and to improving RPA route selection activity.

4. An interpretive case study of organizational learning and performance improvement in the practice of light rail route selection at the Railway Procurement Agency (RPA) in Dublin

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Chapter 4.

An interpretive case study of organizational learning and performance improvement in the practice of light rail route selection at the Railway Procurement Agency (RPA) in Dublin

4.1 Introduction

This chapter presents the results of an interpretive case study of *organizational learning and performance improvement* in the *practice* of light rail route selection at the Railway Procurement Agency (RPA) in Dublin. The research was carried out using the protocol developed in Chapter 3 (Table 3.5). It is claimed that *practice-based organizational learning and performance improvement* of route selection at RPA is an example of contextualization of a problem, de-contextualization of practices, and re-contextualization of procedures (Figure 1.2). The review of prior literature summarized in the conceptual framework in Chapter 2 (Section 2.7.1) is used to formalize the thesis as follows:

Practice-based organizational learning occurs at RPA when new associations between actions and situations are discovered during performance assessment and are abstracted from the details of the discovery situation as lessons learned codified for future use. Practice-based performance improvement of route selection occurs at RPA when exploiting lessons learned from experience on past projects leads to practice maturity.

To test this thesis, data were collected in the form of the four representation types evoked, namely *situations*, *actions*, *performance assessments*, and *lessons learned*, and interpreted using the Contextual-Graphs representation formalism together with three new analytic tools developed in Chapter 3 (Section 3.3.6). The analysis shows that the evolution of *integrity rules* and *inference rules*, expressed in the construct of *practice maturity*, explains the phenomenon of *organizational learning and performance improvement* in terms of the social and cognitive mechanisms of *contextualization*, *de-contextualization* and *re-contextualization*.

The rest of the chapter is organized as follows. Section 4.2 presents a research model of route selection activity as practiced at RPA based on the generic models developed in Chapter 3 (Figure 3.1 and Figure 3.3). Sections 4.3, 4.4, and 4.5 present the results of applying the research model to the study of three line extension projects carried out by RPA. Section 4.6 presents the results obtained from the comparison of route selection practice across the three projects. The

Docklands, Cherrywood, and Citywest extensions to LUAS, Dublin's light rail public transport system known as Line C1, Line B1, and Line A1 respectively and illustrated in Figure 4.1 are presented in this order as this is the order in which they were completed.



Figure 4.1 Luas, Dublin's light rail public transport system showing the three extension projects investigated in the case study (Map © RPA)

4.2 Understanding route selection at RPA

To understand route selection at RPA is, first, to be able to explain the cognitive and social mechanisms involved in the spiral of its continuous improvement (Figure 2.2), in other words, to be able to represent how route selection is performed, assessed, and learned in the RPA organization. To this end data collection is guided by the first research question which applied to route selection at RPA may be stated as follows: How does RPA *represent* its experience in the practice of route selection, *abstract lessons* from this experience and *exploit* the lessons learned to improve its performance of route selection activity? (Table 3.1, RQ1)

To understand route selection at RPA is, second, to be able to explain why RPA is engaged in this activity and how RPA ensures it is doing it right. To this end data collection is guided by the second research question which applied to route

selection at RPA may be stated as follows: How does RPA ensure the relevance of its route selection activity and how does RPA ensure the effectiveness and efficiency of its practice of that activity? (Table 3.1, RQ2)

To understand route selection at RPA is, third, to be able to explain how the process of continuous improvement in route selection is supported by the RPA information system. To this end data collection is guided by the third research question which applied to route selection at RPA may be stated as follows: What opportunities are there for RPA to use context-based intelligent assistant systems (CIAS) support for recording relevant organizational experience in the practice of route selection and for retrieving this experience to improve its performance of the route selection activity? (Table 3.1, RQ3)

To collect data to answer these questions, the research protocol focuses attention first on the organization, then on the activity, and finally on the practice of the activity in realized projects (Table 3.5). Here, the RPA *organization* is modeled as a complex of three organizing systems, the RPA strategic-decision-making system, the RPA operating system, and the RPA information system (Figure 3.3). At RPA, the activity of route selection is expressed in the practices of senior management in the RPA strategic-decision-making system and in the practices of the transport planning department in the RPA operating system. Understanding the route selection activity means understanding the activity of both systems and understanding how the RPA information system supports and links the other two systems (Figure 3.3). Data on RPA route selection *activity* used in both the strategic-decision-making- and operating-systems may be formalized and interpreted using the conceptual framework developed in Chapter 2 (Table 2.18 and Table 2.19) and the data collection strategy developed in Chapter 3 (Table 3.3). Data on RPA route selection *practice* is located in the records and reports of the three RPA extension projects investigated.

RPA route selection *strategic-decision-making system*

Good route selection is critical to RPA's mission "to get people out of cars onto public transport" (Table 4.1). Prior to submission of a railway order requesting planning permission for a new route, the RPA board approves the route selected. The board decision is prepared by the RPA chief executive and top management who are closely involved in all strategic aspects of route selection decisions. Once

a new line is built and in operation the RPA chief executive submits a post-completion project review to the board as part of the organization's continuous improvement process. The project reviews of the three extension projects studied in this research constitute an important source of data on how RPA senior management practices route selection and are included in redacted form in the appendices to the dissertation (Appendix 1, 2 and 3).

Situation assessment is the first contextualizing management activity involving senior management (Table 2.19). Light rail route selection at RPA is modeled as a complex activity (Figure 3.1). The elements of the *external* environment that bear on the activity, as practiced in the particular circumstances of a given project include the project's perceived political, economic, socio-cultural and technological opportunities and threats. The elements of the *internal* environment that bear on the project include the *beliefs*, *preferences*, and *plans* of the organization, and the capabilities and resources that it can deploy in the realization of the project. The conceptual framework suggests that for a given project, RPA senior management uses *beliefs*, *preferences* and *plans* to interpret the evolving situation¹ (Table 3.3). The situation is denoted generically by the elements of the environment perceived by RPA senior management at the time to bear on the activity and referred to specifically by the values they assign to the denoted elements in the particular situation (Figure 2.11). The strength of the context-based intelligent assistant systems (CIAS) approach used here to represent practice is its parsimony; all that is required to represent a situation is the relevant generic element and its specific value. Relevance is determined by the evolving focus of attention, here of RPA senior management, as the activity is realized. Practice associates action with a specific situation in the mind of the practitioner, here RPA senior management.

Decision-making is the other contextualizing management activity associated with senior management. Here, according to the conceptual framework, RPA senior management uses the *logic of consequences* and the *logic of appropriateness* to decide between two courses of action. To represent the practice of strategic decision making in route selection all that is needed is the specification of the *situation* corresponding to the *action* (decision). The selection of which logic to use

¹ *Beliefs* are management assumptions about the facts of the situation, *preferences* are management objectives and *plans* are the options generated by the problem-solving activity (options generated by the transport planners) (Allen, 1984)

in particular circumstances may itself be a denoting element of the situation.

Representing practice is a de-contextualizing management activity. Since representation is always under an aspect (Searle, 2004), what is left out of the representation is de-contextualized. According to the conceptual framework, aspects are used by management to interpret practices (Table 3.3). Aspects are measures of performance of the practice of an activity that emerge after the fact and as such are free of causality assumptions (Section 3.3.6). To qualify an aspect of a practice is therefore to evaluate a measure of performance of the practice. *Performance assessment* is just management qualification of an action in a situation under an aspect. Practice representation is *eo ipso* performance assessment.

Abstracting lessons learned is the second de-contextualizing management activity in the conceptual framework (Table 2.19). De-contextualization abstracts procedures from practices by analogy (Brézillon, 2007; Hofstadter, 2006; Piaget, 2000; Edmonds, 1999). Managers abstract general rules from best practices. Practice-based learning can be characterized in terms of novelty type (Figure 3.4).

Leveraging lessons learned is a re-contextualizing management activity in the conceptual framework (Table 2.19). Contextualization, de-contextualization and re-contextualization are subject to *rules on the integrity of the situation* and *rules about inferring in the situation*. At the strategic level, senior management uses new rules derived from experience to assess the situation assessment or make decisions. Performance improvement is the exploitation of practice-based organizational learning in the form of *new integrity and inference rules* that lead over time to *practice maturity* of the strategic route selection activity (Figure 3.5).

RPA route selection operating system

RPA has a transport-planning department that is operationally responsible for providing expertise on *route selection* to specific projects. Staff in the department includes specialists in town planning and transport engineering. During the early project life, the Transport Planning Department would normally lead and manage the steps from early project generation, feasibility and appraisal, the first two phases in Table 4.1. Later a dedicated project team takes over operational responsibility for each project. Once projects are completed a post completion

review report normally compiles lessons learned as part of the RPA continuous improvement process². In the case of the three extension projects studied in this research, a single post completion project review report collated lessons learned across all three projects. This report included 16 functional area reports and a lessons learned log with 380 items. The project review process included 5 lessons learned workshops and involved 80 RPA staff members. The *RPA Lines A1, B1, C1 Post Completion Review Report* constituted an important source of data on how RPA operations management practices route selection and related activities.

Problem solving is the first contextualizing management activity involving operations management (Table 2.19). The conceptual framework implies that for a given project, RPA operations management, specifically the transport planning department, use *objectives* formulated by senior management to interpret the extent to which different *plans* satisfy the objectives (Table 3.3). At RPA, transport planning domain knowledge is concentrated in a specialist function and the purely technical aspects of the problem solving are delegated by senior management to this specialist function.

Implementing is the second contextualizing management activity involving operations management (Table 2.19). The conceptual framework implies that for a given project, RPA operations management, specifically the project management team use *outcomes* formulated by senior management to interpret the extent to which different *actions* implement the plan (Table 3.3). *Outcomes* function as delegated stopping rules to control the project *actions*. At RPA, project management domain knowledge is concentrated in a specialist function and the purely technical aspects of the implementing are delegated by senior management to this specialist function.

Representing practice, abstracting lessons learned, and leveraging lessons learned all function similarly in the operating system as in the strategic decision making system. *Situations, actions, performance assessments* and *lessons learned* are again the key representation types to be collected in the investigation

² *Independent look back reviews*, foreseen as part of a government value-for-money initiative, had not been initiated at the time of publication of the dissertation. While of interest from a triangulation point of view, especially with respect to *performance assessment* such reviews generally do not focus on *organizational learning*

of the RPA route selection operating system.

RPA route selection information system

RPA has an information systems department that reports to the Director of Communications. At the time of writing the dissertation, RPA was engaged in a project data integration project aimed at increasing the efficiency of responses to demands generated by freedom of information legislation. Project management data from the project management system (Primavera) was being integrated with product data (Enterprise Engineer) in a single document management system (Documentum). The identification of meta-data to be used in this project involves the formal description by department heads of all RPA processes involved in project management. A priori this process presents opportunities for a context-based intelligent assistant systems (CIAS) approach to contextualization.

Route selection activities in the RPA light rail project process

The major phases and steps in the RPA light rail project process are shown in Table 4.1. *Route selection* in the narrow sense covers just *phase two* of Table 4.1, but for the purposes of this research that is not sufficient. To understand *route selection activity* as actually practiced at RPA is to understand the *route selection activities of RPA senior management* across all phases AND to understand the *route selection activities of the transport planning department* in phases one and two AND to understand the *route selection support activities of the RPA information system*.

Table 4.1 RPA light rail project phases and major steps in the project process	
Phase	Step
1. Identify route option	Scheme Generation
	Feasibility
	Route identification
	Initial Route Appraisal
	Public Consultation of Route Options
	Detailed Route Appraisal

Table 4.1 RPA light rail project phases and major steps in the project process	
Phase	Step
2. Route selection	Route Selection (Emerging Preferred Route Corridor)
3. Line and stop design	Outline Design
	Outline Business Case
	Reference Design, Railway Order and Environmental Impact Study
4. Build and operate permission	Oral Hearing and Railway Order approval
5. Construction	Final Business Case
	Procurement
	Construction Supervision and Sign-Off
6. Daily operation	Operational Supervision

The understanding of the route selection activity at RPA presented here is used in the next sections to interpret the data collected on RPA route selection *practice* in the records and reports of the three RPA extension projects investigated.

4.3 Line C1. Docklands the first RPA extension project

In this section the three research questions will be answered using data from Line C1. The extension of the Red Line from Connolly to the Point, known as the Docklands extension project or Line C1 is an interesting case from the point of view of route selection. There was strong opposition by a well-financed group of property owners to the route proposed by RPA. The line was to extend the Red line from Connolly station into the developing docklands in Dublin to a terminus at the Point theatre. The line would go through the 'International Financial Services Centre' (IFSC) and disruption of communication lines during the construction period was a concern to the property owners who privately financed the elaboration of an alternative route proposal. Once the organization (RPA), the activity (route selection), and the actual project (Line C1) were selected, the next step in the investigation was to collect data at both the strategic and operational levels and from an information systems point of view (Table 3.10). Relevant data was found in the organization's documents and supplemented by interviews of top management and operational staff and by observation, which took the form of two route selection workshops and presentations by the IT department of the organizations information systems relevant to route selection. For Line C1, an important source of data was a report by management to the board on lessons learned from the project and the supporting operational reports. The data collected was analyzed using the conceptual framework developed in Chapter 2 and the methodology and analytic tools developed in Chapter 3. The results of the analysis were presented to RPA management for validation and triangulated with expert opinion and public domain information.

4.3.1 Line C1. Representing, assessing, and improving route selection

The first research question asks how experienced organizations represent, assess and improve their performance and learning (Table 3.1). This question is answered first for the strategic level, then for the operational level and finally for the information systems level.

The strategic level

At the strategic level, the route selection activity was represented and assessed by RPA as a report by top management to the board of directors on the 27 October 2011. The report entitled “Luas Docklands (Line C1) Lessons Learned” is an RPA effort to improve performance by leveraging lessons learned from one project to the next. The Board Paper was the culmination of a formal review process that involved 80 staff at RPA. The RPA Director of Operations (DO) who is an expert in light rail and a member of the International Light Rail Organization prepared the document, which narrates the story of the project at a high level and in nontechnical language, concentrating on items likely to be of interest to Board members. The report is structured around seven classic project management themes: project definition, program (time), cost, quality, funding, risk, and governance. The story follows the broad chronology of the project, which was broken down into four phases; Phase 1: from initial route selection to an application for a railway order (RO), Phase 2: from the lodgment of a RO to the granting of an enforceable order, Phase 3: from preparing tender documentation to the commencement of construction, and Phase 4: from commencement of construction to introduction of passenger services. Emphasis is on what was done, assessing the outcome, and drawing lessons for the future.

Twenty-five items are highlighted in the original memo³ and analyzed using the conceptual framework developed in Chapter 2. To facilitate the discussion, the original document was transposed into tabular form as shown in Table 4.2. The tabular representation shows that the ideas of ‘situation’ and ‘action’ are clearly separated in the minds of RPA managers, as are those of ‘evaluation’ and ‘lesson learned’. The first column indicates the reference number used to maintain the chain of evidence to the redacted original document in Appendix 1, the second column shows situations, the third column shows RPA actions in the given situation, the fourth column shows top management’s assessment of the actual performance and the last column shows top management’s representation of lessons learned.

³ cf. Appendix 1 for a redacted version of the original document

Table 4.2 Line C1. Strategic <i>lessons learned</i> as represented by RPA (cf. Appendix 1)				
N°	Situations	RPA Actions	Performance assessments	Lessons Learned
1	Is C1 an extension or a modification of the Red line?	"Line C1 was developed as an extension-modification of the Red Line using a delta junction at Busaras"	"Line C1 is a success project as it was delivered within time and budget and to a high standard"	"There are significant risks attached to building light rail in city centers and the budget and proposed program should make an adequate provision for these risks"
2	How long should the phases of the C1 project be?	"Actual time was 61 months for Phases 1, 2 and 3 and 31 months for construction (phase 4)"	"Time allocated to phases 1, 2 and 3 has been very optimistic"	"The greatest scope for time savings in any project of this type relates to the time devoted to the Phases 1, 2 and 3"
3	How much time should be spent dealing with issues raised by stakeholders?	"Delay and extra cost incurred to deal with stakeholder issues reduced the risk of making an application which might not be successful"	The balance between extra delay and cost v. reduced risk were right	"Any program for phase 1 activities should have a large provision to allow for delays arising from issues raised by stakeholders"
4	Preparation & presentation to the statutory approval authority?	"This phase 2 is largely outside the control of the RPA"	"RO granted and conditions imposed did not create any major problem for RPA"	"Understand and adapt to the statutory approval process of the approving authority"
5	Support for Luas projects from local authorities?	"Both DCC and DDDA were very supportive of Line C1 at the oral hearing"	"There was a lot of discussion in relation to the detail of the application"	"A Luas type project should allow for the time taken to reach a consensus with the relevant local authorities"
6	Running phase 3 in parallel with phase 1 and phase 2?	"Time savings for C1 of 24 months but increased risk"	"Was balance right between time savings and risk of extra costs?"	"The greatest scope for time savings in any project of this type relates to the time devoted to the Phases 1, 2 and 3"
7	Separating contracts?	"Separate contract for utilities diversion and start track design later"	"Was allowing track design start later right?"	"Consider the effect on the program of contract strategy"
8	Starting design before statutory approval?	"Initial concern not to commit resources before statutory approval led to tight time scales for design"	Initial concern was unfounded	"We could have commenced the design of the main contract earlier to avoid tight time scales and extra costs due to changes at construction"
9	Contractual trial running period?	"Allowed access for testing to Veolia while some construction activity was taking place"	"Achieved the targeted opening date"	"Extra costs arose to meet the program objective"

Table 4.2 Line C1. Strategic <i>lessons learned</i> as represented by RPA (cf. Appendix 1)				
N°	Situations	RPA Actions	Performance assessments	Lessons Learned
10	Contracts for infrastructure?	"There were significant differences between the tendered prices of contracts and the final outturn costs"	"The project scope as defined in the FBC was delivered well within budget and this is a very satisfactory result"	"Separate contracts allowed RPA to manage the interfaces in view of opening the line in December 2009 as planned although with higher costs for some contracts"
11	Rolling Stock contract?	"Procured rolling stock for four projects under one contract"	"Rolling Stock was provided to the Line C1 project within budget and without interface problems with construction"	"This worked very well"
12	B r i d g e contracts?	"Works on two bridges were required. Procured as two separate contracts"	"Modification of George's Dock bridge was on the critical path due to its location and the track-work was installed by the bridge contractor"	"Extra costs arose to meet the program objective"
13	New bridge over Spencer Dock?	"The design approved at the railway order was changed at the request of new personnel within the DDDA"	"There were no major interface issues with other contracts that led to increased costs and the contract was well managed by RPA. The design won 2 architectural awards"	"Design changes close to procurement stages of a project will lead to extra costs and should be avoided if possible"
14	U t i l i t i e s diversion contract?	"A FIDIC red book re-measurable form of contract for utilities diversion was settled for €x"	"This is a significant increase over the tendered sum of €y million"	"Contracts for the diversion of utilities should have a large risk figure attached to them allowing for the form of contract used"
15	U t i l i t i e s diversion?	"FIDIC red book re-measurable"	"It is highly unlikely that it is possible to transfer all the risk associated with utility diversions to contractors"	"A form of contract that incentivizes efficient working between client and contractor and recognizes the risks involved might be a better approach for utility diversions"

Table 4.2 Line C1. Strategic <i>lessons learned</i> as represented by RPA (cf. Appendix 1)				
N°	Situations	RPA Actions	Performance assessments	Lessons Learned
16	A g r e e d property acquisitions?	"Acquisition by agreement - Land situated at the Point stop owned by XYZ was acquired for €x million and works estimated at €y million that escalated due to discovery of contaminated land"	"Linkage by XYZ of their agreement with RPA to the agreement between RPA and ABC led to increased costs for mobilization and demobilization of a contractor"	"Where it is not intended to use the CPO process an agreement should be reached, if possible, with the landowner before lodging of an RO"
17	Consider cost for other property issues?	Access land controlled by DEF but owned by the CIE proved contentious and CIE threatened legal action	"The crisis caused for RPA by CIE's threat of legal action had major program and financial consequences for RPA and the project"	"Endeavors to get Department of Transport assistance were of no avail and a license agreement was signed with CIE"
18	Property to be acquired by CPO?	"Acquisition by Compulsory Purchase Order (CPO) of ABC land would have been too costly and was rejected by RPA as an option"	"The FBC figure of €x million for CPO of ABC land based on estimate by property advisors was much less than the compensation sought by ABC"	"Check that estimates by property advisors allow for all costs that could arise in a CPO process"
19	Supply of Special Track-work for Connolly delta?	"A contract was signed with a supplier in advance of the main infrastructure contract due to long lead times"	"There were some issues with the material related to insulation which contributed to extra costs"	"RPA should avoid supplying complex material to contractors for incorporation into the works within a tight timeframe"
20	C o n t r o l Systems?	"The system element was included as a variation in the scope of works of the systems and infrastructure contractor for line B1"	"This contract strategy did work however design changes were required during construction of the infrastructure contract which increased costs"	"The contractor is in a good position commercially unless the scope of work is well defined in the initial tender. Input from a systems contractor should be included in the infrastructure contract before it is issued for tender"
21	M a i n Infrastructure Contract?	"The final account agreed of €x million was a significant increase over the initial tendered sum of €y million"	"We valued the contract at €w million against a claim of €z million from the contractor"	"Laying light rail in a street environment where access to the site is severely restricted has a lot of risk attached to it"

Table 4.2 Line C1. Strategic <i>lessons learned</i> as represented by RPA (cf. Appendix 1)				
N°	Situations	RPA Actions	Performance assessments	Lessons Learned
22	The transport system?	"The systems primary objective of delivering public transport safely and reliably was achieved"	"All the passenger information system and operating systems were available on opening day ..."	"The system has operated safely since it commenced operations in dec 2009. A high quality of finish was achieved. The complex control arrangements for the Connolly delta operated very well"
23	Levies and contributions?	"Levy money received to date is €6.1 million and direct contribution is €3.25 million"	"The FBC envisaged the receipt levy contributions of €15.2 million at 2005 prices and €3.25 million in direct contributions"	"2011 census growth confirms the density of population is at a level that fully justifies investment in light rail. The close integration of land use and transport planning is one of the major achievements of the project"
24	Risks and cost provision for contingency?	"New RPA project management procedures were used for the first time with line item risks identified and costed and a provision for contingency to cover unknown items reserved for the board"	"Achieved a correct balance allowing project management get on with day to day management while an oversight is maintained by the board"	"One could imagine a credible scenario where it would have been necessary to use some of the reserved contingency"
25	Project team and reporting?	"The Board needs assurance that the budget, program and quality are being delivered. This depends on the quality of the project team and on the reports produced"	"From early on in the project there was a high level of confidence in delivering the project within budget but there was a concern about the program"	"NTA project management procedures requiring RPA to seek approval to issue variations may reduce RPA's effective control of the project"

The results from prior literature on *practice-based organizational learning and performance improvement* (Table 2.18) are now used to analyze the data in Table 4.2 in terms of *representing*, *transforming*, and *using* practice-based organizational knowledge. Four formally different types of representation used in the Board Paper are presented in the columns of Table 4.2 under the headings *situations*, *RPA actions*, *performance assessments*, and *lessons learned*. In the following section, the role of each of the four representation types in practice-based organizational learning and performance improvement is discussed and it is shown how Table 4.2 is transposed into the Contextual-Graphs representation formalism.

Representing practice-based organizational knowledge: The first type of representation, *situations*, expresses the elements of the environment interpreted by RPA top-management, at the time of their emergence, as bearing on the unfolding activity of route selection for the first extension project, the Luas Docklands extension, known as Line C1. These elements are shown with a question mark as is the convention for contextual elements⁴ to indicate that the specific value must be added. In the original RPA representation, the Board paper (cf. Appendix 1), the value is specified in the informal description of the *situation*. The *situation* as actually represented by RPA is not formalized as the *value* of a *contextual element* since RPA did not use the Contextual-Graphs representation formalism to present the project review to the board. Nevertheless, dialogue with RPA management arrived at an objective determination of how the RPA documents should be transposed into contextual graphs.

For example, situation n° 1: poses the question “Is C1 an extension or a modification of the Red line?” According to the narrative in the Board paper, the first question that arose concerned the very definition of the project. Because the terminus of the Red line at Connolly Station is at the end of an ‘L’ from the penultimate stop at Busaras, and because both these stops are a close walking distance to each other, it was considered possible to drop the Connolly stop and continue in a straight line towards the Docklands. This option would constitute a *modification* of the existing line as opposed to an *extension*. Since alternative ways of realizing the activity of route selection emerge in the *situation*, it can be represented by a contextual element that draws attention to the specific circumstances that determine which course of action was followed.

Since, representation is under an aspect (Searle, 2004), the name given to the contextual element is chosen bearing in mind the aspect to which attention is being drawn and the purpose of the representation. Most situations have political, economic, socio-cultural, and technological aspects. The situation described in the previous paragraph, involved a first decision by a new Board of directors and for that very reason was eminently political. Likewise, the situation could have been presented under an economic aspect as, for example, a trade-off of the lifetime

⁴ Contextual elements are placeholders that *denote* the elements of the situation but must be given the specific value that depends on the particular circumstances in order to *refer* to the actual situation

cost (investment and operating costs) versus the benefits of time saved by passengers, evaluated using some measure of the value of time. Or, the socio-cultural aspect of the situation could have drawn attention, for example, to the trade-offs between public transport and, say, health or education. Finally, the technological aspect could have emphasized the delta junction's possibilities of opening up different operating patterns in the transport system.

Since the explicitly stated purpose of the original representation, the Line C1 Board paper (Appendix 1) is to support organizational learning and performance improvement at RPA, the aspects interpreted as having most learning value were those that were actually emphasized. This is captured by labeling the CE 'project type?', where the variable project type has three possible values, viz., 'simple extension project', 'project with opportunities for operating modification of the existing system' or 'project with both extension and modification dimensions'. In this way, RPA is drawing attention to the fact that extension projects can present interesting possibilities for modification that should be considered in future projects.

The second representation type in Table 4.2, *actions*, reflects RPA top-management's interpretation of what the organization actually did as the activity of route selection for Line C1 unfolded. For example, action n° 1: "Install a delta junction" is a strategic decision with long-term implications for the operation of the line. The delta junction allow trams passing the Busaras stop either to go left to Connolly Station or to continue in a straight line to the Point. In daily operations, trams from the Tallaght terminus go either to Connolly Station or to the Point, but there is no service from Connolly to the Point. The decision effectively made Line C1 both an extension to and a modification of the existing Red Line.

The action referred to at top-management level is the strategic decision, the authorization to proceed with the delta junction plan, and this action ultimately finds expression in the physical realization of the actual delta junction. This highlights the fact that strategic and operational actions are just different interpretations of the very realization of the activity, different expressions of the practice of route selection activity appropriate to different levels of responsibility in the organization. The organization realized the new route through the actions of both top-management and operations management. The actions of operatives in the field (whether of RPA or sub-contractors or consultants) are outside the focus of

attention and not represented here. Note, what is represented as *actions* of management corresponds exactly to the definition of *action* in the sense of activity theory (Leontiev, 1978). Management *operations* in the sense of activity theory are by definition outside the focus of attention and are not represented.

The third representation type in the Board Paper, namely, *performance assessments* is represented in the document under aspects of practices. Each *performance assessment* draws attention to an aspect of a practice (cf. Section 3.3.7.1). Performance assessment N° 1 "Line C1 is a success project as it was delivered within time and budget and to a high standard" draws attention to the generic performance indicators of project management; namely, time, cost, and quality. The difference between an aspect of a practice and a performance indicator is the *ex post* nature of the former and the *ex ante* nature of the latter. The *ex ante* selection of indicators of performance presupposes a detailed level of knowledge that is unwarranted in many design projects where management activities converge on an emerging realization (Fig. 2.13). In the case of RPA, successive estimates of cost, time, and quality are prepared at different phases of the project and the Lessons learned memo refers to the Final Business Case in which the key variables including cost and time are based on negotiated procurement contracts. While it is interesting that there was no divergence during the construction period, it makes little sense to compare the outcome to an initial ballpark estimate made before the actual route was selected. *Aspectual comparison of practices* is the foundation stone of practice-based *performance assessment*.

Finally, the fourth type of representation, *lessons learned* are guides to be followed in future by RPA staff when confronted with similar problems. The fact that Line C1 can be characterized as an extension/modification is just that, a fact, but the emergence of the possibility of seeing extension project situations as possibilities for modification of the existing system is a *lesson learned* that the organization wants to retain. The *lesson learned* is an abstraction from the details of the specific situation of Line C1. Using the *practice-based organizational learning novelty typology* (Figure 3.4), this particular lesson can be characterized as a new practice (using a delta junction) in a new situation (in a modification-extension type of project). The fact that new practices are emerging and available for future is an indication of increasing practice maturity for the activity of route selection. The

practice maturity model (Figure 3.5) can be used to formally monitor the associated *practice-based organizational learning and performance improvement*. Practice-based performance improvement occurs when exploiting lessons learned from experience leads to improved practice maturity (Section 2.7.1, thesis stated in long-form). As evoked in the Board Paper, Lessons learned N° 1 "There are significant risks attached to building light rail in city centers and the budget and proposed program should make an adequate provision for these risks" is not linked operationally to the question of extension v. modification. Lessons learned that are too general are not easily re-contextualized, in this case there is no indication of how to determine what is an 'adequate provision.'

The formal approach to *lessons learned* advocated in this thesis is practice-based and suggests that *lessons learned* are de-contextualizations of associations of *actions* and specific *situations* (Figure 1.2). The nature of de-contextualization is abstraction away from the details of a specific situation, but those details must exist for there to be practice-based learning.

An example of how situations in Table 4.2 are transposed into a contextual graph (CxG) is illustrated in Figure 4.2 using the *utilities contract* issue⁵. Items 14 and 15 in Table 4.2 highlight two issues related to RPA utilities contracting as part of the route selection activity for Line C1. First, is the question of whether there should be a separate contract for utilities and second, is the question of which type of contract should be used. In Figure 4.2, contextual elements (CEs) are represented in the CxG as nodes in the form of circles; the two issues are represented by the circles numbered '14' and '15' respectively. The specific value of each contextual element appears in the contextual graph as a branch linking the contextual element node to an another node. In the case illustrated, both CEs are bi-valent with possible values 'yes' or 'no'. RPA experience on Line C1 is summed up in the path shown from CE₁₄ through CE₁₅ to A₁₄. The *action* of fixing the risk provision at the amount 'A' is directly linked to a situation, interpreted as it evolved by RPA top management as warranting a separate utilities contract in a re-measurable form⁶.

⁵ Other aspects of the graph are illustrated in a paper (Hegarty, Brézillon, & Adam 2012a) presented at DSS 2012 by the author and for convenience included in the dissertation as Appendix 4.

⁶ The FIDIC (International Federation of Consulting Engineers) red book standard contract type is a re-measurable contract in which the actual payment to the contractor depends on the work as measured after execution

Whether that was right is the subject of the next column in Table 4.2 that shows how RPA management assessed the outcomes of its actions. (In fact X, the settled amount was greater than the tender amount Y plus the risk provision A).

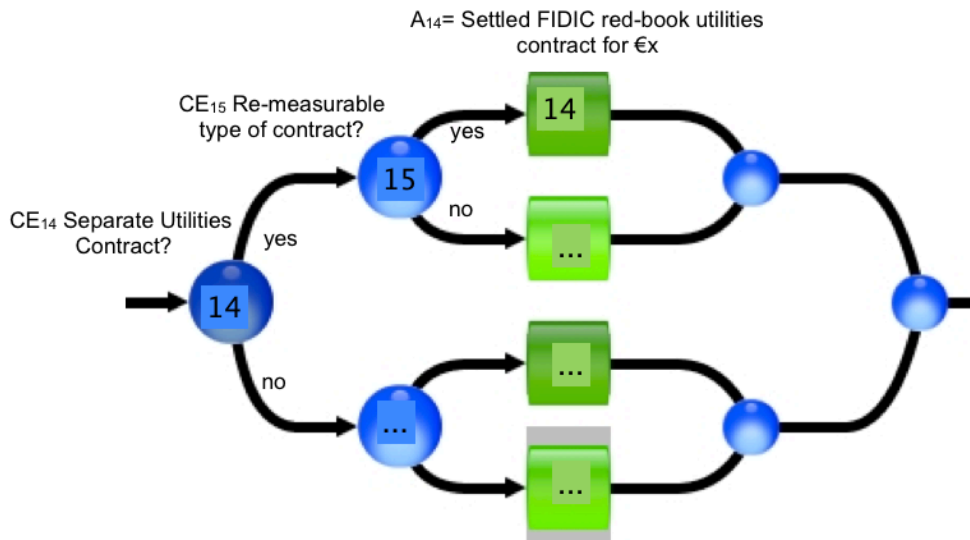


Figure 4.2 Example of a contextual graph for the 'utilities risk contingency' (cf. Table 4.2)

Transforming practice-based organizational knowledge: At RPA, the contextualizing management activities evoked in Table 2.19 and illustrated in Figure 2.13, are divided between top-management and operational management. RPA senior management focuses on *situation assessment* and *decision-making* and RPA operational management focuses on *problem solving* and *implementing* issues. For example, the situation assessment extension/modification by top management depends on having the option of the delta junction worked out by operational management (Line 1, Table 4.2). Similarly, the settlement of the utilities contract by operational management depended on the authorizing decision of top management (Lines 14 and 15, Table 4.2). The segregation of responsibilities is an organizational solution to the problem of increasing complexity and scope of activity. While practice is the basic unit of analysis, it must be specified who's practice. Practice is represented as the practice of an activity by a practitioner with a given role or responsibility level. Therefore there are different representations for the strategic and operational levels. Practice-based organizational learning and improvement has different content depending on the level. The de-contextualizing

management activities evoked in Table 2.19, viz., *representing practices* and *abstracting lessons learned* at RPA senior management level are the key to understanding practice-based double-loop learning (Argyris & Schon, 1978) in the organization.

Using practice-based organizational knowledge: *Situation assessment* and *decision making*, *representing practices*, and *abstracting lessons learned* at RPA senior management level are constrained by *integrity rules* and *inference rules* governing the felicitous use of practice-based organizational learning (Table 2.18). These rules find expression in RPA management's discrimination between situation and activity. Understanding how practitioners represent situated action is to understand the role of context in practice-based organizational learning and improvement. Table 4.2 was used by the researcher together with the *practice-based learning novelty typology* as a tool to elicit the reasoning behind the RPA interpretation of situations and actions as being new and worthy of retention in abstract form as lessons learned for future use.

Results

The above analysis of the representation, assessment, and improvement of route selection practice by RPA senior management leads to six results. The first result concerns the characterization of an item as strategic. Items that went to the board for decision or information were considered strategic by the Director of Operations (DO), who consulted the minutes of all board meetings to identify any such items related to Line C1. In addition the DO included items that did not make it to previous board minutes but that struck him as examples of best practice, worthy of retention for future projects. Together the *lessons learned* constitute a list of questions that a board member should ask when confronted with a new light rail project. In other words, it is the fact that a high level authorization was required, explicitly or implicitly, that determined that an *action* was classified as strategic (cf. interview with DO).

The second result concerns the relationship between the political-strategic and the tactical-operational levels. Items identified as *lessons learned* at the strategic level referred to *action* expressed at the operational level and a strategic choice between alternative ways of realizing an activity. The *situation* at the strategic level emerged from the possible solutions at the tactical-operational level. In other

words, the options generated by alternative solutions developed at the tactical-operational level provided material for strategic decision-making and once the decision was made, responsibility for the implementation of the selected option was transferred back to the tactical-operational level. The story narrated at the strategic level does not go into the tactical-operational detail but the *action* constituting the strategy is ultimately expressed operationally. In the case of Line C1, the Board Paper, which focuses on the strategic situation, is complemented by separate reports on the *lessons learned* at the operations level. This result echoes the link between double-loop learning viewed as feedback to review governing values and single-loop learning viewed as feedback to review action strategies (Argyris & Schön, 1978)

The third result concerns the delimitation of the route selection activity. Actions that led to lessons learned relevant to the route selection activity in future projects were sometimes downstream from the formally identified route selection activity. In other words, the route was not fully selected until the line was built. Hence, all 25 items identified in the Board Paper bear reasonably directly on the route selection activity (cf. interview with CEO 'route selection is absolutely mission critical for RPA').

The fourth result concerns the tacit nature of route selection domain knowledge. The dialogue between *situation assessment* at the strategic level and, *problem solving* and experience at the operational level emerged in large part from tacit domain knowledge in the heads of the participants of the dialogue (cf. interview with the DO 'you wouldn't put a tramway down Grafton Street⁷ would you?').

The fifth result concerns the nature of practice-based organizational learning. Analysis of the Board Paper shows that reporting lessons learned can be viewed as an exercise in externalizing the elements of the tacit knowledge that enabled the recognition of a *situation* requiring action in the first place (column 2 in Table 4.2), linking them to the *actions* actually taken (column 3 in Table 4.2), assessing performance of the actions in the given specific situation (column 4 in Table 4.3) and *abstracting lessons learned* from the details of the specific situation, rules for behavior in similar situations in future (column 5 in Table 4.3). This is the process of contextualization of *problems* (generic situations requiring action) into *practices*

⁷ Grafton Street is one of Dublin's main pedestrian shopping streets.

(actual actions in a specific situation) and de-contextualization of *practices* into *procedures* (generic rules for dealing with new occurrences of the same type of problem) whose re-contextualization in new situations leads to *practice maturity* that explains *practice-based organizational learning and performance improvement* according to the thesis presented here (Figure 2.14).

The sixth result concerns the unfolding of the route selection activity over time. The case studied unfolded over time in a structured manner either sequentially or in parallel action groups and can therefore be represented in a contextual graph (cf. interview with DO). In a previous research paper (Hegarty, Brézillon, Adam, 2012a), included here as Appendix 1bis, this structure was presented in a simplified form with *actions* giving rise to *lessons learned* grouped according to their implications into seven strategic activities, namely defining the project, setting governance objectives, setting program (time) objectives, setting risk and contingency objectives, setting cost objectives, setting quality objectives, and setting funding objectives. These purely analytic strategic activities and the implied structure are better replaced by *a single route selection activity reflecting directly the evolving focus of attention of RPA management on the items in Table 4.2*. The central role in practice-based organizational learning of the evolving focus of attention is an expression of Polanyi's interpretation of attention as holding tacit and explicit knowledge together (Polanyi, 1966).

Operational level

At the operational level, the route selection activity was represented and assessed by RPA in the 'Lines A1, B1, C1 Post Completion Review Report' issued 8th July 2011. This report was compiled as part of a project review process aimed at continuous performance improvement. A lessons-learned coordinator was appointed to manage the overall process, which involved 80 RPA staff and included five lessons learned workshops organized by functional expertise. The methodology followed the prescriptions of the relevant procedures at RPA including applicable Irish government guidelines and National Transport Authority (NTA) instructions.⁸ Criteria used to evaluate the success of the projects were business

⁸ RPA *Project Management Procedures*, National Transport Authority *Cost Management Guidelines for Public Transport Investment Projects* and Irish Government Department of Finance *Capital Works Management Frameworks (CWMF) – Guidance note GN 4.1 Project review on completion*.

objectives, technical performance requirements, and measurable key performance indicators such as cost, time, quality, experience etc.

The output included:

- a business case review comparing assumptions with outcomes on patronage, scope, financing, procurement strategy, capital and operating costs, delivery time, and risk;
- a review of the performance of RPA-provided services to the projects including safety, PR/communications, human resources, quality, and environment;
- a review of the performance of contractors and consultants engaged by RPA in the realization of the project; and
- a lessons learned log and summary report formalizing the output of the five RPA departmental workshops to compile lessons learned by function.

The lessons learned log identified 384 line items for the three extension projects Line C1, Line B1, and Line A1. Each line associates a 'lesson learned' with a 'driver event' and a 'recommendation' and is situated by functional area of responsibility (systems design, commercial, financial, risk, architectural, planning, etc.) and by phase of the project (planning and railway order, design and contract preparation, procurement, and execution). Two of the lessons learned specifically associated with Line C1 in the planning and railway order phase are presented in Table 4.3 as exemplars of how the organization represents and assesses its route selection activity at the operational level.

Table 4.3 Line C1. Operational <i>lessons learned</i> (source RPA Lessons Learned Log)				
N°	Situations	Actions	Performance assessments	Lessons Learned
379	Is there sufficient time between completion of final OCS design and start of installation works?	Legal challenge to service of Statutory Notices	The timescale was too short	A greater gap would have provided more time to deal with issues arising from the service of Statutory Notices and might have avoided legal challenge
381	Are objections from business interests significant?	No agreement was signed with DDDA, which resulted in DDDA not fully supporting Luas at meetings with third parties.	Objections were underestimated and 1 year was lost	Engagement locally neutralized opposition but RPA did this too late. Lack of formal agreement with DDDA compounded this.

The results from prior literature on *practice-based organizational learning and performance improvement* (Table 2.18) are now used to analyze the data in Table 4.3 in terms of *representing, transforming, and using* practice-based organizational knowledge.

Representing practice-based organizational knowledge: Four types of representation used in the Lessons Learned Log are relevant to the thesis of organizational learning defended in this dissertation and these are reflected in the column headings of Table 4.4. The first type of representation, 'situations or decisions' reflects the fact that in the Lessons Learned Log, RPA represented the problem of Luas Docklands at the operational level as a series of 'driver events' situated in time (the project phase) and in an operational domain of knowledge (calling for attention from experts in the domain cited, here 'planning'). Thus, Situation N° 379: "Timescale between completion of final OCS design and start of installation works" is a question that arises during the planning and railway order phase for a planning expert who must avoid legal challenges to statutory notices issued before installation work begins. The second type of representation characterizes the action in the specific situation as illustrated by Action N° 379: "[Deal with] legal challenge to service of Statutory Notices". The third type of representation qualifies the practice (action in the given specific situation) in terms of an aspect perceived as relevant, for example time, in the case of Evaluation N° 379: "The timescale was too short". Finally, the fourth type of representation abstracts from the specific situation what was learned from the experience, for example in Lesson learned N° 379: "A greater gap would have provided more time to deal with issues arising from the service of Statutory Notices and might have avoided legal challenge". In the original lessons learned log, the lesson learned is associated with a recommendation for improvement but this is not included in Table 4.4, which focuses on learning in the strict sense and not on improvement (Fiol & Lyles, 1985).

Transforming practice-based organizational knowledge: The contextualizing RPA operating management activities that transformed the problem posed by route selection for Line C1 into the practice represented in the *situations* and *actions* of Table 4.3 were *problem solving* and *implementing*. The de-contextualizing RPA operating management activities that transformed the practice of route selection in

the case of Line C1 into the *performance assessments* and *lessons learned* in Table 4.3 were *representing practice* and *abstracting lessons learned*.

Using practice-based organizational knowledge: *Problem solving* and *implementing* activity were constrained on the one hand by the objectives set by top-management and on the other hand by the technology deployed, in other words the ways and means of solving the specific problem (Table 2.18). The researcher was able to discover in interviews with the staff of the transport planning department at RPA and in a research workshop on route selection with the current and past heads of transport planning how the coherence and appropriateness constraints materialized in the route selection activity at operational level: the preferred route among feasible alternatives was selected from the possible alternatives on the basis of a multi-criteria analysis using acceptable threshold levels for each criteria imposed by top-management objectives (rather than combining criteria weighted by relative importance), and the feasible alternative routes emerged by eliminating stretches from theoretically possible routes using domain knowledge (about appropriate technology). The above analysis of the representation, assessment and improvement at the operational level of the complex activity of route selection leads to nine results.

Results

The first result is that the route selection activity at the operational level was constrained by the route selection activity at the strategic level on the one hand and by the technology deployed on the other hand. This result is compatible with the activity theory interpretation of the relationship between activity, action and operations; activity is the context of action and action is expressed as operations embodied in technology (implements) (Leontief, 1978; Nardi, 1996; Karpatschof, 2000). It is also compatible with the view that skill-based, rule-based, and knowledge-based human behavior differ essentially in their representation of constraints as signals, signs, and symbols, respectively (Rasmussen, 1983).

The second result is that lessons learned at the operational level were closely related to a function that expresses knowledge of a particular domain and at the same time expands the domain knowledge. Thus, route selection activity at the operational level expresses and expands transport-planning knowledge. This result is compatible with the unified design theory that distinguishes *concepts* from

knowledge and sees *design* as “a mapping between the function space and the attribute space” combined with “a simultaneous knowledge expansion process” (Hatchuel & Weil, 2003).

The third result is that lessons learned at the operational level were closely related to a phase in the unfolding of a project. Thus, route selection activity at the operational level is essentially limited to the planning and railway order phase. The result that learning is related to a project is compatible with the idea that action precedes cognition expressed in the theory of enacted sense making (Weick, 1988), that knowing comes from doing (Pfeffer & Sutton, 2000), and that objects of attention emerge from breakdowns in activity (Ciborra, 2006).

The fourth result is that practice-based learning at the operational level exhibited the same structure as at the strategic level; it is a process of contextualization of problems into practices and de-contextualization of practices into procedures (Figure 1.2); Table 4.3, which formalizes operational lessons learned, has the same structure as Table 4.2, which formalizes strategic lessons learned.

The fifth result is that problems preceded practice-based learning as *situations* calling for *action* or a decision among which actions to take. This result is also compatible with the idea that stimulation as doubt precedes learning (Peirce, 1878); the corollary is that satisfaction with tried practices ultimately undermines the perceived need for exploration (March, 1991a).

The sixth result is that *doing* preceded *practice-based organizational learning*. *Doing* in Table 4.4 covers doing actions, doing in response to events, and doing with the purpose of achieving stated outcomes; in other words events are replaced by the actions to deal with them (control actions) and outcomes are replaced by the actions to realize the outcome. Since the representation of practice, here, is after the fact, the problematic anticipation of events and outcomes is avoided (Savage, 1954; Pomerol & Adam, 2008); what counts in practice-based learning is realized action, i.e. what is done.

The seventh result is that *learning* required distinguishing between *action* and *situation*. This result is compatible with the view that the utility of context comes from the possibility of transference of tried behavior from a learning situation to a new application situation; context is an abstraction of the features that are not

explicitly included in the learning model but used in the recognition of its applicability (Edmonds, 2002). Here, practice is defined as effective action in a situation.

The eighth result is that *performance assessment* preceded *learning*. *Performance assessment* in the case of Line C1 was based on multi-criteria analysis with minimum acceptable thresholds. Since practice by definition is effective, the question of evaluation arose only when more than one way of doing existed, and then only as comparison of the effective practices using one of the criteria. This result is compatible with the idea that representation is always under an aspect (Searle, 2004). Aspectual comparison of practices is an open approach to evaluation that avoids the problematic assumption of causality behind the a priori definition of Key Performance Indicators (KPI) associated with the Balanced Scorecard (Kaplan & Norton, 2001; Talbot, 2010).

The ninth result is that the continuous improvement process at RPA consisted of making available to members of the organization the lessons learned from experience either as actual practices in the post completion review report or as updated procedures incorporating the recommendations that emerged from the review process. This result is compatible with the view of organizational learning as a transformation of organizational codes (March, 1991a).

Information systems level

At the information systems level, the route selection activity of Line C1 was represented and assessed as project specific records and reports in divers technical project documentation systems and the financial accounting systems at RPA. At the time of the research, RPA was engaged in a project to improve accessibility to project data based on contextualization of technical data using organization-wide standardized meta-data. As part of this project, departments within RPA were required to formalize their activities in process flowcharts identifying key documents (data sets) and the associated meta-data. Interviews with IS operational management and the director in charge can be summarized as follows:

The first result is that context is perceived as meta-data associated with technical and financial data.

The second result is that the recording and reporting of data were perceived as serving operational purposes and safeguarding an audit trail but not as designed to support organizational learning.

4.3.2 Line C1. Issues confronting RPA in leveraging lessons learned

The second research question asks what issues confront RPA in leveraging lessons learned from its experience in practicing route selection. The subsidiary questions ask how RPA ensures the relevance of its route selection activity and how RPA ensures the effectiveness and efficiency of its ways and means of realizing its route selection activity. These are questions of governance and stand in relation to the first research question as double-loop learning to single-loop learning (Argyris & Schön, 1978). *Practice-based organizational learning and performance improvement* is ultimately a question of governance.

Interviews with management identified three issues that confront RPA in representing, assessing, and improving the route selection activity. The first issue is the perceived difficulty of formally representing actual practice and in particular of representing the circumstances that bear on decisions and actions at the right level of granularity. In interviews with the researcher, management advanced three explanations for this difficulty. First, it seemed to management that hindsight was required to identify noteworthy practices since at the time of a decision it was not always clear that the action being taken would lead to a lesson worth noting. Second, it was not obvious to management how to motivate individuals who learn lessons to record them for the benefit of the organization, since busy individuals when they find a solution to a pressing problem naturally tend to move on to the next problem. Third, it was not clear to management how to formalize the description of the environment in which the action was taking place without generating much useless information and drowning the essence of the situation in a sea of background data that was too voluminous to be exploited by future users.

The second issue is the perceived difficulty of formalizing the assessment of the route selection activity as opposed to the perceived outcomes of the activity. Management noted that route selection involves finding an acceptable specific solution to a problem posed in very general terms in a land-use and transportation

strategy that is part of a political program. Ballpark estimates of key project criteria of cost, quality, and time, used to narrow down the initial wish list are based on analogy with past similar projects and do not represent a stable baseline as the scope of the project, and the risk appetite and priorities of the project sponsor evolve. This difficulty is compounded by the fact that in the case of RPA, the Irish government is ultimately the project sponsor and so the project sponsor changes with each change of government, as happened recently, with the consequent shelving of some projects for which route selection had been completed and indefinite postponement of others 'until economic circumstances are more favorable'. In practice then at RPA, assessment is based on the so-called Final Business Case (FBC), which is a baseline produced after planning permission is secured by the railway order and the costs are secured by the negotiated procurement contracts. The outcome of the project is compared to the FBC using the classic criteria of project management as detailed in the relevant procedures (cf. footnote on p.112). This leaves unanswered the difficult question of how to assess the activity that resulted in the FBC.

The third issue identified by management as problematic is how to effectively transfer learning from one project to another. Part of the answer is to retain experienced members of a successful team but management noted that this only postpones the problem in the case of the most successful experienced managers until their retirement. Part of the answer is the formalization of best practices as procedures but management pointed out that much of the learning concerns the ability to recognize specific circumstances where the procedures do not apply and there is a danger that newcomers will apply the procedures out of context; the tradeoff between what to put in the procedure and what to leave out was not obvious to management. Part of the answer is the continuous improvement approach of making available experience as project reviews, but the project review process introduces a further complication as management considered the lessons learned at the strategic and operational levels should use different representation formalisms (Board paper v. lessons learned log with supporting technical reports).

4.3.3 Line C1. Opportunities for CIAS support leveraging lessons learned

The third research question investigates what opportunities there are for RPA to use context-based intelligent assistant support (CIAS) for recording relevant organizational experience in the practice of route selection and for retrieving that experience to improve its performance of the route selection activity. This question is about overcoming the obstacles to *practice-based organizational learning and performance improvement* identified when answering the second research question.

The current representation of practice at RPA does not permit an efficient retrieval of experience. This is evidenced by the very large effort required to produce the Line C1 *lessons learned* documents at both the strategic and operational levels analyzed in Tables 4.2 and 4.3. The current representation lacks formal unity in the representation of knowledge, reasoning, and context. Opportunities therefore exist for context-based intelligent assistant support (CIAS) for route selection at RPA since the CIAS approach is built on the uniform representation of knowledge, reasoning, and context. The first opportunity is to use the Contextual-Graphs representation formalism together with the conceptual framework (Table 2.18 and Table 2.19) to *record situation and action concurrently*. This opportunity exists both for the senior management and the transport planning levels since each has its own contextualizing management activities (Table 2.19). The formalization of the constructs *situation* and *action* necessary for the efficient recording of the practice of route selection also serves the efficient retrieval and reuse of the same experience appropriately contextualized, de-contextualized, or re-contextualized.

Performance assessment at RPA is mainly based on *outcomes assessment* with implicit causal assumptions. This is complemented by the evaluation of the process dimension in the lessons learned process. The improvement in the representation of practice as suggested in the previous paragraph opens up a second opportunity for CIAS support for route selection activity at RPA, namely *support for the selection of performance indicators free of causal assumptions* via aspectual comparison of practices as discussed in Chapter 3 (Section 3.3.6).

RPA does not currently *formally* measure *practice-based organizational learning and performance improvement*. This suggests a third opportunity for CIAS support for route selection, namely *measuring practice-based organizational learning* using contextual graphs and the *practice-based organizational learning novelty typology* presented in Chapter 3 (Figure 3.4). The evolution of contextual graphs over time

directly represents learning when interpreted using the practice-based learning novelty typology.

RPA does not currently *formally* assess *practice maturity* of its route selection activity. This suggests a fourth opportunity to use CIAS support for route selection at RPA to assess *practice maturity* using the *practice maturity model* (Figure 3.5) which in turn can be calibrated by using the *practice-based organizational learning novelty typologies* as a tool for characterizing different levels of practice maturity for the route selection activity. *Practice maturity* can then be used to direct management attention to *activities* with low practice maturity.

4.3.4 Line C1. Summary of results from the first RPA extension project

RPA represented and assessed the route selection activity as practiced on the Docklands extension project at three different levels; the strategic level addressed important issues of concern to board members, the operational level covered all other substantive project issues, and the information systems level addressed the actual records and reports generated concerning the project. The method of representation and assessment, and the approach to continuous improvement followed the same structure at both the strategic and operational levels.

At the strategic level, effective practices were presented as actions responding to situations calling for decision by the Board as the project evolved. Each action was situated in the context of the project baseline assumptions (Final Business Case) and outcomes were evaluated using business and technical objectives, and predetermined key performance indicators. *Lessons learned* as suggestions for future practice were explicitly drawn from the experience gained on the project as part of a continuous improvement process. Five results were derived from the analysis of the data collected at the strategic level. They confirm the validity of the thesis that organizational learning may be usefully viewed as a process of contextualization of problems into practices and de-contextualization of practices into procedures to support future practice when the organization is faced with similar situations.

At the operations level, effective practices were presented as actions responding to situations that arose in a particular project phase and functional knowledge domain. Lessons learned were drawn from the specific experience and recommendations were made for future practice. Nine results were derived from the analysis of the data collected at the operational level. They confirm the usefulness of the model of organizational learning as the transformation through management activities (planning, doing, assessing, and understanding) of organizational codes (representations of situations, objectives, plans, practices, and lessons learned) subject to boundary conditions (coherence of the situation and appropriateness of the action to the situation).

At the information systems level, actual records and reports concerning the project included contextual information as meta-data but the different systems were not designed with organizational learning in mind.

The second research question forms a bridge between the description of *practice-based organizational learning and performance improvement* which was the subject of the first question and the *prescription* of CIAS support for *practice-based organizational learning and performance improvement* which is the subject of the third question. It is *diagnostic* in form and concerns the issues that emerge from the manner in which RPA practices *practice-based organizational learning and performance improvement*. It was found that three issues confronted RPA in its efforts to *leverage lessons learned* from the Line C1 project, viz., recording context at the right level of granularity, assessing activity against an emerging baseline, and reporting experience in the right context.

While these three issues emerge from the investigation of route selection in the case considered, they are relevant to the recording, assessing, and improving of any organizational activity. The importance of these real-world concerns about the very formalization of practice-based organizational learning is a motivation for this thesis. Each of the three points is discussed in this section.

Recording context at the right level of granularity

Context is difficult because of two fundamental problems, one related to *formalization*, the other has to do with *interpretation*. Context is difficult to represent

because it is always relative to another context (McCarthy, 1993) and representations are difficult to interpret because they have many aspects⁹ (Searle, 2004). RPA managers have a deep understanding of the difficulty of recording experience in a re-usable way and this realization motivated RPA interest in the research project from the start. The research helped RPA managers to express formally the difficulty they experienced intuitively. The route selection research workshops with RPA managers used the Contextual-Graphs representation formalism to capture route selection activity as practiced at RPA. Using RPA language for the names of actions, activities, and contextual elements existing RPA documents were transposed into contextual graphs allowing practitioners and researcher to reach a common understanding of the formal differences between *situation*, *action*, *assessment* and *lesson learned*. These four elements of the conceptual framework were then used by RPA managers involved in route selection to express the issues that confront them in *leveraging lessons learned* both at the strategic and at the operational levels of the activity.

Assessing activity against an emerging baseline

A quite different problem that confronts RPA management in leveraging lessons learned is that of the emerging baseline. It is the nature of all design projects that the object is not known in all its specifications until the problem is solved (Hatchuel & Weil, 2003; Polanyi, 1966). Outcomes-based performance assessment needs a baseline to keep track of progress but by the time the baseline is fully specified the project is essentially complete. In the case of RPA, the final business case that serves as the official project baseline is established after negotiations with the sub-contractors. A practice-based approach to performance assessment is done only after the project, in the project review process described in this research. What seems to be missing is a near real-time practice-based approach to performance assessment and this seems to be almost a by-product of the formalization effort suggested in the previous paragraph.

⁹ Searle's notion of aspect of a representation (Searle, 2004) seems to correspond to Dewey's sense of value of an object (Dewey, 1929) and both seem to be measures of reality.

Reporting experience in the right context

RPA managers flagged the danger with systems of recording experience that people unfamiliar with the learning situation might reuse the experience out of context. This is the danger of imputed similarity between cases in Case-based systems of leveraging experience. The CIAS approach does not have this problem as it is open to new contextual elements and new actions at all times. If the situation is new, so too will be the practice but the newness will be recorded in the contextual graph for future reference. The practice maturity model can be used to monitor the practice maturity of activities and direct attention to those with low practice maturity.

The three gaps identified in the previous three paragraphs are at the same time the opportunities for context-based intelligent assistant support (CIAS) for route selection at RPA. During the route selection research workshops RPA managers verified the feasibility of using contextual graphs at both the strategic and operational levels to record practices without getting lost in a sea of irrelevant data. This opens up an opportunity to improve the recording of practice, the assessment of performance, and the leveraging of lessons learned in the organization. The construct of practice maturity represents a unifying theme for these opportunities and it comes together with a toolkit consisting of the *Contextual-Graphs representation formalism*, *aspectual comparison of practices*, a *practice-based organizational learning novelty typology*, and a *practice maturity model*.

4.4 Line B1. Cherrywood, the second RPA extension project

The second case concerns the activity of route selection as practiced in the Cherrywood extension, also known as line B1, illustrated in Figure 4.2. This southwards extension of the Green Line from Sandyford to Bride's Glen was the second of three extension projects realized by RPA. Whereas, opposition from business interests characterized the Docklands project described in Section 4.2, the Cherrywood extension was characterized by the proactive involvement of developers who participated in its financing as a Public Private Partnership (PPP). Instead of following an old railway line along the seafront, the route was deviated inland to serve proposed new development. RPA ensured that the extension was compatible with government policy and in the public interest. Line B1 started operations in October 2010. The rest of this section presents results that derive from an analysis of the data collected on the B1 project in response to the three research questions.

4.4.1 Line B1. Representing, assessing, and improving route selection

The first research question applied to B1 asks how RPA represented, assessed, and improved its performance and learning of route selection in the case of the Cherrywood extension. At the operational and information systems level, the answer to this question is simply the same as for line C1; from the perspective of organizational learning at the operational and information systems levels, the three RPA extension projects were identical and the lessons learned from all three were collected as a single process, as discussed in Section 4.2.1. However at the strategic level differences were discovered in the manner in which RPA represented and assessed its route selection activity and in the RPA approach to leveraging lessons learned and these are the focus of this section.

Route selection activity at strategic level on line B1 was represented and assessed by RPA in an 18-page document entitled "Luas Cherrywood (Line B1) Project Review" presented to the RPA Board on 23 February 2012. This document built on comments from the Board on the "Luas Docklands (Line C1) Lessons Learned" document presented four months previously; in particular the Board had expressed the view "that the papers on B1 and A1 should also review the importance and

impact of Board decisions”. The content of the Board paper is transposed in Table 4.4 using the conceptual framework developed in Chapter 3.

Table 4.4 Line B1. Strategic <i>lessons learned</i> , as represented by RPA (cf. Appendix 2)				
N°	Situations	Actions	Performance Assessment	Lessons Learned
1	«Divert the route to serve new development?»	«The alignment was diverted off a more direct route. The line now serves the large development in Central Park and the then existing and proposed developments off Ballyogan Road»	«The strategic decision was the correct one because the alternative using the Old Harcourt line would have served an area with a low density of development»	Density of development may justify diversion of the alignment
2	«Railway Order (RO) funded by developers?»	«RO application was funded by a company set up by interested developers»	«Some delays in the finalization of the RO documentation due to differences between some of the developers»	Funding an RO by developers can be reasonably effective

Table 4.4 illustrating the strategic *lessons learned* from Line B1 has the same structure as Table 4.2 which illustrated the strategic lessons for Line C1. It shows route selection *situations* (elements of the environment perceived by RPA as bearing on its action), RPA *actions* taken in response, the *assessment* of the appropriateness of the action to its situation, and the *lessons learned* abstracted from the details of the specific situations. Two line items are shown to make the point. The full report, in redacted form, is included in Appendix 1. The difference between the representation and assessment of strategic learning between the two extension projects Line C1 and Line B1 is not significant. There are however two important differences in Table 4.4 compared to Table 4.2. First, there is a subtle change of point of view from that of *management* in Table 4.2 to that of *governance* (Board of directors) in Table 4.4, and second, the *lessons learned* that are explicit in the Board paper in the case of Line C1 are left implicit in the case of Line B1. These differences lead to two research results.

The first result of the analysis at the strategic level is that the representation of practice and the assessment of performance at RPA in the case of Cherrywood was from a specific point of view, that of the Board, i.e. each action was evaluated in the light of the situation perceived by the Board as prevailing at the time of the

strategic decision. This result is compatible with the research literature on the aspectual nature of representation (Searle, 2004, p. 66).

The second result follows from the change of point of view and is highlighted in the change of title of the Board papers from 'lessons learned' to 'project review'. The management report to the Board reviews the project but does not abstract lessons learned on behalf of the Board. Board level lessons learned are left *implicit*. A consequence of leaving learning without an explicit trace in an organization code is the danger of its being lost. Practice-based organizational learning involves explicit de-contextualization; in other words, to be useful in future a lesson must be explicitly abstracted from the details of the learning situation (Figure 2.14). Although Table 4.5 shows that the B1 document is implicitly rich in *lessons learned*, the emphasis in the narrative was not on practice-based organizational learning but on conformance to procedures and comparison of the outcome to the Final Business Case. RPA management confirmed to the researcher that the Board preferred the 'Project Review' format of B1 to the 'Lessons Learned' format of C1. This result highlights the importance and difficulty of representing lessons learned at the strategic level.

4.4.2 Line B1. Issues confronting RPA in leveraging route selection lessons

The issues of recording, assessing, and reporting experience evoked in the discussion of Line C1 confront RPA in leveraging lessons learned from its practice of route selection on all projects and the discussion of those issues is not repeated here. However, as a result of the Board's request for a review of the strategic decisions, the Board paper on the Cherrywood extension provided more data on governance issues than did the paper on the first extension project. The review of Line B1 provides answers to the subsidiary questions entailed in the second research question, *viz.*, on how RPA ensures the relevance of its activities, and on how RPA ensures the effectiveness and efficiency of its ways and means of realizing its route selection activity.

To answer the questions on governance and risk management at RPA, data were collected and analyzed using the methodology developed in Chapter 3. The results were validated in the route selection research workshop with top management at

RPA and in follow-up interviews with RPA management, civil servants in the Department of Transport and the Department of Finance in Dublin, and in the European Commission Directorate General, DG Move in Brussels.

Governance issues

Institutional and organization-level data on the RPA mission, values, and risk appetite were collected. RPA has a statutory mandate to procure light rail infrastructure as part of an integrated transport system for Dublin. The organization is incorporated as a 'commercial semi-state' whose sole shareholder is the Irish government and its Board of Directors reports to the Minister of Transport. Investment in transport infrastructure projects is subject to approval by the Department of Finance who issues methodology guidelines for cost-benefit analysis and determines the discount rate to be used when discounting project cash flows. Investment projects must also conform to European Union rules on procurement and EU Public Transport Policy.

The RPA vision is summed up in the phrase «getting people out of cars and onto public transport» (Table 3.2) and RPA values include value-for-money, sustainability, and cooperation with other agencies. The risk appetite of the organization is moderate; it was situated by the CEO as «less risk-seeking than the typical private enterprise and more so than the typical commercial semi-state like CIE».

The first result from the analysis of governance data is that RPA uses a *multi-criteria* approach in project selection and uses *thresholds* rather than weights. Acceptable expected rate of return on investment is one of the thresholds. Once technical and economic feasibility is confirmed to satisfy other goals at an acceptable level of risk, each project's estimated rate of return is compared to the acceptable rate of return determined by the prevailing government policy for public transport infrastructure projects. In other words, infrastructure projects at RPA must demonstrate their contribution to high-level organizational goals and have an expected return on investment acceptable to the government; RPA determines the expected cash-flows, the government fixes the discount rate.

The second result from the analysis of governance data is that governance sets the task for risk-management activity as ultimately giving assurance as to the expected cash flows from the project.

Risk management issues

To answer the question of risk management at organization-level, data on risk management were collected. A review of RPA risk management procedures combined with management interviews validated the researcher's understanding of the RPA approach to risk management.

The main result from the analysis of organization-level data on risk management is that RPA manages risk at the strategic level by identifying *events* that could threaten its high-level objectives, assessing the risk associated with the identified events, developing risk response plans, and putting in place *control activities* aimed at reducing the impact of the envisaged events or the probability of their occurrence. This result is exploited at the project level.

To answer the question of risk management at project-level, data was taken from the section of the B1 project review entitled «review of Board strategic role and decisions» which lists five decision items of strategic interest. To facilitate the analysis, the Board paper discussion is transposed in Table 4.5 into the terms of the conceptual framework developed in Chapter 3; the events recorded in the Board paper correspond to *situations* whose implicit assessment justified strategic *actions* by RPA as control activities; the *evaluations* of the control activities' appropriateness to the situations led to implicit governance *lessons learned*.

Table 4.5 Line B1. Strategic risk management (cf. Appendix 2)				
Item	Situations	Actions	Evaluations	Lessons learned
1a	«Risk of development cost overrun?»	«Negotiate funding of 50% by developers»	«Flexibility to explore different mechanisms to achieve the high level objective helped management»	Set high level objectives without specification of implementation mechanisms
1b	«Risk that the developers' company would renege on contribution to development cost?»	«Board decision that bilateral agreements with developers be signed before RO application»	«Decision strengthened Management's negotiating position»	Active Board involvement helps management negotiate commercial agreements

Table 4.5 Line B1. Strategic risk management (cf. Appendix 2)				
Item	Situations	Actions	Evaluations	Lessons learned
2	« Risk of insufficient oversight?»	«Reporting to Board according to Project management procedures»	«Achieved a correct balance between day-to-day management and oversight»	Current procedures give high quality reporting and avoid major surprises
3	«Risk of scope creep?»	«Scope changes subjected to Board approval: increased platform lengths to 53 m »	«Provided for future capacity expansion of Luas»	Using detailed scope statement and reserving changes of scope for the Board is good practice
4	«Planning risk?»	«Applied for RO without agreement with an affected homeowner»	«It would have been desirable to avoid the judicial review»	Notwithstanding the best plans and project systems significant events will affect the project
5	«Risk of individual contract overruns?»	« Procurement strategy tolerated the risk of variations»	« There were significant variations between the tendered value and the outcome of individual contracts»	Passing on as much of the risk as possible to arrive at a fixed price early on does not guarantee the best overall cost

The analysis of project-level strategic risk management data in Table 4.5 yields six results that together illustrate how the RPA risk management process is realized in practice. The first result is that risk management activities involved real actions in response to hypothetical events perceived as threatening strategic objectives; the events considered in risk planning are hypothetical but the actions they trigger are real. For example, in Table 4.6, item 1b, the perception that the hypothetical event of the developers reneging on their joint commitment to participate in the funding threatened the strategic objectives of the Cherrywood extension triggered the real action of bilateral agreements with each of the developers. This action is a control activity because its intention is to address an identified risk; it is situated in a context of proactive risk assessment. Hypothetical actions are not represented in the report which states «it is difficult to now predict the flow of events given different decisions to those that were made».

The second result is that risk management involved contextualization; representing risk management practice is a matter of specifying the assessment of the risk situation that pertained at the time of realizing a given control activity. The *situations* column of Table 4.5 shows the *contextual elements* that RPA implicitly

assessed at the time it decided on the *control activities* reported. The assessment is based (according to RPA risk management procedures) on a measurement of the impact of the object-threatening event and its likelihood of occurrence.

The third result is that the practice of risk management led to opportunities for double-loop organizational learning; breakdowns in control activities led to lessons learned about values. This result follows from the fact that control activities are explicitly situated in the context of threatened objectives and is compatible with the research literature on the theory of values (Smith 2010; Hayek, 1945; Ehrenfels, 1890). Item 5 in Table 4.5 is a particularly clear illustration of this result; failure to keep contracts within the cost estimate is not a sufficient reason to put in question the value of risk-sharing.

The fourth result is that RPA embedded control activities in its practice of route selection on Line B1. Item 1a in Table 4.5 is an example of an activity to control cost; the control activity of negotiating developer participation in funding is embedded in the route selection activity for Line B1. Risk management control activities, by their nature, address specific aspects of an underlying activity they are meant to secure; they implement constraints that otherwise might not be in the focus of attention during the realization of the activity. This result suggesting that risk management is a form of meta-planning with look-ahead reasoning is compatible with the research literature; control activities viewed as additional constraints on the original route selection activity involve plans about plans (Wilenski, 1983), and situating control activities in the context of hypothetical events involves look-ahead reasoning (Pomerol & Adam, 2008).

The fifth result is that RPA does not use a different approach to risk management and opportunity management. Item 3 in Table 4.5 is a good example; the opportunity of exploiting new technology as it becomes available involves acceptance of scope creep. This approach to risk (and opportunity) management is compatible with the *ISO 31000* definition of risk as 'effect of uncertainty on objectives' including upsides as well as downsides (ISO, 2009).

The sixth result is that the RPA mix of risk assessment and performance assessment was compatible with the qualification of the organization's risk appetite

as moderate. The more *risk assessment* leads to *control activities*, the less *aspects* of an activity are salient in performance assessment; in other words, the less things that can go wrong, the less are the opportunities to learn from experience.

4.4.3 Line B1. Opportunities for CIAS support leveraging lessons learned

Opportunities were identified in Section 4.3.3 for context-based intelligent assistant support (CIAS) of *practice-based organizational learning and performance improvement* in route selection at RPA. Here, an opportunity is identified to extend CIAS support to leverage lessons learned in the *governance* and *risk management* of route selection at RPA; in other words, to use CIAS to support double-loop learning in route selection activity at RPA. The fact that *control activities* are embedded in the route selection activity implies that the evolution of a contextual graph of route selection over time can be used as a direct measure of both single-loop and double-loop learning if *control activities* are clearly identified as such.

Risk management activity, both at the strategic level and at the operational level, can be represented directly in the contextual graph formalism by using *contextual elements* to represent *risk situations* i.e. events that situate control activities. These *risks elements* are facts¹⁰ of management interpretation of the unfolding situation that explain actual control activities. The *practice-based organizational learning novelty typology* illustrated in Figure 3.4 extended from single-loop to double-loop learning can be used to distinguish between assimilation of new *risk situations* and accommodation of new *control activities*. It follows that the evolution over time of the nodes representing *control activities* and *risk situations* in a contextual graph of RPA's route selection activity is a direct measure of double-loop organizational learning.

The concept of *practice maturity* of an activity illustrated in the practice maturity model in Figure 3.5 can be extended to include governance activity and risk management activity. The initial growth of *control practices* is followed by a concentration on a *few best* control practices and leads over time to an *optimized* way of securing the activity against risks.

¹⁰ Risks represented by contextual elements are not to be confused with *a priori* probabilistic assessments such as are found in decision trees.

4.4.4 Line B1. Summary of results from the third RPA extension project

At the operations and information systems levels RPA represented and assessed its route selection activity as practiced on the Cherrywood extension in the same way as for the Docklands extension. However, at the strategic level the representation and assessment of the Cherrywood project emphasized governance and risk management rather than *practice-based organizational learning and performance improvement* and yielded two interesting results. First, at the strategic level, the representation of practice and the assessment of performance was contextualized from the point of view of the Board of directors. Second, strategic lessons learned were left implicit with a danger that the learning will be lost when those involved leave the organization.

De-contextualizing actions from the specifics of the learning situation is an essential part of practice-based organizational learning. It is more difficult and politically more sensitive to do this at the strategic level than at the operational level.

Leveraging lessons learned in route selection in the case of the Cherrywood extension confronted RPA with two types of issues not discussed in the discussion of the Docklands case, viz., governance and risk management issues. The case revealed two interesting results concerning governance and risk management. Each of these is discussed in this section.

Multi-criteria evaluation with thresholds

RPA used a multi-criteria approach with thresholds to select the route. The criteria used are imposed in the statutory mandate of RPA, and include guidelines issued by the Irish Government (Department of Finance) for capital investment projects. The guidelines are silent on the trade-off mechanisms to be used in evaluation. The use of thresholds by RPA rather than weights is an expression of a vision of the nature of route selection as a trade-off between incommensurables. The RPA CEO summed this up succinctly during the route selection workshop 'route selection is not arithmetic'.

Relevance of control activities

RPA used risk management to have assurance on expected cash flows in the case of the Cherrywood extension. Potential impact on cash flow ultimately determined which control activities were considered relevant. Specification of the impact and likelihood of cash-flow-threatening events implicitly or explicitly determined the priority with which control activities were put in place.

There is an opportunity to extend CIAS support to governance and risk management applied to route selection by representing risk situations using contextual elements and control activities as actions and activities in the contextual graph of the activity for the given level of responsibility. The uniform representation of knowledge, reasoning, and context is here exploited in a manner that reflects double-loop learning.

4.5 Line A1. Route selection for the third RPA extension project

The third case concerns the activity of route selection as practiced in the Citywest extension, also known as Line A1, illustrated in Figure 4.1. This spur¹¹ extension to the Red Line from the existing Belgard stop to a new terminus at Saggart was the third extension project realized by RPA. The Citywest project is interesting as an example of a new approach to public private partnership by RPA. Developers involvement went much further than the Cherrywood extension described in Section 4.4. For Citywest, developers set up a special purpose vehicle, Citywest Luas Limited (CLL) that entered into a contract with RPA to deliver Railway Order application documents, civil works, and land. CLL also contributed 50% of the overall cost upfront, whereas contribution from the private sector in the case of Cherrywood was in the form of development levies spread over a much longer time horizon. Since “RPA does not have to do everything itself” this case presents an opportunity to understand how RPA decides which activities it must carry out internally and how it manages those that are carried out externally. From an organizational learning point of view it contributes to a richer understanding of the distinction between exploration and exploitation (March, 1991a); it represents an interesting case of exploration of a new approach encouraged by the successful exploitation of experience gained in previous projects. RPA ensured that the extension was compatible with government policy and in the public interest. Line A1 commenced passenger operations in July 2011. The rest of this section presents results that derive from an analysis of the data collected on the A1 project in response to the three research questions.

4.5.1 Line A1. Representing, assessing and improving route selection

The first research question applied to A1 asks how RPA represented, assessed, and improved its performance and learning of route selection in the case of the Citywest extension. This question is first answered for the strategic level and then for the operational and information systems levels.

¹¹ A spur is a secondary railway line which branches off a more important through route, usually a main line

The strategic level

At the strategic level, route selection activity on Line A1 was represented and assessed by RPA in a 17-page document entitled “Luas Line A1(Citywest) Project Review” presented to the RPA Board on 28 June 2012. This document “focuses on decisions of a strategic nature taken by the RPA Board following submissions put forward by the Executive throughout the Luas Citywest project lifecycle”. Table 4.6 illustrates six of these decisions using the conceptual framework (Section 2.7.1).

Table 4.6 Line A1. Strategic <i>lessons learned</i> (cf. Appendix 3)				
Item	Situations	Actions	Assessment	Lessons Learned
1	«Operate as shuttle rather than a spur service?»	«A tram runs from Connolly to Saggart at least every 15 minutes at peak periods and at least every 30 minutes off-peak »	«RPA is delivering on its obligations even with recent timetable changes »	The report is silent on the service that would be provided if there were no contractual obligation
2	«Public private partnership?»	«Developers special purpose vehicle (CLL) delivered EIS, civil works and land, and also made a financial contribution to RPA works»	“Represented the best deal to date for RPA”	“RPA does not have to do everything”
3	«Contribution mechanism?»	«Upfront contribution by developers»	“Less risk attaching for RPA in that the contribution was independent of development occurring”	“Structured and gated approach stood the test of a failing property market and the deteriorating solvency status of individual developers”
4	“Level of supervision?”	«The agreement with CLL allowed RPA to review and comment on the EIS and allowed for a full design and construction review and approval»	“The quality of both the EIS and the works delivered by CLL were up to RPA standards”	“This level of supervision and management is important in any future engagement with third parties on actual delivery of works”
5	“Security mechanism?”	“CLL provided bank guarantees and additional/alternative security”	“Successful outcome for both parties”	“Importance of flexibility to explore different mechanisms”
6	«Patronage and revenue estimates?»	“Patronage was estimated using land-use projections based on a significant increase of both population and employment being in place in 2016”	“Patronage has been significantly less than forecast in the Final Business Case; development levels anticipated for 2016 for the Greater Dublin Area are now forecast for 2025”	“For future scheme appraisal RPA has revised its model assumptions (including sensitivity tests)”

What is striking about Table 4.6 is the light it throws on practice-based organizational learning in situations of intermediation, here Public Private Partnerships (PPP). In the case of Citywest, RPA made a commitment in the PPP agreement to a level of service in absolute terms (item 1 in Table 4.6) in return for security on investment cost. A consequence of this is that RPA lost the opportunity to *leverage* lessons learned about demand by adapting its level of service freely to actual demand. Similarly, CLL, the PPP private party, made a commitment to contribute to infrastructure (items 2, 3, 4, and 5 of Table 4.6) in return for the long-term commitment by RPA to the agreed level of service. However, since CLL is a *special purpose vehicle* it cannot leverage lessons learned in future.

The first research result from the Citywest analysis at the strategic level is that the cost of lost opportunities to leverage lessons learned was not considered explicitly in the decision about intermediation; public private partnership was applied as a matter of government policy. The emergence of the opportunity cost associated with the non-exploitability of lessons learned in PPP projects as a 'hidden' transaction cost¹² is a lesson learned in the case of the Citywest project.

A second research result at the strategic level concerns the manner in which performance is represented in the Line A1 Board paper. The discussion of "very disappointing" passenger numbers is introduced by the statement "the system achieved its primary objective of delivering public transport safely and reliably". This effectively separates the objectives of providing infrastructure from the question of demand for the service. In a research interview a member of the planning department evoked the question of RPA mission in the following terms: "are we a project company as suggested by the engineers, or are we a passenger mover as suggested by the transport planners?" The response implicit in the Board memo is that RPA is both. From an organizational learning point of view this can be expressed by saying RPA uses both exploitation of experience (getting more people on the existing network) and exploration (of new routes to enhance the network). A corollary is that exploration and exploitation are related to the focus

¹² The transaction-costs approach suggests conditions under which it makes sense to replace internal coordination by arms length transactions at market prices (Williamson 1975; Ciborra, 1993, p.141).

of attention, when the focus is on the existing network every line extension is an exploration project, but when the focus of attention is on transport planning, route selection is an activity in which RPA exploits its experience through practice-based organizational learning and performance improvement.

The operational and information systems levels

At the operational and information systems level, the RPA manner of representing, assessing, and improving route selection was the same as for Line C1 and Line B1, and has been described in Section 4.3.1. The lessons learned log includes lessons learned by RPA staff in the execution of RPA staff responsibilities; these responsibilities are different depending on the project but the manner of recording learning is the same across projects. In other words, the content of learning differs but the same representation formalism is used to record the content. For example, in the case of the Environmental Impact Study (EIS) that is an important part of the Railway Order application, RPA was not learning about managing an EIS service provider but rather about managing CLL who procured the EIS; “the agreement with CLL allowed RPA to review and comment on the EIS” (item 2, Table 4.6). The Citywest case underlines the importance of hierarchical activity representation in order to leverage lessons learned at different levels across projects.

4.5.2 Line A1. Issues confronting RPA in leveraging route selection lessons

Of the issues that confronted RPA in leveraging route selection lessons in Line A1, those of recording, assessing, and reporting experience have already been evoked in the discussion of Line C1 and those of governance and risk management have been evoked in the discussion of Line B1 and these issues will not be repeated here. A new issue in the case of the Citywest extension concerns the representation of project management practice. Route selection practice represented as a realized project embedded in the context of a process of project management (Figure 2.3) can be assessed in terms of project management best practice. Table 4.7 reproduces a table presented in the “review of Board strategic role and decisions” section of the Line A1 Board paper as evidence that RPA responsibly applied good project management practices in the case of Citywest.

Table 4.7 lists eleven project issue types taken by RPA from the project management research literature (Morris & Hough, 1987) and for each lists mitigation actions adopted with the private sector on the Citywest project. This evidence of RPA concern for process reflects the value it attaches to accountability, which in turn perhaps reflects its government agency status.

Table 4.7 Line A1 Project issues and mitigating actions (cf. Appendix 3)		
Item	Issue (Morris & Hough, 1987)	Luas Citywest mitigation adopted with private sector
1	Unclear project objectives	Formalized through Heads of Agreement and its evolution to full agreement
2	Changing sponsor strategy	Developers required establishing a Consortium to act as a single point of contact
3	Poor project definition	Early organization objectives, scope & risk definition and allocation
4	Technology difficulties	Early definition of requirements
5	Concurrency	Program Management framework adopted
6	Inappropriate contract strategies	Contract risk management, use of standard FIDIC terms supplemented by special conditions
7	Unsupportive political environment	Early engagement and inclusion in T21
8	Level of top management support	Clearly demonstrated early
9	Funding difficulties	Performance security structure (Bank guarantees, service agreements, performance bond, retention monies and security pack)
10	Inadequate manpower	Early market engagement and organization resource planning across T21 program
11	Geophysical conditions	Early geotechnical, slit-trenching & radar

From a *practice-based organizational learning and performance improvement* point of view, the main research result from the analysis of Table 4.7 is that actions may be represented on the one hand as the practice of a process activity dependent on domain knowledge like route selection, or, on the other hand as the *practice of project management* which has its own specific body of knowledge; in other words, *practice* is both *process* and *project*. This result is compatible with the structuralist

conjunction of synchronic functions and diachronic transformations (Lemoigne, 1999, p.39).

4.5.3 Line A1. Opportunities for CIAS support leveraging lessons learned

In section 4.3.3 opportunities were identified for context-based intelligent assistant support (CIAS) to *practice-based organizational learning and performance improvement* in route selection at RPA and in section 4.4.3 an opportunity was identified to extend CIAS support to *governance and risk management* of route selection at RPA. Here, an opportunity is identified to extend CIAS support to the *project management* of route selection activity. Project management activity, both at the strategic level and at the operational level, can be represented directly in the contextual graph formalism as long as actions are situated in time. This can be done in two ways; an action 'definition of [technology] requirements' (item 4, Table 4.7) qualified as having been done 'early' can be linked to a contextual element with 'early' as a value or it can be placed with other actions in an activity 'things that must be done early'; both actions and activities in a contextual graph can be represented as serial or parallel in time. The rule that context is always relative to a focus of attention applies also to the dimension of time; the characterization of an action being on the critical path does not in and of itself have explanatory power unless the actor is aware of this and the action chosen at a point in time was chosen because of the criticality of time.

4.5.4 Summary of results for the third RPA extension project

At the strategic level, RPA represented, assessed, and improved route selection in the case of Citywest by first addressing the process of route selection using *transport planning domain knowledge*, then considering the purpose of the activity using *governance and risk management knowledge*, and finally considering the project in its resource and temporal dimensions using *project management knowledge*. The research yielded two interesting results. First, intermediation may involve losing opportunities for leveraging lessons learned. Second, when assessing performance, RPA attaches importance to both outcome and to process.

At the operations and information systems levels, RPA represented and assessed its route selection activity as practiced on the Citywest extension in the same way as the Cherrywood and Docklands extensions. The Line A1 project underlines the importance of hierarchical activity representation for leveraging lessons learned when the organization exercises different degrees of intermediation in its projects.

At the strategic level, the issue of representing action in time arose out of the necessity to demonstrate that the infrastructure project was responsibly realized in spite of disappointing results in terms of patronage. The issue of justifying action is less salient at the operations and information systems levels as these levels are engaged in *problem-solving* and *implementing* rather than *situation assessment* and *decision making* (Figure 2.13).

The Citywest project drew attention to the opportunity to extend the context-based intelligent assistant support (CIAS) to *leverage lessons learned* in the *project management* of route selection activity.

4.6 Evolution over time of route selection practice at RPA

It is interesting to consider the evolution of route selection practice at RPA on the basis of the results presented in the three cases studied. The results of this cross-case analysis is presented in this section.

In the first case, the Docklands extension known as Line C1, route selection practice was represented by RPA as route selection *actions* taken by RPA in response to *situations* that emerged from the environment. Different forms of representation were used for different levels of responsibility. At the top-management level, the representation took the form of a board paper concentrating on the two dozen most important items. At the operation management level, the representation took the form of a project review by function, complemented by a *lessons learned log* with more than a hundred items relating to Line C1.

The formal distinction of *actions* and *situations* proposed in the conceptual framework was tested by transposing the management representations at both levels into contextual graphs and validating the transposition with the authors of the original representations. This was done in the contextual graph research workshop carried out at RPA headquarters and in follow-up communications with the

managers involved. RPA represents its route selection practice as a structured relationship between RPA actions and elements of the evolving situation that bear on the action. The context of the action is formally captured on the one hand by the activity designation (here *route selection at top-management level* and *route selection at operational management level*), and on the other hand by the situational elements and their specific values at the time of the action.

The Cherrywood case differs in its *point of view* from that of the Docklands in its emphasis on *governance and risk management*. RPA embedded *risk control activities* in its practice of route selection in response to *risk situations* perceived as threatening its objectives.

Route selection activity on the Citywest extension was intermediated by a consortium in Public Private Partnership (PPP) with RPA and was represented as the practice of *project management* (of route selection).

The focus of management attention moved from describing the substantive activity in Line C1 to describing how the activity is kept under control in Line B1, to how the activity can be delegated in Line A1. This is evidence of RPA confidence increasing with experience leading to a more sophisticated approach to its route selection activity. In the first extension project, Line C1, the practice and performance of route selection was represented as a demonstration of RPA ability to select the best route in spite of well-organized opposition from powerful business interests. In the second extension project, Line B1, the emphasis has moved to control of an activity that the organization confidently masters. In the third extension project, Line A1, the delegation by RPA of some important route selection activities to a consortium of developers demonstrates an increasing practice maturity level (Figure 3.5).

In the Docklands case, three issues were identified as critical to leveraging lessons learned from experience, *viz.*, recording context at the right level of *granularity*, assessing activity against an *emerging baseline*, and reporting experience in the *right context*.

In the Cherrywood case, additional issues were ensuring *alignment of objectives* with RPA mission and values, and with government policy; and ensuring risk

management gave *assurance on expected cash flows*, appropriate to RPA *risk appetite*.

In the Citywest extension, RPA was confronted with the additional issue of representing route selection activities in *time*, as a project.

Over time the issues that confront learning organizations are increasingly complex. The first extension project confirmed the difficulty in formalizing lessons learned in a way that is exploitable on future projects; this real-world difficulty was a primary motivation for the thesis (Figure 1.3). The second extension shows the additional difficulty of situating the activity of route selection in a *governance and risk management* process. The third extension highlights the further difficulty of situating the route selection activity together with its control activities in the real-time world of *project management*.

The Docklands case revealed the opportunity for CIAS support in the real-time concurrent recording of situation and activity data, and the reporting of experience as actions situated in their context as essential to leveraging lessons learned from *practice-based organizational learning*. The Cherrywood case revealed the opportunity to extend CIAS support to leverage lessons learned in the *governance and risk management* of route selection at RPA. The Citywest extension revealed the opportunity to extend CIAS support to the *project management* of route selection activity.

Over time different opportunities for CIAS support emerged at RPA first in *practice-based organizational learning and performance improvement*, then in *governance and risk management*, and later in *project management*. This evolution towards more complex forms of support echoes the increasing confidence of the organization and the increasing *practice maturity* of its route selection activity.

4.7 Summary of the results of an interpretive case study at RPA

'Route selection is not arithmetic' in the words of the RPA CEO. The sophisticated models and cost-benefit analysis of RPA transport planners is combined with the 'emergence of urban form' of RPA architects. The route that emerges from the route selection process at RPA gives meaning to route selection actions of the organization (RPA's vision is 'to move people from cars onto public transport') and

the route selection actions of the organization give meaning to the route (the realization of a proposed route depends on RPA actions demonstrating the route's meaningfulness to the arbiters of public interest in the railway order process). In the sense of the hermeneutic circle, route selection *actions are the parts* and route selection *activity is the whole* (Klein & Myers, 1999). This interdependent relationship is captured in the uniform expression of route selection *knowledge*, *reasoning*, and *context* in the contextual graphs used to interpret the data collected at RPA for this case study.

In interpreting the contextual graphs of route selection activity, the *focus of attention* is either on the nodes that express route selection *knowledge*, or on the branches that link the nodes and express route selection *reasoning*, or on the whole graph that expresses the route selection *context*. When the focus of attention is on a contextual element node it expresses existential *situational knowledge*, i.e. activated contextual elements indicate the existence of a route selection situation.

When the focus of attention is on an activity node or an action node it expresses route selection *domain knowledge*. *Situation knowledge* and *domain knowledge*, what Aristotle called *phronesis* and *techne* (Kavanagh , 2012) and Polanyi called *know-when* and *know-what* (Polanyi, 1966) always go together, the former guiding the application of the latter. As Dewey pointed out, 'knowledge attends strictly to its own business: transformation of disturbed and unsettled situations into those more controlled and more significant' (Dewey, 1929, p. 295). Sensing that a route selection *situation* exists precedes route selection *action* and explains it.

When the focus of attention is on the structure of the route selection contextual graphs, i.e. on the relationship between the nodes in the graph, it expresses route selection *reasoning*. Branches in route selection contextual graphs connecting two contextual elements express *reasoning about* a route selection situation (integrity rules) and branches connecting a contextual element to an action or activity node express *reasoning in* the route selection situation (inference rules). *Reasoning about* a route selection situation is time-dependent and *reasoning in* a route selection situation is role-dependent.

Time-dependency can be captured in a route selection contextual graph by recording the evolution of the structure over time¹³. Role-dependency can be captured in a route selection contextual graph by collecting practices that interpret the same role¹⁴. This was done in the RPA case by separating the graphs for *top-management route selection* from the graphs of *operations-level route selection*.

When the focus of attention is on the graph as a whole, the route selection activity¹⁵ is interpreted as a finality¹⁶ of the route selection practices it expresses. Route selection performance assessment is an interpretation of the activity and practice of route selection in particular circumstances. Whether to *exploit* the activity or *search* for new activities depends on the *strategic relevance* and *practice maturity* of the activity (March, 1991). In the case of RPA, route selection is mission-critical and its practice is maturing through the efforts being made to record and exploit lessons learned described in this research.

The considerable effort required by the current RPA approach to *practice-based organizational learning and performance improvement* suggests that an alternative approach is worth investigating and explains the motivation of RPA to participate in the research project presented here. The transposition of RPA documents into contextual graphs (CxG) and their analysis with RPA management in the CxG *research workshops* demonstrated the relevance of the context-based intelligent assistant support (CIAS) approach to *practice-based organizational learning and performance improvement*. The next chapter presents conclusions and further research.

¹³ A route selection contextual graph is both a snapshot of the activity at a point in time and a film of the unfolding activity. The evolution over time of route selection contextual graphs can be interpreted using the *practice-based organizational learning novelty typology* and monitored using the *practice maturity model*.

¹⁴ Roles correspond to different interpretations of responsibility and different logics. The Contextual-Graphs representation formalism is not bound to any particular logic and as such offers an opportunity to 'explore behavioral logics as complementary rather than assume any dominant logic' (March & Olsen, 2004).

¹⁵ Moreover, the Contextual-Graphs representation formalism highlights the recursive nature of the route selection activity insofar as route selection *actions* can be represented as route selection *activities* in contextual graphs within contextual graphs. The *parts* are *wholes* depending on the *focus of attention*.

¹⁶ Activity, the purpose that guides action, is the reference of *context* in the context-based intelligent assistant support (CIAS) paradigm. It is this *context* that is proceduralized as the activity is realized and is formalized as the *proceduralized context* which expresses the evolving state of affairs at the moment of action.

5. Conclusions and further research

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Chapter 5. Conclusions and further research

5.1 Introduction

This chapter presents the thesis conclusions and indicates some avenues for further research in support of the wider research program outlined in Chapter 1, namely, extending the use of the context-based intelligent assistant systems (CIAS) paradigm to *practice-based organizational learning and performance improvement* research and practice. The results of the case study presented in Chapter 4 contribute to the understanding of the role of context in *organizational learning and performance improvement* and identify CIAS support opportunities, thus achieving the research objective that emerged from the literature review in chapter 2. Section 5.2 presents elements towards a theory of *practice-based organizational learning and performance improvement*. These elements include the thesis, conceptual framework, and supporting propositions from prior literature presented in Chapter 2 and three new analytic tools presented in Chapter 3. Central to this theory are the contextualizing, de-contextualizing and re-contextualizing management activities presented in the conceptual framework. Section 5.3 shows how the results of the interpretive case study presented in Chapter 4 support the thesis and contribute to closing the three research gaps identified in Section 2.7.2. Section 5.4 presents a contribution to the practice of research. The contextual graphs research workshops are shown to be a powerful tool for field research that avoids the trap of eliciting espoused processes as opposed to real practices. Section 5.5 draws implications for two research communities that straddle computer science and information systems, viz., CIAS and Decision Support (Systems) (DS(S)). Section 5.6 concludes with an indication of avenues of future research that seem likely to yield fruitful results.

5.2 Towards a theory of *practice-based organizational learning and performance improvement*

The results presented in Chapter 4 confirm the relevance of the practice-based approach to the study of organizational learning and performance improvement and the initial intuition expressed in the spiral of continuous improvement that

performing, assessing, and learning are embedded activities (Figure 2.3). The natural starting point was to enquire about the *representation* by the Railway Procurement Agency (RPA) of its route selection practice. This led to the question of how the organization *assessed* its performance of the route selection activity in each of the three cases considered. This in turn led to the question of how RPA *leveraged* the lessons learned from its growing experience in route selection and what opportunities for a CIAS approach this opened up. The answers to these questions contribute towards a theory of *practice-based organizational learning and performance improvement*. The purpose of this section is to review our thesis on *practice-based organizational learning and performance improvement* in the light of the empirical evidence provided by the RPA case study in Chapter 4. For convenience, the thesis is restated and illustrated in Figure 5.1.

“Practice-based organizational learning occurs when new associations between actions and situations are discovered during performance assessment and are abstracted from the details of the discovery situation as lessons learned codified for future use. Practice-based performance improvement occurs in organizations when exploiting lessons learned from experience in realizing an activity leads to increased practice maturity.”

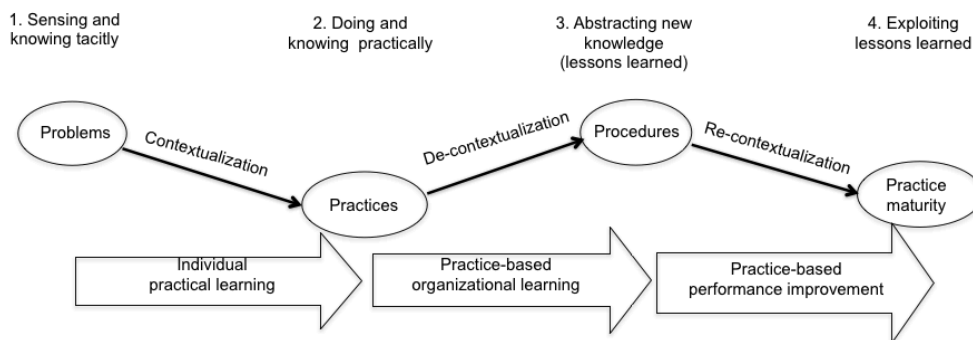


Figure 5.1 Practice-based organizational learning and performance improvement

In short form, the thesis states that “*Practice-based organizational learning and performance improvement* of an activity is a dynamic process of *contextualization* of problems, *de-contextualization* of practices, and *re-contextualization* of procedures leading to *practice maturity* of the activity”. The dynamic process has cognitive and social aspects. As a cognitive process, practical learning is an

attentive fusing of situation and action by a practitioner realizing an activity (Hegarty, Brézillon, & Adam 2012a). As a social process it is an *acquisition*, *transformation*, and *sharing* of codes about what to *do* in a given *situation*. The cognitive and social aspects are brought together in the *representation of practices*, a cognitive *formalization* and social *interpretation* of situated action.

Representations of practices are central to any theory of *practice-based organizational learning and performance improvement*. Here, the CIAS approach to context is used to represent practice. The context of an activity is defined as the *elements of the environment interpreted as bearing on an activity without entering into its description*. Context is relative to the evolving focus of attention of the practitioner as the activity is realized. Proceduralized context is defined as the elements of the environment interpreted by the practitioner as bearing on the activity as the situation unfolds. It dynamically represents the context relevant to the current action in the evolving situation. The focus of attention of the practitioner traces a path in a contextual graph as the activity unfolds. Each path in the contextual graph of an activity represents a way of realizing the activity in particular circumstances, i.e. paths in contextual graphs represent practices.

Representations of problems are the beginning point of the contextualization process. From a cognitive point of view, seeing a problem is sensing an incoherence that comes from the 'intimation of the coherence of hitherto not comprehended particulars' (Polanyi, 1966). From a behavioral point of view, a problem is a gap between stimulus and response calling for a plan (Miller, Galanter, & Pribram, 1960). From a social point of view, a problem is a task to be realized that motivates activity (Leontiev, 1978). The CIAS approach, used here, brings these three views together by representing a problem as an *activity*, subject to *integrity rules*, governing the relationship between elements of the environment describing the *situation*, and *inference rules* governing the relationship between elements of the environment and *action* in the situation. In the Contextual-Graphs representation formalism, each graph corresponds to an activity. Moreover, practices of one activity may include activities of another activity or of the same activity recursively.

De-contextualization is a cognitive process of abstraction of similarity. Representations of practices reflect the specific circumstances in which an activity

was realized and the circumstances are unlikely to be met again in exactly the same form. Therefore lessons learned must be abstracted to a more general level if they are to be of use in guiding future action. Since the abstracted form is generally applicable, *lessons learned* have the form of *procedures*, i.e. rules to guide action in general ways that need to be adapted to specific circumstances at the moment of application.

Re-contextualization is the process of exploiting lessons learned in new circumstances and involves the same cognitive and social mechanisms as contextualization. The only difference is that, at the starting point, lessons learned in the form of procedures are available to guide action. And at the end point *practice maturity* of the activity is increased.

Problems, practices, procedures, and practice maturity are representations of knowledge, reasoning, and context that are the *focus* of management attention in the seven activities listed in Table 5.1. Four of the activities are qualified as *contextualizing*, two of the activities are qualified as *de-contextualizing*, and one of the activities is qualified as a *re-contextualizing management activity*.

Table 5.1 Formalizing concepts related in a conceptual framework			
Four management foci of attention	Four contextualizing management activities	Two de-contextualizing management activities	One re-contextualizing management activity
Problems Practices Procedures Practice Maturity	Situation assessment (sensing) Problem solving (planning) Decision making (committing) Implementing (doing)	Representing practices Abstracting lessons learned	Leveraging lessons learned

The thesis formalizes a theoretical claim using the concepts of *activity, action, situation, performance assessment, lessons learned, and practice maturity* that form part of a wider conceptual framework of *practice-based organizational learning and performance improvement*. The formalizing concepts and the relations between them that constitute the conceptual framework is a tool for understanding *practice-based organizational learning and performance improvement* that finds its meaning and justification in a number of interpreting propositions that emerged

from the review of prior literature. First presented in Table 2.18 they are repeated here for convenience as Table 5.2.

Table 5.2 Interpreting propositions from prior literature		
Prior results		On
1	Representing practice-based organizational knowledge involves <i>formalizing</i> and <i>interpreting</i> an organizational activity together with the elements of the environment that bear on its realization in a given situation.	Practice-based Knowledge
2	Transforming practice-based organizational knowledge involves <i>accommodating</i> an activity in an organization to a new situation in which it is realized and <i>assimilating</i> the new situation to the activity.	Practice-based Learning
3	Using practice-based organizational knowledge involves reasoning about situations and reasoning in situations and is subject to <i>integrity rules</i> and <i>inference rules</i> .	Practice-based Reasoning
4	Situation assessment: <i>Analogy</i> and <i>enactment</i> are used in organizations to determine which elements of the environment bear on an activity in the organization's expected, desired, and planned worlds.	Contextualizing management activities
5	Problem solving: <i>Means-ends analysis</i> and <i>heuristics</i> are used in organizations to determine which <i>action</i> , taken in a given situation, would bring the expected and desired worlds together.	
6	Decision making: <i>Reason</i> and <i>rationality</i> are used in organizations to chose among hypothetical plans of action in a given situation.	
7	Implementing: <i>Technology</i> and <i>practices</i> are used in organizations to implement chosen plans of action.	
8	Representing practices: <i>State descriptions</i> and <i>process descriptions</i> are used in organizations to represent different aspects of their practices. A representation of practice is <i>eo ipso</i> a <i>performance assessment</i> .	De-contextualizing management activities
9	Abstracting lessons learned: <i>Measurement</i> and <i>evaluation</i> are used in organizations to abstract <i>lessons learned</i> from experience.	
10	Leveraging lessons learned: <i>Exploitation</i> of lessons learned is an alternative to <i>exploration</i> of new practices and activities used in organizations to improve performance. It leads to <i>practice maturity</i> .	Re-contextualizing management activity

The first three propositions in Table 5.2 together reflect the founding axiom of the CIAS approach, viz., the uniform representation of knowledge, context, and reasoning (Brézillon, 2011). Knowledge is the domain of facts, context the domain of values, and reasoning the domain of actions.¹ All three are embedded in the spiral of continuous improvement (Figure 2.2). The general principles expressed in the first three propositions elucidate the social and cognitive mechanisms of knowledge, learning, and reasoning in general. They apply to management in all its forms. The next four propositions in Table 5.2 elucidate contextualization in

¹ Truth, beauty, and goodness in large polities are furthered by transparency in methods of fact determination, explanation of preferences, and sharing of practices (Gardner, 2011)

management activity. These four propositions concern individual practical learning as shown in Figure 5.1.

Finally, the last three propositions in Table 5.2 elucidate the activities of de-contextualization and re-contextualization in management activity that directly concern *practice-based organizational learning and performance improvement* as shown in Figure 5.1. They bear directly on the research objective of this thesis, viz., *to understand the role of context in practice-based organizational learning and performance improvement and to identify opportunities for a CIAS approach to practice-based organizational learning and to improving organizational performance*.

In this section, general conclusions about the role of context in *practice-based organizational learning and performance improvement* are presented under the headings of each of the three de-contextualizing and re-contextualizing management activities, viz., *representing practices*, *abstracting lessons learned*, and *leveraging lessons learned*.

General conclusions on *representing practices*

The case studies showed that RPA represented its route selection practice in Board memos and lessons learned logs as actions in specific situations (Tables 4.3, 4.4, 4.5, 4.6 and 4.7). Situations were represented in terms of elements of the environment that bore on a given action as the activity unfolded. In a sense the activity separated the world into an inner and outer environment as shown in Figure 5.2 and elements of both environments were used to situate the action.

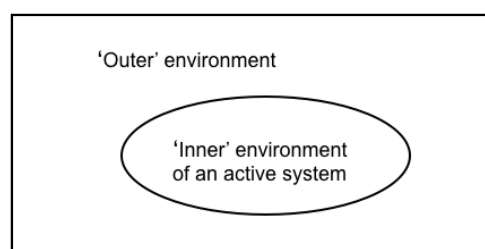


Figure 5.2 Inner and outer environments of an active system

In Figure 5.2, the oval represents route selection at RPA² interpreted as a 'black box' with a purpose in an active environment AND as an active route selection structure, functioning and under-going transformation (Lemoigne, 1999, p.41). The performance of the activity, in each of the three projects studied, was described by RPA in terms of changes induced in RPA and its environment AND actions constituting the activity. These state and process descriptions correspond to the two main types of description of complex systems (Simon, 1996, p.210) and it is interesting to note that RPA attaches importance to both.

The feasibility and utility of the Contextual-Graphs (CxG) formalism in representing the practice of route selection at RPA was confirmed by RPA management in the CxG research workshops on route selection. Route selection practices were captured in contextual graphs of the activity. A contextual graph represents an activity that for cognitive psychologists gives meaning to actions (Miller, Galanter & Pribram, 1960; Leontiev, 1978; Leplat & Hoc, 1983; Karpatschoff, 2000). It made sense for RPA to represent its experience of route selection activity differently at the strategic and the operational levels, and this is reflected in different contextual graphs for each level. At both levels, the contextual graphs used to represent the route selection activity at RPA contained activity nodes that recursively capture different 'levels' of organization, exploiting the separability of inner and outer environments found in all complex systems (Simon, 1996, p.7, footnote 4).

The first general conclusion is that complex real-world problems and their solutions can be usefully represented in the Contextual-Graphs representation formalism. This result is a prerequisite to using the CIAS approach in closing the research gaps that motivated the research (Section 2.7.2). The contextual nodes represent those elements of the situation that bear on the action. The representation is efficient because only salient elements of the environment enter into the representation of the situation; irrelevant context does not clutter the representation of what was done and why.

Organizational performance can be measured directly by *aspectual comparison of practices* that realize the activity (section 3.3.6.2). The practice of route selection in the case of Cherrywood was compared to the practice of route selection in the

² The route selection activity represented in Figure 5.1 is embedded in the RPA organization modeled as a complex of decision-making, information, and operating systems (Figure 3.1, p.87).

other two cases (Docklands and Citywest) under different aspects. The aspects used to compare two practices were key performance indicators (KPIs) set out in the Final Business Case.

The second general conclusion is that the Contextual-Graphs representation formalism facilitates assessing performance as aspectual comparison of practices. This result is a contribution to closing the first research gap that motivated the research (Section 2.7.2). Aspects need not be pre-determined in a planning activity, although in the case of RPA this was the case.

General conclusions on *abstracting lessons learned*

Practice-based individual learning is from an internal (the practitioner's) point of view, in the sense of having a first-person ontology (Searle, 2004, p.84). For an organization, *knowledge* is expressed in codes and *organizational learning* is the evolution of its codes over time (March, 1991a). Organizational codes are associated with roles and practice-based organizational learning is also from an internal (the role-player's) point of view, regardless of where the role is situated in the organizational hierarchy. It was shown in the case study that RPA codified lessons learned in route selection at the operational level differently from those at the strategic (top-management) level across all three extension projects. In the case of Line A1, political (Board) level lessons were left implicit and ipso facto 'codified' differently from strategic lessons learned.

For each level, *lessons learned* were represented by RPA as either new ways of doing route selection or new ways of seeing the route selection situation. In the CxG formalism, the former shows up as new action nodes or new activity nodes in the evolving graph of the activity over time, the latter as new contextual nodes or new branches from existing contextual nodes.

The third general conclusion is that the evolution of contextual graphs over time is a diachronic representation of practice-based organizational learning. This result is a contribution to closing the second research gap that motivated the research (Section 2.7.2).

Practice-based organizational learning in route selection at RPA, if represented diachronically in a contextual graph, can be characterized using the *practice-based organizational learning novelty typology* (Figure 3.4) as was confirmed by the RPA Director of Operations. The learning novelty types can be used to assess practice maturity of the activity using the *practice maturity model* (Figure 3.5).

The fourth general conclusion is that used together **practice-based organizational learning novelty typology** and **practice maturity model** are a step towards closing the third research gap that motivated the research (Section 2.7.2). These two tools developed during this research are presented as a contribution to the theory and practice of organizational learning and performance improvement.

General conclusions on *leveraging lessons learned*

The case study described the formal process of continuous improvement at RPA and identified issues that confronted the organization in *leveraging lessons learned*. First among these is the difficulty in formalizing the representation of practice. The approaches used at RPA do not permit the uniform representation of knowledge, reasoning, and context. Behind the representation of practice is the management of activity depending on practice maturity.

The fifth general conclusion is that there is an opportunity to extend the CIAS approach to organizational learning to performance improvement using the *practice maturity model*. Management effort should be directed to activities that exhibit low *practice maturity*.

Table 5.3 summarizes the general conclusions.

Table 5.3 Summary of general conclusions in support of the thesis	
General Conclusions	Thesis claim supported
1. Complex real-world problems and their solutions can be usefully represented in the Contextual-Graphs representation formalism	There is an <i>a priori</i> case for extending the CIAS paradigm to <i>practice-based organizational learning and performance improvement</i>
2. The Contextual-Graphs representation formalism facilitates assessing performance as aspectual comparison of practices	<i>A representation of practice is eo ipso a performance assessment</i> without causality assumptions
3. Evolution of contextual graphs over time is a diachronic representation of practice-based organizational learning	Practice-based organizational learning is a dynamic equilibrium between assimilation of reality to the activity and accommodation of activity to reality
4. Used together learning novelty types and the practice maturity model can be used to assess practice-based organizational learning and performance improvement	Practice-based organizational learning leads to practice maturity of activities
5. Management effort can be directed to activities that exhibit low <i>practice maturity</i>	<i>Practice maturity</i> is an expression of practice-based performance improvement

The last four general conclusions in support of the thesis summarized in Table 5.3 represent the contributions of the research towards a theory of *practice-based organizational learning and performance improvement* and as such are discussed in the next section.

5.3 Contributions to the theory and practice of *organizational learning and performance improvement*

This research makes four contributions to the theory and practice of organizational learning and performance improvement. First, a new method of selecting Key Performance Indicators (KPIs) was developed which overcomes one of the main weaknesses of alternative methods i.e. hidden causality assumptions (Talbot, 2010). Second a new method of measuring organizational learning was developed which goes beyond current methods of measuring change or quantifying knowledge (Fiol & Lyles, 1985). Third, a new method of assessing organizational learning was developed which can serve as a guide to researchers and

practitioners of practice-based activity management. Fourth, a new method of characterizing organizational priorities was developed which combines strategic relevance and practice maturity. Each of the contributions is discussed in this section.

5.3.1 A new method for selecting Key Performance Indicators (KPIs)

Contextual graphs represent practices in the context of the activity they realize. It makes sense therefore to compare two practices that realize the same activity. This comparison can be under any aspect and is called *aspectual comparison of practices*. This use of contextual graphs provides a tool to support the emergence of indicators of performance that do not use causality assumptions (Searle, 2004).

The first novelty of this approach to the selection of Key Performance Indicators (KPIs) resides in the manner in which knowledge, reasoning and context are rendered explicit as the activity to be evaluated unfolds. This excludes the possibility of ex-post rationalization and renders the approach transparent. Contextual graphs are a powerful tool for all those who sincerely support more transparency in decision-making in corporate governance and public administration.

The second novelty in this new approach to selection of KPIs is the openness of the approach. KPIs can be chosen after the execution of the activity to be evaluated and any aspect of a practice can be used as a KPI. This protects the approach from manipulation by those who would rather have positive results that relevant ones.

The third novelty of the approach is the rigorous comparison of 'apples to apples'. It makes sense to compare two practices that are alternative ways of realizing a given activity but it makes less sense to compare a practice with a theoretical way of doing the activity. Most other current performance evaluation techniques compare a high-level 'budget' (theoretical procedure) with a more detailed level 'actual' (practice). This restatement of the 'budget' in terms of the situation that actually obtained creates a false sense of comparability with the actual outcome. The fragility of this latter approach compared to the practice-based approach defended in this thesis is that it is not based on the knowledge available at the time of the decision and therefore does not permit valid inferences about learning.

5.3.2 A new method for measuring practice-based organizational learning

Recording the evolution over time of contextual graphs supports the characterization of *practice-based organizational learning* by type. The appearance of new contextual elements or new instances of existing contextual elements in a contextual graph expresses *assimilation* whereas the appearance of new actions or activities signals *accommodation*. Figure 5.3 shows four learning novelty types depending on whether the situation and/or the practice is new.

New Situation	Assimilation of a new situation to an existing practice	Assimilation of a new situation to a new practice and accommodation of the new practice to the new situation
Recognized Situation	Confirmation that an existing practice continues to be appropriate in a recognized situation	Accommodation of a new practice to a recognized situation
	Existing Practice	New Practice

Figure 5.3 A practice-based organizational learning novelty typology

Figure 5.3 is presented as a contribution to theory and practice (O’Raghallaigh, Sammon & Murphy; 2010). It extends the CIAS paradigm to organizational learning and the difficult problem of measuring learning. Together with the Contextual-Graphs representation formalism it provides a tool for objectively carrying out the measurement.

The novelty of the approach is that it permits a separation of context and action that adapts to the focus of attention. Practitioners know what the context is as the activity evolves and for that reason they have no incentive to record the situation in an explicit and formal manner. However, if an organization wants to leverage lessons learned it must have access to the situation data. Since context is infinite, identification of those elements of the environment that bear on an activity is the key contribution of experienced practitioners to sharing practical knowledge. Contextual graphs is a simple way for experienced practitioners to formalize their experience base.

Once an experience base is formalized its exploitation depends on clearly identifying when a situation is new and when a practice is new. The typology proposed in Figure 5.3 is a simple tool to ensure that an experience base is accessible in a useful way. This is essential to leveraging lessons learned.

The novelty of practice-based learning is its partial re-usability compared to case-based learning. If any elements of the situation are identical to elements of the situation encountered on a previous occasion then part of an existing practice can be exploited. On the other hand, for learning to be leveraged in a new case all elements of the case must be identical (or at least similar, in ways that may not always be clear).

5.3.3 A new method for assessing practice-based organizational learning

Organizations develop practices over time. Initially there is just one practice, later new ways of realizing the activity are discovered and the number of practices increases. This can be observed in a densification of the contextual graphs used to measure the practice-based organizational learning as shown in the previous section. As time goes on, better practices displace less effective ones in the process of continuous improvement. And as the activity increases in practice maturity further optimization leads to the one best way. Practice maturity is the reflection and measure of activity maturity. The practice maturity model expresses this idea schematically in Figure 5.4.

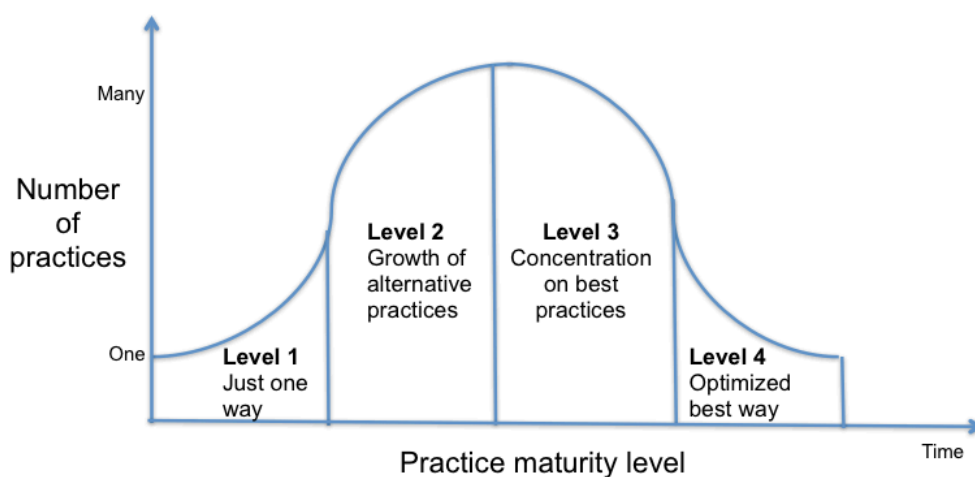


Figure 5.4 A practice maturity model

Insofar as the levels of practice maturity are measured by observing the evolution in contextual graphs, the practice maturity model represents an extension of the CIAS paradigm to *activity management*.

The novelty of the practice maturity model is that it looks at the maturity of an activity by considering the actual ways of realizing the activity for a given role. Route selection at RPA is modeled at the top management level in one contextual graph and at the transport planning operational level in another contextual graph. This opens bridges to the *communities-of-practice* approach to organizational learning (Brown & Duguid 1991; Lave & Wenger, 1990) in which the central issue in learning is *becoming* a practitioner not learning *about* practice.

The practice maturity model also provides a means of formalizing the emergence of best practices where actual practice becomes canonical. This opens up ties to best practices research (O'Leary, 2006).

5.3.4 A new method for prioritizing activity improvement efforts

The characterization of activities by practice maturity level in combination with an assessment of the strategic relevance of an activity in an *organizational-performance-improvement prioritization matrix* is a new tool to support the prioritization of activity improvement efforts. Activities with high strategic relevance and low practice maturity are high priority for maturing the practice through exploitation of experience as shown in Figure 5.5.

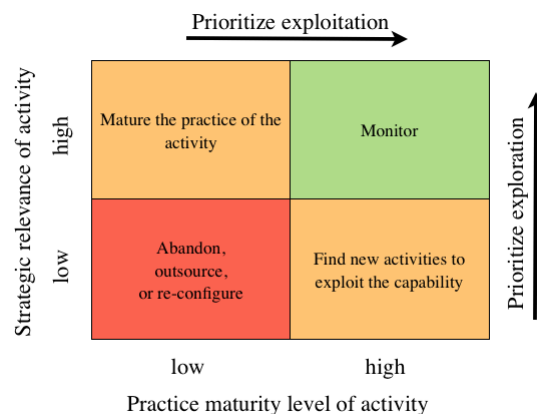


Figure 5.5 An organizational-performance-improvement prioritization matrix

The novelty of the prioritization matrix is the combination of two orthogonal views of performance. Other things being equal, putting effort into strategically relevant activities increases an organization's effectiveness and putting effort into practice maturity increases its efficiency (Porter, 1996). It is an unstated assumption of this thesis that both must be considered simultaneously and across all activities if an organization is to thrive.

5.4 A contribution to the practice of research

The feasibility and utility of the new tools were tested using rich data collected in an interpretative case study of an organization dealing with a complex real-world problem that combines managerial/political and technical aspects. The process of testing the CIAS approach with practitioners in Contextual-Graph research workshops led to the discovery of several interesting opportunities for a CIAS approach to *practice-based organizational learning and performance improvement*. The novel approach used in the Contextual-Graph research workshops constitutes a contribution to the practice of research. The contextual graphs (like any model) are a transitional object with which researchers and managers can play to build a better understanding of past and future possibilities; "people change their own mental models and build up a joint model as they talk" (de Geus, 1988). The contextual graphs research workshops provide a safe environment in which this play can take place.

CxG research workshops at RPA concerned route selection, a transport planning knowledge domain but the approach is applicable in all areas that involve complex activity that is context dependent. The methodological approach is summed up in the slogan *ask about practice not about procedures*. No questions are asked about procedures to avoid triggering answers based on espoused practices rather than actual practices.

CxG research workshops consist in developing a contextual graph for an activity with at least two practitioners of the activity. After a very brief introduction to the CIAS approach and the concepts of the generic framework (Figure 2.11), the researcher starts up the software³ and asks each practitioner to describe an instance of their practice of the activity. A dummy contextual element is created at the outset with a branch for each practitioner's practice. Activities, actions and

³ The open-source software used is available for download on www.cxg.fr.

contextual elements are recorded on the fly as each practitioner describes their particular practice of the activity. Discussion among the practitioners is very likely as they discover differences in practice they were unaware of even if they are close colleagues. It is useful to record the discussion as was done at RPA as some contextual elements tend to be overseen in the first pass. Practitioners can themselves record their practice after a short familiarization with the software.

5.5 Implications for computer science and information systems research

The results of this research have implications for the CIAS paradigm in artificial intelligence and for the Decision Support Systems (DSS) paradigm in management information systems. Both are presented in this section.

5.5.1 Implications for the CIAS paradigm in artificial intelligence

The implications for the CIAS paradigm are twofold. First, the opening up of new domains of application shows that generality is a force of the CIAS paradigm. This is one of the first applications of CxG to organizational learning and performance improvement. The activity of route selection in light rail is complex, the evaluation of performance is politically sensitive, and the leveraging of lessons learned is a real-world problem. The CIAS paradigm proved to be a powerful tool in narrowing important theoretical gaps in the organizational learning and performance evaluation research literature.

The second implication for CIAS is a warning that the higher the level in the organization the more difficult it is likely to be to get up-take. This was seen in the case study. At operational level, CIAS support in the form of CxG driven meta-data for tagging project documents with contextual information might well be implemented at RPA when the economic situation improves. However the reticence to use contextual graphs in Board papers is more likely to only be overcome if the request comes top-down. Contextual graphs are an interesting tool for introducing transparency in governance. Boards of Directors may find it useful to impose the representation formalism on their CEOs.

5.5.2 Implication for the Decision Support (Systems) paradigm in Management Information Systems

The main implication of this research for the Decision Support (Systems) (DS(S)) paradigm is to highlight the fecundity of inter-disciplinary research across computer science and management information systems and more specifically between the CIAS and the DS(S) approaches. In this research, *decision making* is one of the four contextualizing management activities converging on an emerging realization (Figure 2.13). The path in a contextual graph that represents a practice at the same time represents real decisions concerning the way of realizing an activity that were taken as the activity unfolded. In this way contextual graphs represent real rather than 'reified' decisions.

5.6 Further research avenues

Five specific avenues of future research are presented in Table 5.4. Each avenue of research takes one of the five thesis claims supported by the research and presented in Table 5.3 and explores how these claims could be extended further.

Table 5.4 Building on the current research results	
Thesis claim supported	Avenues of future research
There is an <i>a priori</i> case for extending the context-based intelligent assistant systems (CIAS) paradigm to <i>practice-based organizational learning and performance improvement</i>	The socio-cultural aspects of practice-based organizational learning and performance improvement could be studied by studying the same activity (light rail route selection) in other socio-cultural contexts (RATP/STIF in Paris and MVV in Munich for example)
<i>A representation of practice is eo ipso a performance assessment</i> without causality assumptions	The relationship between representation formalism and causality assumptions could be investigated using contextual graphs to make explicit the assumptions in Balanced Scorecards or Tableaux de Bord.
Practice-based organizational learning is a dynamic equilibrium between assimilation of reality to the activity and accommodation of activity to reality	The practice-based approach to learning could be compared to the communities-of-practice approach using contextual graphs generated in different communities-of-practice
Practice-based organizational learning leads to practice maturity of activities	The qualitative approach to practice maturity could be quantified, for example by tying the practices to taxonomies of activities and best practices
<i>Practice maturity</i> is an expression of practice-based performance improvement	The characterization of <i>strategic relevance of an activity</i> could be studied using contextual graphs within contextual graphs to model a functional hierarchy of objectives

In addition to the specific avenues of research outlined in Table 5.4 there are three general areas of further research that build on the work already done. These are integrating context recording in existing systems for the purpose of *practice-based organizational learning and performance improvement*, maintaining *practice-based organizational learning and performance improvement* information systems up-to-date, and reporting action in context.

Integrating context recording in existing systems and work environments is a manner of supporting real-time acquisition of practice. Once an activity is defined, the identification of contextual elements is a relatively easy task for practitioners. The problem is getting the right granularity of activity. Here research is needed to

determine criteria to guide researchers and practitioners in scoping the activity for which *practice-based organizational learning and performance improvement* are envisaged. In the case of the route selection activity at RPA the scope of the activity was fairly clearly delimited at the operational level, roughly following the transport planning department's remit. However at the top-management level the delimitation of the activity was much more diffuse. Research is therefore needed on both operational activities and strategic activities. A starting point could be the loose definition of an activity with the generation of contextual graphs by different communities of practice within the organization leading to the emergence of tighter definitions of activities. An alternative and complementary approach is to start with a canonical taxonomy of activities in an organization and to develop contextual graphs that fill out the content of the taxonomy.

Maintenance is an issue in all experience-based systems (cf. history of case-based reasoning systems for example) and specific research is needed on the topic for practice-based systems. For practice-based organizational learning and performance improvement systems an additional difficulty is the maintenance of the validity of lessons learned when underlying practices are deemed to be out-dated.

Reporting action in context is a requirement of good governance that is closely related to *practice-based organizational learning and performance improvement*. Once an action is defined, the task of identifying the values of contextual elements at the time of its occurrence is relatively easy. The difficulty is the definition of the action in the first place. Research is needed to determine the criteria for defining the scope of an action.

This section indicates just some of the research avenues going forward from the work done in this thesis. The topics suggested are all amenable to the same research approach used here that is practice-based, interdisciplinary, and human-centered.

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Railway Procurement Agency

Board Meeting 132

Thursday, 27 October 2011

Luas Docklands (Line C1)

Lessons Learned

Red numbers
refer to
Table 4.3 of the
thesis
"Leveraging
lessons learned

Background

Following the successful completion of three Luas light rail extension projects, C1 Docklands, B1 Cherrywood and A1 Citywest, RPA have compiled a Post Completion Review Report which details lessons learned for the projects in accordance with RPA, NTA and Department of Finance Guidelines. The review was done at this stage to allow for an input from staff that have since left RPA or are leaving under the Voluntary Severance Scheme. A total of 80 staff were consulted as part of this review. The review focussed on comparing the final outcome of the implemented project with what was stated in the final business case, which was the project approved by the RPA Board and the Department of Transport. A series of workshops was held to capture the experience of people who worked on various stages of the projects. This resulted in creation of a lessons learned log with 380 items. These were mainly related to operational issues and can be seen as a form of continuous improvement. An example is attached as Appendix 1. It is intended that this log and the reports referred to below will be available to all future RPA project management teams and that lessons learned in implementing Luas Docklands will influence management of those new projects.

Also a total of 16 reports have been generated by the review, giving a comprehensive analysis of the complete project throughout its lifecycle. The reports are as follows:

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|----------------------|--------------------------|-----------------------|
| • Safety | • Quality | • Environment |
| • Human Resources | • Communications/PR | • Risk |
| • Transport Planning | • Procurement | • Finance |
| • Scope | • Programme | • Commercial |
| • Contractor | • Consultant Performance | • Lessons Learned Log |
| Performance Report | Report | (Workshops) |

This paper sets out to critically examine the Docklands project, especially the strategic type decisions that are often taken early on in the project lifecycle. This examination takes account of the lessons learned reports but in some cases it extends outside of the structure of it as the lessons learned was largely related to comparing what was stated in the final business case with the actual outcome. It is proposed to present similar papers to the Board on Luas Cherrywood and Luas Citywest.

The paper mainly sets out to examine the three critical areas that are normally seen as essential to project success namely programme, budget and quality. The paper does not focus exclusively on areas where problems arose as it is important to note where processes worked well in order to highlight the importance of continuing to use them.

Programme

It is useful to simplify the project programme by breaking it into four broad Phases for the purposes of this paper.

Phase 1: This covers the work involved in bringing the project from initial route selection stage to an application for Railway Order (RO). In the case of Line C1 it is reasonable to assume this phase commenced when a decision was made to develop Line C1 as an extension of the original Red Line rather than modifying the Red Line to accommodate Line C1 which was looked at in 2001. This phase, commenced circa April 2002 and a RO was submitted in December 2005 giving an overall period of 44 months.

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Phase 2: This covers the time from the lodgment of a RO to the granting of an enforceable order. In the case of Line C1 this took 14 months from December 2005 to February 2007.

Phase 3: This covers the work involved in preparing tender documentation, the procurement Phase and confirmation of the availability of funding to proceed to construction. It is assumed that this phase ends with the commencement of construction on site. In practice it did extend beyond this date as other contracts were being procured in parallel with construction as they had a later start date. This phase can proceed in parallel with Phases 1 and 2 but the earliest end date is around two months after the end of Phase 2 to allow for the formalization of contracts following the confirmation of the statutory powers to commence the works. Also the end of this phase can be delayed by the time taken to get access to property. Construction work commenced on site about three months after the end of Phase 2 in May 2007.

Phase 4: This phase commences with construction on site and ends with the introduction of passenger service. It includes the time taken to test, commission and carry out trial running. In the case of Line C1 this period took 31 months as construction commenced in May 2007 and passenger services commenced in December 2009.

Using the above high level analysis the overall Line C1 program was 92 months with 61 months taken to get to Phase 4. A lesson learned is that the greatest scope for time savings in any project of this type relates to the time devoted to Phases 1, 2 and 3 and that generally the time allocated to these phases has been very optimistic when compared to the actual outcome. This phenomenon is not unique to RPA projects and it is a common feature of projects of this type.

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In the case of Line C1 the largest delay occurred during Phase 1. This was due to the fact that a strong well-resourced objection to the chosen route arose and we spent a lot of time dealing with this which included carrying out a detailed analysis comparing the chosen route with an alternative of using North Wall Quay. The objectors claimed to favour this alternative route. The analysis and exchanges with the opposition group did not result in any change to the preferred alignment.

At this stage it is opportune to consider whether the philosophy RPA has generally adopted of responding to issues by seeking to reach agreement with stakeholders is always justified, taking into account the delays and the extra costs involved. The rationale for such an approach is to minimize the delays that could arise in Phase 2 and to mitigate the risk that an application for a RO may not be successful. This is a difficult issue for us as different design solutions always exist which could provide the same customer benefits with the possibility that some are more acceptable than others to influential stakeholders. In the case of Line C1, this strategy was successful in that the RO was granted and it was clear that we had dealt with the issues raised by the objectors in a very professional manner. It is difficult

to determine if the same result could be achieved if the RO was submitted earlier. A definite lesson learned is that any programme for Phase 1 activities should have a large provision to allow for delays arising from issues raised by stakeholders, and delays arising from these

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issues should be monitored in order to balance the risk of making an application which might not be successful against the delay and extra cost that arise in trying to deal with these issues prior to submitting the order. Also a strong argument can be made that this phase should be dealt with well in advance of funding for a project so that agreed plans, in as much as this is possible, are readily available for submission for statutory approval as this is likely to result in a much shorter project delivery time.

Phase 2 was dealt with under legislation whereby the relevant Minister was the deciding body for an RO and it was mandatory to hold a public inquiry into an application. As regards programme we felt that the best realistic date for this phase was 9 months. In the case of Line C1 this phase took 14 months. The RO was submitted in December 2005, the public inquiry was held in May 2006, the Inspector's report was produced in July 2006 and the Minister made his decision in December 2006 resulting in an effective order in February 2007 after the expiration of the judicial review period. This phase is largely outside the control of the RPA and in this case the additional time was caused by the time taken by the Minister to set up the oral hearing and to make a decision following receipt of the Inspector's report.

The public inquiry into Line C1 followed a precedent that was created by the first public inquiry into Line A (Tallaght to Abbey Street) and there was good understanding within RPA of the process that would likely to be followed. A thorough checking process was created to check the application before it was submitted as it is important to ensure that drawings, property referencing, the draft order, work schedules and the Environmental Impact Statement (EIS) are correct and co-ordinated with each other. Also a process was in place to assess submissions/objections which were received and to decide how to deal with them. This process ensured that RPA was well prepared for the inquiry and we presented as a capable and professional organisation. The Inspector recommended granting the order and conditions imposed did not create any major problem for us. This statutory approval process is now changed and An Bord Pleanála (ABP) is the deciding body and their approach to oral hearings varies as can be seen when one compares the oral hearings for Metro North with Luas BXD and the proposal for Metro West. It is desirable that we develop a similar understanding, if possible, of the requirements of ABP for RO application and oral hearings.

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Another important point to note is that it is highly desirable if not essential to have support for Luas projects from local authorities given the fact that it uses road space that is controlled by them and that they are planning authority. Both DCC and DDCA were very supportive of Line C1 at the oral hearing and it is highly likely their support was an important consideration by the Inspector in recommending that an RO should be granted for Line C1. A lesson that should be continually applied is that the programme for a Luas type project should allow for the time taken to reach a consensus with the relevant local authorities as there is always a lot of discussion in relation to the detail of an application even if there is an objective at a high level to support an application.

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Phase 3: In relation to funding for the project no delay occurred as the Final Business Case (FBC) was approved about a month after the RO became enforceable.

A strategic issue that always arises in relation to this phase is when it should commence and whether it should run in parallel with Phases 1 and 2. This decision will be largely driven by

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the importance that is given to programme in the high level project objectives as significant time savings will arise if it is run in parallel with Phases 1 and 2. An estimate of the time savings for Line C1 is 24 months as the detailed design and procurement would not have commenced until after the RO was granted. This has to be balanced against the risk that extra costs or unnecessary costs arise due to the possibility that statutory approval might not be obtained, conditions may be imposed on the grant of the RO which may lead to significant redesign or funding may not be received for construction stage of the project. A brief description of the work involved is, the development of a contract strategy, the mobilization of a design team which may involve the procurement of consultants, the production of contract documentation, issue of tender documents, evaluation of tender

proposals leading to contract award. The contract strategy chosen will determine to some extent what is critical in relation to programme in Phase 3 activities. An example is a

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strategy which involves a separate contract for utilities diversion. In this scenario the contractor laying the tracks cannot be given access to the site until the utilities are diverted and the track contract can, therefore, be awarded much later than the utilities and this will affect the time when the design of this work must commence.

Following the announcement of Transport 21 in November 2005 a huge emphasis was placed on delivering the various projects as soon as possible and it was clear that

programme has priority over other issues. Initially we had a concern that we should not commit resources to this phase without statutory approval, given the strong opposition to the

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scheme. With the benefit of hindsight this proved to be unfounded and we could have commenced this phase earlier for some of the contracts especially the design of the main infrastructure contract. While this decision did not delay the overall project delivery date it did reduce the time available for design activities and this may have led to some extra costs at construction stage.

Overall it is necessary to balance the time benefits of the running this phase in parallel with the statutory approval process with the extra costs that may arise. Also the effect on the programme of the contract strategy chosen should be considered as well as the setting of tight time scales for design activities in complex projects with multiple interfaces will force decisions which may have to be changed at the construction stage.

Phase 4: Traditionally a lot of effort is focused on producing and continually monitoring contract programmes in this phase. In the case of Line C1 the most optimistic programme that was produced envisaged opening the line at the end of 2009. This target was achieved

and the line opened to passenger service on 9 December 2009. This required a lot of proactive management of the contractors on site and their active co-operation which was generally forthcoming. Delays arose with utilities contract, there were problems with site access, and there were issues related to giving access to the system contractor earlier that were envisaged. Delays related to access were generally managed by phasing handover to the next contractor once workfronts had completed. Also it was necessary to allow access for testing for Veolia while some construction activity was taking place. Veolia agreed to reduce their contractual trial running period in order to achieve the targeted opening date.

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The input of RPA staff at both the managerial level and the technical level played a significant part in achieving this objective. Overall the achievement of the objective of opening the line in December 2009 was a significant one. Extra costs arose in order to meet this programme objective.

This confirms the need to have experienced staff managing the contracts with the required authority to make decisions bearing in mind the critical objectives of the project and with the ability to manage the often conflicting interests of various parties whose input is required in order to achieve the targeted opening date.

Cost

The approved budget as per the FBC for Line C1 was €98.7 million. The projected outturn cost is €87.1 million. There is now a very high degree of certainty in relation to this figure as the construction works are complete, final accounts have been agreed with the contractors for all the main contracts, all significant properties issues are closed out and the snagging works are complete. The project scope as defined in the FBC was delivered well within budget and this is a very satisfactory result.

There were significant differences between the tendered prices of contracts and the final outturn costs. The contracts where this was most apparent were the utilities diversion contract and the contract for the main infrastructure works. Looking at the project from a high level the first decision that influenced this was the selection of the contract strategy to deliver the scope of the project. An option is to decide on a lump sum contract to deliver the entire scope - a form of turkey contract would in theory have given greater certainty early on into the final outturn cost but it is highly likely that it would not be possible to transfer all the risk associated with these works especially the utilities diversion and the third party type risks such as those associated with the Spencer Dock works and liaison with DCC.

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A useful exercise is to take the chosen contract strategy and comment on whether it was successful bearing in mind the overall result. The objective of delivering the project in the

shortest time possible was one of the main factors that influenced the selection of the procurement strategy. Also it is normally the situation that the more individual contracts on a project the more interface management is required by RPA and the more risk that interface difficulties will lead to increased costs. On the other hand interfaces issues are not eliminated by having fewer contracts but they have to be managed by another entity and this should be reflected in contract prices. The list below includes the main contracts associated with C1 but the minor contracts are not included.

Rolling Stock

At the time that Line C1 procurement strategy was being determined we had a requirement for rolling stock for four projects and a decision was therefore made to procure rolling stock for all these projects as one contract. This was a very sensible decision as it brought economies of scale and it avoided the possibility of having separate types of Rolling Stock on the Luas system. Also we had a good understanding of the interface issues that existed with the infrastructure and we had staff who were capable of managing them. Overall this worked very well and the Rolling Stock was provided to the Line C1 project within budget and no interfaces issues that caused problems arose during the construction phase of the project. The ticket vending machines and the stop furniture were procured using a similar approach in order to ensure consistency across all lines and to get the benefit of larger orders.

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Bridges

The project required the modification of an existing bridge at George's Dock and the construction of a new four lane bridge over the Royal Canal at Spencer Dock. These were procured as two separate contracts as the Georges Dock was on the critical path due to its location. Trackwork was also installed at Georges Dock Bridge by the bridge contractor.

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The bridge at Spencer Dock is an interesting example of issues that arise with planning authorities. The bridge that received approval at the RO was a bow string arch and this had been selected following a series of workshops with RPA, our consultants and DDDA. Following the grant of the RO and a change of personnel within the DDDA, the DDDA lobbied to get this changed. The bridge was constructed to a radically revised design using pre-stressed concrete to a very pleasing flowing design. Planning permission was granted for the change by DDDA, under their streamlined procedures. DDDA contributed [REDACTED] towards the extra cost but it is likely that extras costs over this figure arose because of the design change. The bridge has received two architectural design awards. However design changes made close to procurement stages of a contract will lead to extra costs and should be avoided if possible. There were no major interface issues with other contracts that led to increased costs and the contract was well managed by RPA

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Utilities

Utility diversions always present major challenges given their complexity. There are multiple reasons for this such as the problem in determining the locations of utilities, the diversion of them often involve complex sequencing which is affected by traffic and pedestrian management, finding space for them is often a challenge, the utility companies have their own statutory rights to be in the streets, design standards are applied in relation to clearance that are not complied with in the current network, utility companies have constraints in relation to external parties that bind the companies to minimum performance levels which affects when/how they will allow work on their networks etc. This creates a formidable project management challenge. The most recent notable example of this is contained in a report by the *Scottish Audit Office* into the Edinburgh light rail project where they estimated that problems with utilities have led to a cost increase to the project of £67million (€76.6 million at current exchange rates).

The budget for utilities as per the FBC was [REDACTED] consisting of [REDACTED] for a utility diversion contract, a risk provision of [REDACTED] and a direct payment to utilities for works carried out of [REDACTED]. A contract was awarded to [REDACTED] for utility diversions in May 2007 for [REDACTED] under the FIDIC red book which is based on a design by the client and is a re-measurable form of contract. In November [REDACTED] submitted a claim for [REDACTED] and the final account was settled for [REDACTED]. This is a significant increase over the tendered sum. Some of these costs related to scope increases where for example works originally intended to be carried out by utility companies directly were done by [REDACTED] and works originally intended for the main infrastructure contractor were carried out by [REDACTED]. These resulted in a saving to these contracts and were instructed in some instances to meet the target opening date. Claims arose in relation to accelerations costs, extension of time and delay and disruption costs, traffic management changes and responsibilities. Overall the final outturn cost for utilities of [REDACTED] which was well below the budgeted figure of [REDACTED].

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The lessons are:

- Contracts for the diversion of utilities should have a large risk figure attached to them allowing for the form of contract used.
- It is highly unlikely that it is possible to transfer all the risk associated with utility diversions to contractors or if it were possible that value for money would be achieved.
- It is very difficult to produce a design that will not be changed during the construction stage.
- Difficulties with unforeseen utilities still arise despite extensive exploratory investigations. An example is the fact that the base of a large four metre deep manhole conflicted with

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the top of an old brick arch sewer. RPA was not aware of the existence of the sewer until construction was underway.

- Scope changes instructed during the construction phase are likely to be more costly than if they were included in the original tender.
- There is a major project management challenge in dealing with utility companies during the construction stage as programmes are constantly changing. There were up to 17 different entities with utility plant on the Line C1 project.
- Reaching agreement on traffic management to meet the requirement of the contracts when viewed from a financial perspective will always be a challenge.
- Issues arise with abandoned utility plant.
- A form of contract that incentivises efficient working between client and contractor and recognizes the risks involved might be a better approach for utility diversions.

Property

One could see this element of the project as simply implementing the Compulsory Purchase Orders (CPO) as per the RO. This is a very unwieldy and often an expensive mechanism as it does not allow for the benefits of the project that accrue to the seller of property particularly developers, it does not allow for the shared use of space which can apply with a light rail scheme and the compensation for injurious affection and disturbance can be significant. All the land required for the scheme was referenced but it was intended that land would mainly be acquired by agreement rather than by exercising the CPO. The figure included in the FBC for property acquisition was [REDACTED] and the actual outturn cost is likely to be [REDACTED]. However significant extra costs were incurred in carrying out works as part of a property deal and property issues occurred which led to increased costs.

There were two significant parcels of private land required for the scheme:

- Land at Spencer Dock where the freehold interest was owned by CIE with an agreement in place with [REDACTED] allowing development on this site. This company was controlled by [REDACTED]. There was a condition attached to the planning permission for this stating that land should be provided free of charge for Luas Line C1. This site was effectively controlled by [REDACTED] at the time construction commenced on Line C1. At the oral hearing CIE had no major objection to Line C1. They asked that an underground substation should be moved 25 metres to move it further away from Dart Underground (DU) and that a leasehold interest in the property should be obtained by RPA as they needed the substratum of the land for DU. At that stage it seemed that agreement was reached and that any dealings should be with [REDACTED] in relation to construction. Construction of the substation commenced on site as [REDACTED] allowed access for these works while

a detailed agreement was under negotiation in relation to construction of the main railway works. At that time they had significant construction on site themselves including the conference centre and ultimately an agreement with complex access arrangements were agreed with them which worked to the benefit of both parties. It seemed that [REDACTED] felt that they had the right to allow us access under their agreement with CIE. CIE became aware of this well into the construction and they threatened to seek an injunction to stop our work. At this time their design for DU was more advanced than at the public inquiry stage and they were probably motivated by a desire to pass the risk of any future ground settlement to RPA. Unfortunately this happened on the same day that an agreement was to be signed with a company called [REDACTED] in which [REDACTED] also had a controlling interest. This led to [REDACTED] refusing to sign the agreement until the [REDACTED] agreement was also signed presumably because they felt that they had more leverage over RPA in relation to the [REDACTED] agreement and that CIE may have been legally correct in relation to access to Spencer Dock. This led to increased costs as a contractor had mobilized to carry out work associated with the [REDACTED]

deal and had to demobilize to some extent. A license agreement was signed with CIE allowing access for construction and it reflected the need for an agreement with

[REDACTED] as well as provisions in relation to DU. A formal lease for the lands has yet to be signed with them despite repeated efforts by RPA to finalise arrangements.

- Land owned by [REDACTED] which was situated at the Point Stop. No formal agreement was signed with them in advance of submitting the RO which created a risk that the CPO type cost could arise if we could not reach agreement with them. In preparing the capital cost estimate for the FBC a figure of [REDACTED] which includes a risk figure was included for this property. This was the opinion of our property advisors at the time and they later stated that this figure could be over [REDACTED] following the receipt of a letter from [REDACTED] seeking compensation of [REDACTED] reducing to [REDACTED] if RPA provided an underpass under the Luas line. We therefore formed the view that we could not take the risk of acquiring this land using the CPO. Negotiations commenced with Wintertide at which we stated we had no option but to terminate the line at Spencer Dock if that was the cost of land to us. DDDA were very supportive of our position in this regard and a deal was ultimately signed with [REDACTED] under which we agreed to pay [REDACTED] (including fees) for the land and agreed to carry out significant underground piling works as part of the main track infrastructure contract, which allowed for the linking of their site at this location which was severed to some extent by the Luas Line. The estimated cost of the works was [REDACTED] but increased significantly due to the discovery of

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contaminated land on the site. We also arranged to give access to the site along the Luas line from Castleforbes Street.

The lessons to be borne in mind is that in situations where it is not intended to use the CPO process an agreement should be reached, if possible, with the relevant landowner in advance of lodging an RO as a lot of leverage is lost if an RO is received and construction has commenced. This is likely to be more successful if a developer is gaining a benefit from the scheme. Also people who are referenced for CPO acquisition are nearly always contacted by advisors in relation to the claims for compensation they can submit which can result in a much higher compensation. Another advantage of finalizing an agreement in advance of lodging an RO is that provision can be made for accommodation works that facilitate a commercial deal. At this stage it is difficult to state if RPA could have signed an agreement with [REDACTED] in advance of lodging an RO. The crisis caused for RPA by CIE's threat of legal action had major programme and financial consequences for RPA and the project. We had endeavoured to get the assistance of the Department of Transport in dealing with the matter, but to no avail.

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Also we should be skeptical of estimates by property advisors and we should check that they have fully allowed for all costs that could arise in a CPO process. These advisors are normally used to pricing property transactions where there is a willing buyer and a willing seller.

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Special Trackwork

A contract for the supply of special trackwork for the Connolly delta was signed with a supplier in advance of the main infrastructure contract due to the long lead times involved. This was done in order to meet the programme as the Connolly Delta had to be installed in the summer of 2008 during a planned closure of the stops at Busáras and Connolly. Also agreement had been reached with DCC to restrict traffic in Amiens Street during this period. There were some issues with the material related to insulation which contributed to extra costs that arose in meeting the tight timeline for installation of the Connolly delta.

A lesson is that RPA should avoid supplying complex material to contractors for incorporation into the works within a tight timeframe. In case of this particular situation it was unavoidable because of the need to meet the project programme.

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Control Systems

This element of the work relates to the various control and operational systems that are required to operate a modern light rail system. Examples are the systems that are required

to provide passenger information at the stops and vehicle location systems. Also it is necessary to integrate these into an operating interface without disruption to service. A problem arises in integrating new lines into existing systems as the choice that often exists is to use the existing system which implies a lack of competition for this element of works or procure a new system which is retrofitted to the existing lines. The nature of this work is also very specialised and there are a limited amount of contractors that can supply such a system. A decision was made that the scope of works of the systems and infrastructure contractor for Line B1 would include the option for provision of a system that could operate the existing network and that provision would be made for variations to this contract whereby the contractor would also provide this service for other new lines on the network. This provided operational certainty to RPA and eliminated the risk of completing systems not integrating with each other. Therefore the infrastructure contract for Line C1 did not include a system element and RPA managed this interface. In contrast to the Rolling Stock control there are numerous interfaces to manage and co-ordinate with this contract strategy. This contract strategy did work and good co-operation was achieved in order to meet the targeted opening date. However design changes were required during the construction phase of the infrastructure contract which increased costs.

The lessons to note are that the contractor is quoting for work as a variation to an existing contract and they are in a good position commercially unless the scope of the work is well defined in the initial tender. This will not always be possible. Also it is desirable that this mechanism includes for an input from a systems contractor into the design of infrastructure contract before it is issued for tender.

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Main Infrastructure Contract

This contract covering the laying of all the physical infrastructure for the systems such as the track works, the points and crossing, the electrical power system, the stops, the surfacing along the route. The form of contract used was the FIDIC Red Book which is a re-measurable one and where the contractor builds to a design provided by the employer. The decision to opt for an employer design was influenced by the problems encountered by the contractor on the original Luas contracts under the FIDIC Yellow book where the design is provided by the contractor. They had major problems with producing a co-ordinated design and they commenced work on site without a complete design which resulted in a lot of inefficient working and unnecessary disruption. The option of a client design did not fully eliminate these problems but it definitely allowed the employer to respond quickly to issues as they arose in order to meet the project programme.

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The initial tendered sum for this contract was [REDACTED] and the final account was agreed for [REDACTED] following the submission of a final account by the contractor for [REDACTED]. This was a significant increase over the initial tendered sum. One of the reasons for the increase was due to extra costs incurred to implement the [REDACTED] deal and extra works carried out to comply with CIE requirements in relation to DU. These extra costs were in the order of [REDACTED].

Design variations arose due to requirements of DCC and IFMS, due to the discovery of uncharted utilities, utilities at different locations to that predicted especially in relation to their actual depth below the surface, errors in the design, phased handover of the site from the utility diversions contractor, dealing with interface issues with third parties, changes made to accommodate the system design. These costs were estimated to be [REDACTED].

Other estimated cost exposures arose under the following headings:

Third party requirements	[REDACTED]
Acceleration costs	[REDACTED]
Delay costs	[REDACTED]
Increased contract preliminaries	[REDACTED]
Total	[REDACTED]

We, therefore, valued the contract at [REDACTED]. The contractor as one would expect had a different view. Initially a panel with two representatives from RPA and two from the contractor was set up to work their way through each outstanding item. This commenced with the Bill of Quantities which should have been the easiest element. Progress was extremely slow and following another period of negotiations the final account was agreed at a sum of [REDACTED].

Overall it seems that these costs could not have been avoided once the contract was entered into. We would have undertaken the [REDACTED] works, even if we were fully aware of the extra costs associated with the contaminated ground, given the large cost exposure of acquiring the land by the CPO. It would have been possible to avoid some of the costs caused by the CIE if a formal agreement had been concluded with them at the public inquiry. This would not have been an easy task as for example a lease for the lands is still not finalized with them and at time they were not focused on the settlement risk associated with the DU project.

The acceleration costs were necessary as the primary objective of the project was to achieve the project programme and some of them, such as the Connolly delta, were in reality essential.

This element of the project did not have sufficient budget provision for it in the FBC. This was partly due to reliance of rates in the original Luas contracts and in particular the cost differential between laying tracks in a street environment and the more open suburban area.

The lesson is that laying light rail in a street environment where access to the site is severely restricted has a lot of risk attached to it. Provision should be made for this risk in the cost estimate. It is unlikely that a contractor will enter into a contract where all this risk is carried by them. It is extremely difficult to avoid a myriad of small design changes which can have significant commercial effects as for example it may not be possible to comply with agreed traffic management arrangements.

Quality

The most important quality item is that the system achieves its primary objective of delivering public transport safely and reliably. This was achieved as the commissioning, trial running went very well and there were very few issues which were resolved quickly when the system commenced passenger operations.

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All the passenger information system and operating systems were successfully commissioned such that they were available on opening day. This was a major achievement as Line C1 became the first line that was incorporated into the new operating system and complex interface issues arose given the contractual structure that existed.

The final traffic management design has worked well particularly the decision to close the Mayor Street arm of its junction with Amiens Street to all traffic except trams. This could not have happened without the agreement of DCC and DDDA.

Safety approval was achieved from the Railway Safety Commission (RSC) prior to commencement of operations and the system has operated safely since it commenced operations in December 2009.

A high quality of finish was achieved particularly with the surfacing and the stops.

The complex control arrangements which were required for the Connolly delta have operated very well.

Funding and Operating Costs

The FBC envisaged the receipt of levy contributions of [REDACTED] at 2005 prices towards the capital cost of Line C1 and that a direct contribution of [REDACTED] would be received from the DDDA which was related to the return of money paid for the acquisition of Connolly ramp for the original Red Line and [REDACTED] would be received from SDDC as a contribution towards the cost of constructing the bridge across the Royal Canal. The direct contribution of [REDACTED] was received and the levy money we have received to date amounts to [REDACTED]. This excludes a figure of [REDACTED] which we had to return following the outcome of a High Court case challenging the grant of planning permission by the DDDA for a development by the [REDACTED] group.

Since the project commenced construction in 2007, the economic downturn has inevitably affected patronage but the passenger numbers using the extension are good and have performed better in patronage terms than would have been expected from the business case forecasts. This is due to fact that events at the O2 and Grand Canal Theatre are boosting patronage. Also one would expect that the undeveloped area adjacent to Line C1 will develop rapidly when economic conditions improve given the existence of the Luas and its proximity to the city centre. The 2011 Census of Population results show that the growth in population in the Luas Docklands catchment area was greater than anywhere else in Dublin and that the density of population is at a level that fully justifies investment in light rail. The close integration of land use and transport planning is one of the major achievements of the project.

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Project Management

Line C1 was the first line that opened using the new RPA project management (PM) procedures that were developed following the completion of the original Luas lines. These did achieve a correct balance of allowing the Project Manager and his team to get on with day to day management of the project while an oversight is maintained by the Board.

The PM systems required the preparation of a detailed scope definition in order to develop a robust cost estimate with an appropriate risk provision and any subsequent changes in scope required Board approval. The cost estimating procedure has a procedure to evaluate the risks and include them as a line item in the estimate. Risks are items that the project team can identify as difficulties that could arise during the course of the project delivery. We also have a requirement to add a provision for contingency which is to cover items that are unknown. The expenditure of this element is reserved for the Board. There is often pressure especially when funding is tight to take a more optimistic view in relation to cost estimation especially in relation to risk and contingency. We should be wary of changing our

current approach. It ensures that the project appraisal is based on a capital cost with a high level of certainty and that appropriate funding is available for a project. It does not mean the entire funding should be expended. A lesson from Line C1 is that one could envisage a credible scenario where it would have been necessary to use some of reserved contingency.

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Another item the Board needs assurance on is that the budget, programme and quality are being delivered. This is largely dependent on the quality of the project team and on the reports that are produced. Cases often arise where reports are produced where the actual exposure is not reported due to the fact that an optimistic view is taken on the value of claims or due to the fact that it is difficult to evaluate the merit of some claims without seeing all the detail of the contractors' position as they always submit exaggerated claims as a starting position. In the case of Line C1 the reporting was to a high standard and an overall summary of the reporting from early on in the project was that we had a high level of confidence in delivering the project within budget but there was a concern about the programme.

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Another thing worth noting is that RPA had effective control of the project and we were reasonably free to manage it and we did not need to seek approval from any third party if the project was being delivered within budget. This made it easier to develop a strategy in relation to dealing with issues as they arose. This has now changed given the project management procedures that NTA have imposed on us where one could need approval to issue variations. They have exercised these procedures in a pragmatic manner to date but that may be due to the fact that they inherited these projects from the Department of Transport. This issue is likely to be a challenge in the future as dealing with difficult contractual issue is often a matter of judgment and the more parties involved the more difficult it is. This could lead to a practice of letting the procedures in the contract determine the outcome such as the use of adjudication. This seldom leads to the best overall outcome given the extra costs involved in resolving the disputes and fact that few issues are black or white.

Conclusion

Line C1 is a success project as it was delivered within time and budget and to a high standard.

In a project of this magnitude and complexity, issues arise that need proactive management.

We had a very competent PM team on this project and a lot of the experience gained on the original Luas lines was reflected in how this project was managed.

It is a difficult if not impossible task to produce a design that will not need to be changed during construction. This reality should inform the form of contract for implementing projects such as this and the project management procedures to be used by the infrastructure agency.

There are significant risks attached to building light rail in city centres and the budget and proposed programme should make an adequate provision for these risks.

The active involvement and cooperation of the relevant local authority is essential to the success of a light rail project.

Frank Allen

18 October 2011

Appendix 2: Leveraging lessons learned in organizations FOR INFORMATION

Railway Procurement Agency

Board Meeting 136

Thursday, 23 February 2012

Luas Cherrywood (Line B1)

Project Review

Numbers in red
refer to Table 4.5
in the thesis
"Leveraging
lessons learned in
organizations"

Background

Following the successful completion of three Luas extension projects, C1 Docklands, B1 Cherrywood and A1 Citywest, RPA have compiled a Post Completion Review Report which details lessons learned for the projects in accordance with RPA, NTA and Department of Finance Guidelines. The review was done at this stage to allow for an input from staff that have since left RPA or are leaving in 2012. A total of 80 staff were consulted as part of this review. The review focussed on comparing the final outcome of the implemented project with what was stated in the final business case, which was the project approved by the RPA Board and the Department of Transport (DoT). A series of workshops was held to capture the experience of people who worked on various stages of the projects. This resulted in creation of a lessons learned log with 380 items. These were mainly related to operational issues and can be seen as an input to our continuous improvement. An example that relates to Line B1 is attached as Appendix 1. This log and the reports referred to below will be available to all future RPA project management teams and it is intended that lessons learned in implementing these projects will influence the management of any new projects. Overall these lessons learned reports have focussed more on day to day operational type issues and are therefore too detailed for a Board paper. Also there is a greater emphasis on detailed design and construction issues which mainly occur at the latter phases of a construction project.

This paper sets out to critically examine the Cherrywood project, especially the strategic type decisions that are often taken early on in the project lifecycle. It also addresses the view expressed at the Board meeting in October, following a discussion of a paper on lessons learned on the Docklands line, that the papers on B1 and A1 should also review the importance and impact of Board decisions. This paper mainly focuses on this aspect by outlining the development of the project with a commentary on the most critical events and the involvement of the Board in these events. All the minutes of Board meetings since the establishment of RPA on 28 December 2001 were examined for items dealing with Line B1

and all Board papers related to B1 were read as well as correspondence in relation to some of the critical items referred to. A route map of Line B1 is attached as Appendix 2 to aid an understanding of some of the items raised.

Initiation of Cherrywood Project

A significant amount of work was carried out on Line B1 prior to the establishment of RPA in December 2001. Prior to the establishment of RPA the Luas projects were managed by the Light Rail Project Office (LRPO). The LRPO was essentially a project team under the control of CIÉ and it had no independent statutory basis. CIÉ had an ambivalent attitude towards light rail and they did not, apart from the LRPO, proactively engage in promoting it. The CIÉ Board approved items such as the submission of Railway Orders (RO) and award of contracts on the basis that they were acting as agents of the Department of Public Enterprise.

In 1999 a group of developers and Dún Laoghaire Rathdown County Council (DLRCC) under the auspices of Dún Laoghaire Chamber of Commerce engaged consultants Peter Bacon (PB) and Associates together with Steer Davies Gleave (SDG) to examine the feasibility of extending the proposed Light Rail line to Sandyford further southwards to serve the Carrickmines/Cherrywood area. They proposed an alignment which diverged at Sandyford from the disused railway formation of the Harcourt Street line and ran along the Ballyogan Road resulting in two crossings of the then proposed South Eastern Motorway which is now part of the M50. They also developed a proposal to fully fund it based on the provision of land by developers and a bond which would be financed by development levies. They carried out this study independently of the LRPO.

In 2000 they approached the LRPO to progress the development of the project and discussions took place with them. The result of this engagement is that they agreed to pay for the cost of a feasibility and route selection report as LRPO felt that their report was not sufficient to support an application for an RO and also that their estimate of the capital cost was too low. This report was completed in March 2001 and it was project managed by LRPO with inputs from McHugh Consultants, Mott MacDonald, SDG and PB. The payment to LRPO for this work was channeled through the [REDACTED] Group. At this time [REDACTED] was the Managing Director and he was one of people who was actively promoting the line in co-operation with other developers. The study was carried out in accordance with procedures which had been developed by the LRPO based on experience of ROs which had been submitted up to that date. In relation to the alignment the LRPO preferred alignment was via the Ballogan Road using a reservation that was a condition for development at Central Park and it also proposed using a reservation for a roadway that existed to the south

of Glencairn Stop. At that stage it was likely that it would be necessary to acquire and demolish a house called Clonlea House to accommodate this alignment.

The capital cost was estimated at €184.5 million as against a cost estimate of €56 million in the original PB report. The study indicated that an alignment along the Ballyogan Road had a positive benefit to cost ratio.

Under current RPA procedures the alignment decision would have required Board approval.

There is a strong argument that the strategic decision to divert the alignment off a more direct route was the correct one as it now serves the large development in Central Park and the then existing and proposed developments along the Ballyogan Road. The alternative via the Old Harcourt line would have served an area with a low density of development and Leopardstown Racecourse which is highly unlikely to be developed.

1

In Spring 2001 the developers formed a company called [REDACTED] to progress the development of the Cherrywood line. They appointed a fulltime Chief Executive and technical advisors and [REDACTED] became Chairman. The developers involved were [REDACTED], [REDACTED], [REDACTED], [REDACTED] and [REDACTED] who owned about 4 hectares of land adjacent to what is now Carrickmines Stop and with hindsight could not be described as developer in a similar fashion to the others. They all owned land in the catchment area with [REDACTED] as the largest as they were contributing 41% towards the cost of [REDACTED]. Some developers in the area did not participate in [REDACTED] apparently taking the view that they could get all the benefits without incurring any costs.

[A consortium of developers]

[REDACTED] agreed to fund the cost of preparing a RO application and the LRPO mobilized a team to do this work. The expenditure involved was of the order of €2.1 million. Discussions also commenced on how they could contribute towards the cost of constructing the project. Also DLRCC were heavily involved in the development of the project and a sense emerged that the three parties should co-operate to ensure that the project was delivered. DLRCC produced a draft Local Area Plan (LAP) for the Stepside area (south of Ballyogan Road) which was later ratified and a draft LAP for the Carrickmines area which did not materialize. [REDACTED] were reasonably effective and they did help to resolve issues of detail between LRPO, DLRCC and individual developers even if some delays did result in the finalization of RO documentation due to difference between the parties.

2

Developments from 2002

The first mention of the Cherrywood line in the Board minutes was those related to February 3rd 2002 where it was recorded that the Chairman had a meeting with [REDACTED] and that the acting Chief Executive should prepare a briefing note as it was proposed that [REDACTED] would make a presentation at the next Board meeting. [REDACTED] and DLRCC made a joint presentation to the March Board where they made an offer to fund 50% of the cost based on a capital cost of €152 million. The feedback from the developers and DLRCC to the RPA project team was that the Board were not positively disposed towards the project as it might not be compatible with the proposed Metro proposal from the Airport to Shanganagh. The minutes of the Board meeting were not that negative and there is a sentence stating *“it was agreed that this (material received from [REDACTED]) would be studied by RPA with a view to arriving at a decision at an early date on the RPA attitude to the proposal”*. Ultimately this misunderstanding did not create any difficulty and work continued on producing the documentation required for the RO and on the commercial discussions. The possibility of using levies as authorized by the 2000 Planning and Development Act as a funding mechanism was considered and DLRCC were favorable to that idea. The documentation for the RO was effectively complete by August 2002 apart from some property referencing.

At the September 2002 Board meeting a presentation was made on the B1 line and the Chief Executive was authorized to revert to [REDACTED] and DLRCC indicating our interest in the proposed project subject to the achievement of satisfactory commercial terms and the agreement of the DoT. Discussions took place with DLRCC and [REDACTED] and a paper which was presented to the October Board was approved. This involved the acceptance of a commercial deal and the application for an RO to the Minister for Transport. The deal was based on the making of a levy scheme for the line at agreed rates, the provision of upfront contributions of €78 million which would be later offset against the levy payments. The deal involved reaching agreement with the [REDACTED] Group on the provision of some infrastructure and land and an agreement with [REDACTED] in relation to the provision of land for a park and ride and a contribution towards the capital cost of it. The capital cost was estimated at €222.3 million at May 2002 prices.

The DLRCC County Manager commenced the necessary statutory procedures to implement the levy scheme at their meeting in October. Around this period [REDACTED] gained control of the [REDACTED] Group. This fundamentally changed the relationship within [REDACTED] as the [REDACTED] style was not conducive to working in a group where there was a need for consensus. At the RPA December 2002 Board meeting a proposed heads of agreement with [REDACTED] was discussed and approved. However at their Board meeting in December [REDACTED] were unable to ratify the proposed heads of agreement due to the fact that [REDACTED]

were not prepared to commit any funds to the project. The DLRCC County Manager deferred consideration of the levy scheme which was due to come before the council members at their December meeting due to the lack of support from [REDACTED] for the project. This was a very disappointing result given all the work that had been done to ensure that the three major parties in the project ([REDACTED], DLRCC and RPA) were committed to the project and it put the development of the project in doubt.

Also a further issue had arisen in that a joint venture between [REDACTED] and [REDACTED] was due for renewal. They controlled a significant amount of land in the Cherrywood area in conjunction with DLRCC and had an agreement in place whereby they shared the costs and benefits of development in the area. As a result of this [REDACTED] became more involved in [REDACTED] and it was apparent that Dunloe and British Lands were not in agreement on how development would take place in Cherrywood.

A meeting was arranged with the DLRCC County Manager in January 2003 where a range of options including cancelling the project was discussed. A relevant factor at this stage was the proposed issuing of the DLRCC draft development plan. The County Manager put the levy scheme before the members in January and it was approved. This was a very positive decision by the County Manager as DLRCC made their commitment to the project without any definite commitment from the other two parties. Also the idea of making the development of the town centre in Cherrywood contingent on the provision of Light Rail was discussed. The Board was informed of these developments at the January and February meetings in 2003.

A brief narrative outlining subsequent developments in years 2003 to 2006 is included below. This is mainly based on a review of Board papers and minutes.

2003

1. [REDACTED] bought out the [REDACTED] interests in the Cherrywood lands.
2. A lot of detail was examined in relation to modifying the deal with [REDACTED] including examination of the capital cost estimate, differing estimates of the levy yield, the value of their land interests, the possibility of them carrying out some of the works required for the scheme, the scope of works that should be included in their funding requirements, value of work carried out in Central Park to facilitate Light Rail, betterment value due for works that would be carried out for statutory bodies particularly DLRCC. The overall objective was to achieve a 50% sharing of the capital cost between the public and the private sector.

3. A decision was made in October 2003 authorizing the executive to write to [REDACTED] that a proposal we had received from them was not acceptable but we were open to discussions on an agreement that was broadly in line with that approved by the Board in December 2002.
4. It was becoming apparent that [REDACTED] was having difficulty in arriving at a consensus in relation to submitting proposals to us.
5. RPA established direct relationships with all of the principals of the development companies involved in [REDACTED].
6. DLRCC were kept informed of developments
7. By December following negotiations we received a letter from [REDACTED] outlining a proposal which was presented at the December 2003 Board meeting. The Board approved the continuation of negotiations with [REDACTED] on the basis of this proposal. However by January 2004 it appeared that certain members of [REDACTED] were not in agreement with the proposal they had sent us. This was further confirmation of disagreement among the developers.

2004

1. It became clearer that [REDACTED] would be unable to deliver agreements to RPA that would bind the developers legally. We wrote to them frequently requesting that they clarify their position. The last formal response was in June 2004.
2. [REDACTED] presented proposals for the proposed Town Centre in Cherrywood which involved extending the line to the south side of the Wyattville Road. Also they indicated that the provision of Luas was essential to their development proposals for the area.
3. It seemed to RPA that [REDACTED] had effectively withdrawn from active participation in [REDACTED] and they were engaged in bilateral discussions with the other developers.
4. Difficulties arose between the developers in relation to the location of stops and the extension to the line as proposed by [REDACTED]. [REDACTED] undertook to find a resolution to these issues.
5. A level of confidence developed that we could make progress and teams were mobilised to commence work on updating the RO which had been completed in August 2002 and on preparing an Outline Business Case (OBC) for the project.
6. A mechanism developed whereby we felt we could make progress by concluding agreements with [REDACTED] and individually with the various developers and if possible DLRCC. Discussions were held with the developers to progress these and this culminated in a detailed submission to the Board in September 2004 in relation to each individual agreement. The finalization of agreements with the individual developers and [REDACTED] in accordance with the submission was approved. At that

stage the agreement with [REDACTED] was more of a framework agreement whereby they were to use their best endeavours to ensure that their members conclude agreements with us with only one real commitment related to contributing €405,000 towards the cost of updating the RO for Line B1.

7. At the October Board meeting, approval was received to finalise the OBC for submissions to the DoT in accordance with a presentation that was made. This outlined the scheme details, the capital cost, proposals for funding, the procurement strategy, and the high level risks attached to the project.
8. RPA became aware that the various developers were questioning the value of continued active existence of [REDACTED] and in fact they were unable to deliver on the €405,000 and they ceased to play an active role in Line B1 developments.
9. In November 2004 we wrote to the developers individually asking them to contribute a stated amount which collectively summed to €405,000 and also asking them to confirm that they were in agreement with a proposed scheme plan. The letter also mentioned our requirement to conclude bilateral agreements in advance of submitting a RO for Line B1. All of the developers eventually responded with the agreed amounts and stated that they were in agreement with the proposed scheme plan. At this stage RPA took on some of the roles of [REDACTED] especially in relation to keeping the developers informed on progress. Also we received an extra amount of €50,000 from [REDACTED] to cover the fact that the other developers felt they should bear this extra cost given the changes they had requested. Also at that time [REDACTED] had agreed to provide us with a structural design for a proposed viaduct in Cherrywood.
10. [REDACTED] was appointed as Project Manager with a remit to manage the detailed design and procurement of the project as well as the construction.
11. An open day was held in Dún Laoghaire in December to inform members of the public in relation to the project and to discuss any concerns they might have. Overall the response was very positive and this was hugely influenced by the fact that the Red and Green lines had commenced operations during 2004.
12. Work commenced on finalizing legal agreements with the individual developers. This proved to be a very time consuming and onerous task. This was due to the difficulty in getting the various developers and their legal teams to engage with us and due to decision we made to sign detailed agreements. We decided to draw up contracts for sale for all the lands that were required for the scheme rather than an option to purchase the lands. That meant that all the detail in relation to title was dealt with and this proved to be time consuming. Also detailed development agreements were negotiated where developers were to provide infrastructure for us at Cherrywood and Carrickmines. Also issues arose that we had assumed had been sorted within [REDACTED]. One example relates to Central Park where we felt we should get land for free as it

was a condition of planning. Issues were raised in relation to the condition as it was not correctly phrased in relation to the geography of the site, questions as whether it was legally enforceable, possibility of compensation for work carried out on a car park roof to accommodate Luas, genuine difficulties in relation to carrying out our work and theirs and the need to deal with different sequencing options, complications in relation to Line B1 levy as they had planning for development which did not attract the levy and the fact that we needed access to stop from the adjacent public road network.

2005

1. Work progressed on the finalization of the necessary documentation for an RO such as alignment drawings, property drawings and the EIS.
2. The Board made a site visit to the B1 line in February where a briefing was provided by the project team on the key issues.
3. The awarding of various contracts was approved by the Board such as the provision of consultancy services, site investigation works and provision of insurance.
4. The OBC was submitted to the DoT and they indicated they were in favour of the scheme. Discussions were held with the NDFA in relation to funding for the scheme and a proposal emerged involving direct exchequer funding minus any funds that were available because of direct contributions from developers and any levies received prior the completion of the construction. Some of direct exchequer funding was considered a loan which would be become repayable as levies were collected.
5. The Board at its April meeting approved the lodging of an RO for Line B1.
6. RPA agreed that all the agreements with the developers would be held in escrow by [REDACTED] solicitors and that we would not sign them until we had received signed agreements from all the developers. The process of finalizing the various legal agreements was a difficult and time consuming process particularly with [REDACTED]. Extensive negotiations took place with him including one session which went on through the night. The first ones were signed by [REDACTED] in April and they were all finally signed by October. There were a total of 18 separate agreements. This was the achievement of a major milestone for the project as it allowed for the submission of an RO and it ensured significant financial contributions towards the project.

It is useful, given subsequent developments to provide a brief outline of the agreement with [REDACTED]. In the original [REDACTED] deal he was providing a relatively small parcel of land which was required for a substation. However he purchased a section of the formation of the Old Harcourt Railway including the Old Station House

at Carrickmines and these lands were needed for Line B1. We commenced negotiations with him with a view to having an agreement to purchase his strip of land as well as an extension to the Old Station House which had to be demolished to accommodate Line B1. The deal was based on a land valuation we had from 2002 and one of the reasons for delays related to his view that this was a low valuation. He did ultimately broadly agree to this valuation subject to an agreed inflation rate of 8% from February 2006. We assumed we would be able to close this sale without incurring of a lot of extra costs due to the inflation provision. There was a clause in the land sale agreement that we would include for compulsory acquisition in the RO a parcel of land which was needed for access to the proposed park and ride and which property was owned by DLRCC with a requirement that we would either make it a public road or give him a right of way over it. The roadway we intended to build was part of the Spine Road (see Appendix 2) and the provision of this roadway was an objective of DLRCC development plan. Also provision was made for this roadway in the construction of a roundabout at junction 15 on the M50.

The development agreement required him to construct a 350 space park and ride facility with no consideration for any land interests. We agreed to pay him €5.85 million which was based on him contributing €1.6 million towards the capital cost. The deal was on the basis that he could receive planning permission for development on his land and the park and ride would be incorporated into this. At the time there was a high degree of confidence that an LAP for this area would be made which would allow planning permission to be applied for. These two agreements proved to be very commercially attractive to RPA given the large escalation in land values which occurred up to the period when construction commenced.

7. Discussions were held with DLRCC. They were in agreement with the changes to the alignment at Cherrywood and the provision of another stop at Brennanstown. They had a problem with a mechanism that we had proposed to the developers whereby they got a levy offset against the reduced cost of the land as opposed to receiving a direct payment. DLRCC felt this created difficult legal problems for them. As a result of this the Board approved a change to the developer's agreement whereby we agreed to pay the developers directly the reduced cost of acquiring the lands for Line B1. They raised a fundamental problem in that they were opposed to the at-grade crossing of Burton Hall Road. We did not change the scheme. Board approval was received to pay DLRCC for the provision of a liaison person for the scheme. They informed us that the Council could not legally agree that the levy scheme would not be changed in the future, as this would bind a future elected

council, which is not acceptable. This fact was included in the risk register for the project.

8. A RO was submitted on 7 November 2005 following the announcement of Transport 21 on 1 November 2005 and the Minister for Transport very quickly appointed an inspector to conduct the mandatory public inquiry.

2006

1. Preparation was made to present our evidence at the public inquiry which opened on 6 March and closed on 13 March 2006. The issues raised that are relevant to subsequent developments were those from DLRCC and the owners of [REDACTED] House.
2. DLRCC submitted a list of concerns to the Inquiry and they were legally represented. They indicated that their objective was to conclude an agreement with us. We engaged in extensive negotiations with them and their submission to the inspector was very positive in that it just made reference to a list of 48 items on which they had reached agreement with RPA. The inspector attached this list to his report. We also reached a commercial settlement in relation to the purchase of land and provision for betterment. Overall this resulted in budget saving of €1.5 million. This settlement was ratified by the Board at the March meeting.

They did cause a problem by objecting to the compulsory purchase of a parcel of land which was required for access to the proposed park and ride at Carrickmines. This change by the Council resulted in RPA not being able to fulfill our agreement with [REDACTED], but we agreed to the Council's request on the basis that the Inspector would have agreed to such a request by the Council and we were confident that we could reach an alternative agreement with [REDACTED]. Discussions took place to resolve the issue, which were not successful as he did not accept a form of wording which was included in the agreement with DLRCC. We felt that the new situation complied with the spirit of the agreement with [REDACTED] but not with the letter of the agreement. This situation was not helped by comments from DLRCC personnel that access via the Spine Road onto to the roundabout might not be suitable for development. It was not clear then or later why DLRCC took such a strong view on this issue as they subsequently disposed of this land to us and they confirmed that the existing road network was capable of handling development on the [REDACTED] site.

3. [REDACTED] House was a protected structure. It was located where Glencairn Stop is shown on the map in Appendix 2. It was owned by Mr. and Mrs. [REDACTED] and the house had a large enclosed site attached to it. Mrs. [REDACTED]'s brother who had an

intellectual disability lived in a separate building within the site and there was also accommodation for a carer within the site. In the DLRCC development plan there was a roads' objective, known as the Murphystown Parallel Road, which would involve the demolition of [REDACTED] House. During the detailed design phase options were examined to avoid the demolition of the house. Due to its location close to the residence of the British Ambassador, the existing built environment, and the need to accommodate the roads' proposal it was not a practical option to avoid the acquisition of the house. We were not acquiring all the land they owned. The owners did not engage with us in any meaningful way during the design period.

The owners objected to the acquisition of the house on three grounds at the Public Inquiry. They stated that the Environmental Impact Statement was deficient in that it did not examine all the alternatives and that it did not deal properly with human beings as there was no reference to the particular circumstances of their family. They stated that RPA did not have the power to acquire and demolish a protected structure and that they were afforded protection under the European Convention on Human Rights. An engineer gave evidence on their behalf and he put forward alternatives to the proposed one. We felt that we had responded well to their submission.

4. Most of the work related to procuring contractors for the construction was carried out during year and Board approval was received to award contracts for minor enabling works, design services, utility diversions and roadworks and the bridge structures. The award of the works contracts was subject to the receipt of a RO and approval of the Final Business Case (FBC) by the DoT.
5. In June advisors to [REDACTED] reported that they were not making progress with a planning application for their development at Carrickmines due to the absence of a LAP and the prospect that it would be some time before one would be made. The agreement for the park and ride at Carrickmines was contingent on [REDACTED] receiving planning permission for a development on his site. Advisors to the various developers engaged proactively with us to resolve detailed interface issues related to construction.
6. In April the Inspector published his report following the public inquiry. He was very supportive of the RPA position particularly in relation to [REDACTED] House and he recommended to the Minister for Transport that he should approve the RO subject to relatively minor conditions. He also recommended that the [REDACTED]'s costs related to attending the Inquiry should be recoverable by them. The Minister signed the RO on 13 August 2006 and this initiated the 8 week judicial review period. At the end of this

period in October 2006 the [REDACTED]'s sought leave to bring judicial review proceeding challenging the RO.

We decided that we should not object to them bringing the proceedings in order to deal with the issue as quickly as possible. A full hearing on the matter was scheduled in the High Court for 23 January 2007. Some discussions took place via legal advisors and also through an intermediary with a view to reaching a settlement. Board approval was received to offer them up to €14 million for all their land as this was the option that they had instructed their legal advisors to pursue. This was on the basis that we would later dispose of the surplus land. We had discussions via an intermediary exploring a settlement whereby we would reduce the referenced land take by not acquiring land for a substation and whereby we would facilitate a development on their retained lands. It seemed that the latter option was the one that they would negotiate on and approval was received from the DoT to deal with them on this basis as there was not a quorum to enable the RPA Board to make a decision.

The matter was settled on the first day of hearing on terms that the land for the substation was excluded, they got paid €8 million for the land we were purchasing, we allowed them to stay in the house for a 12 month period, we paid €200,000 as their costs for the public inquiry and the judicial review, and we agreed to provide ducting under the line to accommodate services in the future. This deal was formally ratified by the Board at the February meeting, once the Minister appointed sufficient members to constitute a quorum.

7. The FBC was approved by the Board in June for submission to the DoT subject to incorporating any changes that would result by way of conditions attached to the granting of the RO. The approved budget for the project was €323.4 million in cash terms i.e. allowance was made for inflation based on applied inflation factors and a proposed programme for the works. This figure included a contingency figure of €22.08 million which was reserved for allocation by the Board.

2007 to 2010

This covered the construction period and therefore the level of reporting increased. The paper would be very lengthy if all the detail in relation to issues with the various contracts were outlined. A brief description of events over the three years is as follows:

1. The RO became effective following the settlement with the owners of [REDACTED] House. The DoT approved the FBC and construction commenced very quickly as all the

construction contracts were ready for signing. The major contracts were the supply of Rolling Stock by [REDACTED], the construction of bridges by Laings under a client design form of contract (FIDIC Red Book), the diversions of utilities and the construction of a new road along the Ballyogan by [REDACTED] under the FIDIC Red Book and the construction and commissioning of the main infrastructure works by a joint venture consisting of [REDACTED] under a design and build contract (FIDIC Yellow book). Approval to award the SBS contract was received at the March 2007 Board meeting.

2. At the commencement of construction the programme generated the commencement of operations in September 2010. The actual date on which operations commenced was 16 October 2010. The park and ride at Carrickmines was not available on that date.
3. As construction progressed extra works were instructed due to requests from utility companies and due to decisions made by RPA. Examples were the laying of extra ducting along the Ballyogan Road which was paid for by the ESB and decision to increase the length of the platforms to cater for 53 metre trams. Also claims were received from contractors. The final accounts were settled mainly by agreement following Board approval on all the contracts. [REDACTED] referred one issue to the Dispute Arbitration Board (DAB) following a determination by the Engineer in favour of the RPA. The DAB found in favour of [REDACTED]'s position. The final account figures were in excess of the tendered sums.
4. All the projects reports indicated that the project would be delivered with a saving against the budget figure and that it would not be necessary to use any of the contingency sum. The reported savings varied depending on the projected outcome of contracts and on the risk provision.
5. [REDACTED] wrote informing us that we had not fulfilled one of the conditions attached to sale agreement for the railway land. This created a risk that we would have to exercise the CPO in order to acquire this land and pay a much higher price for the land. A feel for the difference involved can be appreciated by noting that we paid €4.311 million to [REDACTED] for a section of the Old Harcourt Street line with an area of 0.2856 ha. The land we needed to acquire from [REDACTED] has an area of 0.7954 ha and it is immediately to the east of this land. Also the [REDACTED] land had part of a dwelling on it which we needed to demolish. The agreed value of the land under the bilateral agreement with him was €3.3 million with 8% inflation applying from February 2006. The valuation of the [REDACTED] land on a pro rata basis is €12 million and [REDACTED] had given us an estimate of €15.4 million having taken into account disturbance and injurious affection. [REDACTED] did not prevent us from accessing his land for construction

purposes and the risk of a large cost increase was removed when the sale was closed under the original terms after DLRCC had transferred the land at the roundabout to us.

6. It was not possible to deliver a park and ride for the opening of the line to passenger services. The cost of implementing such a scheme using the CPO process would have been extremely expensive as in effect it would be necessary to purchase the land in the area for the exclusive use of the RPA and this acquisition would divide the site and would result in significant extra costs under the CPO system. This is a good example of where a CPO approach is very expensive as opposed to an agreement with the landowner. Under the agreement with [REDACTED] the development potential of the site was not really compromised if the underground car park was designed such that it could accommodate a development above and there was a shared use of access roadways which were required, in any event, for development on the site. We decided not to rely on the CPO process to deliver the park and ride facility given the significant costs involved.

As has been mentioned previously the agreement was contingent on [REDACTED] receiving planning permission for a development on his site which would include the park and ride facility. At the time the deal was negotiated the 2004 DLRCC development was made and the area was zoned for development subject to the making of an LAP which DLRCC had commenced work on. During the time leading up to lodging the RO application, DLRCC were expressing a high level of confidence that planning would not be a problem as a LAP for the area would be made. As early as June 2006 advisors to [REDACTED] were reporting that they were not making progress on the planning due to the absence of an LAP and even due to the fact that DLRCC had a view that the Spine Road might not be the best solution as regards the road infrastructure in the area. It seems that the relationship between DLRCC and [REDACTED] deteriorated further and they were not prepared to proactively engage with him. His site is at the edge of the LAP zone and it should have been acceptable to allow a limited amount of development that incorporated the park and ride. Following a long series of engagements a position was arrived at that development would not be allowed on his site. Also preparations commenced on making the 2010 DLRCC development plan. Ultimately DLRCC decided to abandon the making of an LAP for the area and they got the area designated as Strategic Development Zone (SDZ). They are currently working on this as they have a statutory obligation to have a draft available by May 2012. The formalization of this process could take some time as an appeal to An Bord Pleanála can be made even if the SDZ is ratified by the members of the council.

Various options were examined including getting the necessary land interests to build the underground car park under the planning approval in the RO, the possibility of using another location at Leopardstown Racecourse, the possibility of building an over-ground car park, which would require planning permission, on land purchased from [REDACTED]. None of these options were acceptable to all the parties involved. Around the middle of 2009 the idea of using some of the [REDACTED] land for a temporary surface was explored as it was unlikely that this land would not be developed in the immediate future. DLRCC indicated that they would not be opposed to this idea subject to the normal planning process. Plans were prepared to lodge a planning application for this and negotiations commenced with [REDACTED] to deal with the commercial aspects. It took a lot of time to receive planning. DLRCC raised issues and sought further information. This created a need to renegotiate the proposed agreement with [REDACTED]. The outcome is that we did not open the temporary car-park until November 2011. The conditions of planning were onerous, which made the cost of implementation very high.

Project Outturn

1. The project was delivered well within the total approved budget. There is now a high degree of certainty in relation to costs as final accounts are settled for all the major contracts. The budget for the project as per the FBC was €323.4 million. The projected outturn cost is €289.7 million and €280 million has been certified to date. The difference between these latter two figures is mainly related to a provision that has been made for the future construction of a permanent park and ride facility at Carrickmines. This is a very satisfactory result.
2. The project was delivered within two weeks of the date that was specified in the original construction programme. An item to note in relation to programme is that it took about 63 months to get the project from its initial stage to applying for a RO. A similar situation arose in the case of Line C1 Docklands. It took 14 months to receive statutory approval. This includes the time delay caused by the judicial review proceedings.
3. Significant contribution was received from the private sector towards the cost of the project and the application of the B1 levy scheme will generate further income over the life of the scheme. The largest contribution from the private sector was achieved because we were able to purchase land at a very deep discount to its market value, not to mention the potential cost of CPO acquisition. An indication of the savings can be had by noting that we paid €99.3 million per ha for land in Sandyford and €15

million per ha for land at Carrickmines. We purchased 7.168 ha from the developers at a cost of €14.634 million which equates to an average cost of €2.04 million per ha.

██████████ constructed a bridge which is approximately 500 metres long to carry Line B1 at Cherrywood. The value of this to RPA was estimated at €3.5 million. We do not have exclusive rights to the bridge.

We have received levy income of €23.5 million to date.

4. The system achieved its primary objective of delivering public transport safely and reliably. The commissioning and trial running went very well and there were no reliability issues when the system commenced passenger operations. Safety approval was achieved from the Railway Safety Commission (RSC) prior to commencement of operations and the system has operated safely since it commenced operations in October 2010.
5. The line has not achieved its projected passenger patronage. This is due primarily to the absence of development, particularly in the Carrickmines/Cherrywood area. The economic recession also contributes to low patronage. We expect that the undeveloped area adjacent to Line B1 will develop rapidly when economic conditions improve given the existence of the Luas and its proximity to the city centre. The line serves an area where there is an objective to provide high density development and it is in a desirable location. There is, therefore a high likelihood that the development will commence as economic conditions improve and the necessary planning framework to allow development is in place. The close integration of land use and transport planning is one of the major achievements of the project. DLRCC remain committed to sustainable land use in close proximity to the Luas line and the 2011 Census of Population shows that there has been population growth in Dún Laoghaire and that the level of unoccupied properties is relatively low.

Review of Board Strategic Role and Decisions

1. It is clear from the above brief narrative of developments that the Board was actively involved in providing strategic direction in relation to the project and provided full support to Management in negotiating commercial agreements. Examples from the early days was a decision to negotiate an agreement with developers in order to achieve a high level objective of getting a contribution of 50% towards the capital cost of the project. There was a flexibility to explore different mechanisms to achieve this bearing in mind the realities that existed. Another example is where there was a firm decision not to lodge an application for an RO until all the developers had

completed bilateral agreements with us. This decision by the Board greatly strengthened Management's negotiating position.

2. It is clear that the Board received the necessary reports and authorization was sought for decisions according to project management procedures put in place after completion of the original Luas lines. These did achieve a correct balance of allowing the Project Manager and his team to get on with day to day management of the project while an oversight is maintained by the Board. The reporting was to high quality and there were no major surprises as regards programme, cost or quality.
3. The procedure which required the production of a detailed scope statement which was then used to produce a cost estimate with an appropriate provision for risk and contingency worked well. Changes to the scope are reserved for the Board and an example where authorization for a scope change was sought is the decision to increase platform lengths to 53 metres, when Management considered it appropriate to provide for future expansion of Luas capacity.
4. Another item to note is that notwithstanding the best plans and project systems significant events will occur which will affect the project parameters. There are numerous examples in the above narrative. One could do a detailed analysis of any of them with a view to determining if better planning or a different reaction could have produced better results. It is difficult to now predict the flow of events given different decisions to those that were made. There are no obvious examples where major strategic type decisions was made where it is now clear that better ones existed. It would have been desirable to have avoided the delays that arose with [REDACTED] and the developers, to have avoided the judicial review by the [REDACTED]'s and to have seen more progress in relation to the planning issues in the Carrickmines/Cherrywood area.
5. There were significant variations between the tendered value and the actual final outcome for individual contracts. Decisions that led to this were made early in the project when the OBC was discussed and approved. The procurement strategy and the sharing of risk were largely determined at that stage. It is an option to consider passing on as much of the risk as possible in order to arrive at a fixed price early on. However this may not be the best value for money and it may not be possible to achieve it. Its almost certain that it would not be possible to pass the planning risk to a third party and is difficult to pass all the risks in relation to utility diversions to contractors given the complexity associated with them.

The chosen strategy set out was to share the risk and make provision for it in the budget in order that funding would be available if the risk materialized. Increased costs arose because RPA instructed variations such as the lengthening of the

platforms and the provision of park and ride spaces in Sandyford. We instructed variations that were priced as options in the contracts. These were made to improve the final project but they obviously resulted in increases in the relevant contract value. Other variations were issued to deal with items that arose on site such as constructing walls and screens as part of property settlements. Variations were issued due to requests from third parties such as a request from the ESB to lay extra ducting along the Ballyogan Road and a request from DLRCC to construct a bridge and roadworks at the Glenamuck Road. This resulted in increases in the contract values but the costs were recovered. Claims were received from contractors which were ultimately settled leading to an increase in the contract value. We were exposed to these bearing in mind the contract terms and conditions once we signed the various contracts and the reality is that they will arise with works of the nature we were involved in. They were dealt with professionally by the project and the projected outcomes were included in project reports as the work proceeded. Board approval was received for the final settlement with the contractors and all the final accounts are now agreed for all the major contracts.

Frank Allen

15 February 2012

Appendix 3: Leveraging lessons learned in organizations FOR INFORMATION

Railway Procurement Agency
Board Meeting No. 140
Thursday, 28 June 2012

Luas Line A1 (Citywest)
Project Review

Numbers in red
refer to Table 4.7
in the thesis
"Leveraging
lessons learned in
organizations"
Numbers in blue refer to
Table 4.8

Introduction

RPA Management conducted detailed post completion reviews of the three Luas extension projects, C1 Docklands, B1 Cherrywood and A1 Citywest in accordance with the following guidelines:

- RPA Project Management Procedures
- Cost Management Guidelines for Public Transport Investment Projects – NTA – 23 June 2010
- Capital Works Management Frameworks (CWMF) – Guidance Note GN 4.1 Project Review on Completion

The objective of these guidelines is to achieve continuous performance improvement, both within projects and from one project to the next. Workshops were conducted with relevant project and functional managers before implementation teams were demobilised and while the memory of issues encountered was still recent. The overall conclusion of these reviews was that RPA has succeeded in achieving the main project objectives set out when projects were approved. It is also clear that RPA has continued to build on experience gained through implementing successive projects. This post project completion report is intended to facilitate formal information sharing within RPA and will facilitate the more efficient delivery of future projects.

The Luas Citywest project performed against the Final Business Case (FBC) baseline parameters as follows:

- Programme: There was a 4 month delay to the 30 month implementation FBC programme (Construction, Test & Commissioning and Test & Trial Running). This was due to delay of commencement of developer's works and delay to transfer of shareholder property title that deferred the start of and compressed RPA Systems works.
- Budget: The projected outturn for RPA's element of the Line A1 works shows a saving of 4.7% on the nominal capital cost included in the FBC i.e. including risk, contingency and inflation.
- Scope: All scope and project deliverables were achieved; scope changes to the FBC baseline were in accordance with RPA's Project Management Procedures and are detailed below.
 - Kiosk at Cheeverstown de-scoped in September 2009.
 - Reorganisation of Central Control Room (CCR) at Red Cow
- Risk: The risks and mitigations identified in the FBC were managed successfully and within the provisions allocated.
- Quality: The most important quality item is that the system achieves its primary objective of delivering public transport safely and reliably. This was achieved as the commissioning and trial running went very well and the very few issues that arose were resolved quickly when the system commenced passenger operations. The CCR was also successfully upgraded during this time without interruption to the existing Luas service.
- Passenger numbers were substantially lower than forecast. This is discussed below.

Purpose

This Board Report focuses on decisions of a strategic nature taken by the RPA Board following submissions put forward by the Executive throughout the Luas Citywest project lifecycle. The Board received 55 submissions over six years beginning in May 2005. In addition to regular project progress updates (programme, cost, risk, design and construction, stakeholder and public relations management) the RPA Board was requested to make decisions across the following categories:

- Key Milestone: Progress to next stage (6)
- Procurement related (14)

- Development Agreement with Citywest Luas Limited (CLL) and performance security (9)
- Property related (6)

Following a review of all Board papers and minutes of Board meetings for items related to Luas Citywest, this paper focuses on the following topics of strategic interest as presented to the Board:

1. Stakeholder Alignment & Scope Clarity
2. Development Agreement and Ancillary Security Contracts with CLL
3. Belgard Canopy
4. Passenger Numbers

1.0 Stakeholder Alignment (DoT, DTO, SDCC, CLL, RPA) & Scope Clarity

Meaningful negotiations commenced in May 2005 with a group of developers led by [REDACTED] and also comprising [REDACTED] [REDACTED] part of the [REDACTED]. The negotiations led to legal agreements under which the developer group would make direct contributions, through provision of works, land, rail order application support documentation and cash to the Line A1 project. In parallel to the discussions with [REDACTED] RPA informed the Department of Transport (DoT) of the proposals being considered. The extension of Luas to Citywest was included in the RPA submission to the Department in relation to the 10 year draft transportation plan (Transport 21). However it was not seen at that stage as a priority project. The RPA Board supported the concept of entering into a partnership with CLL but requested guidance from the DoT on whether such a proposal, promoted by private interests, would be consistent with the draft Transport 21. The DoT confirmed its support in principle to the project once all stakeholders had bought into the scheme. On-going negotiations with the developers were structured through the development of a non-binding Heads of Agreement. The main objective was to ensure that a contribution of at least 50% of the overall cost was received from the private sector towards the capital cost of the A1 project and that the scheme was in keeping with Government transport policy. It was also essential that the procurement strategy was compliant with relevant EU Procurement Directives and that the scope of works was to be clearly

defined and stakeholder objectives were clarified as discussions progressed. The key issues that the Board focussed on were:

- Total Capital and Operational Cost Estimate of Scheme (and the extent of contribution by Developers).
- Compatibility of the proposed spur with the proposed rail transit network for the Greater Dublin Area.
- Feasibility of operating the extension as a shuttle rather than a spur service.
- Developer commitment to deliver works rather than be limited solely to a financial contribution.
- Resolution of Local Authority issues (capacity afforded to Tallaght Town Centre, impact on a potential spur to Clondalkin and design interface with a road scheme in the planning stage).

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Following elaboration and explanation of these issues and the development of outline Cost-Benefit Analysis and Feasibility reports, the Board granted approval to enter into a non-binding Heads of Agreement in September 2005 for a scheme terminating at Fortunestown Lane. The shorter line was due to lack of agreement between the [REDACTED] and the two other partners. Following the good progress made after entering into the non-binding Heads of Agreement on the proposal to Fortunestown Lane and its inclusion in the publication of Transport 21, the possibility of a further extension to Garter Lane was put forward by the [REDACTED]. However, this was not supported by satisfactory evidence of agreement and formal commitment by all three developers. This did not delay RPA's public consultation which commenced in February 2006 at a formal project launch at South Dublin County Council's (SDCC) offices. This consultation clarified RPA's negotiated position and soon after a commitment was provided by [REDACTED] to contribute to the scheme. While not party to parallel detailed discussions between the local authority and the Developers in relation to a re-zoning variation to the County Development Plan, RPA did liaise with SDCC on their progress. Following confirmation of this variation in May 2006 and subsequent discussion the Board approved that RPA enter into a binding Heads of Agreement with the Developers. On the 18 October 2006, following a period of detailed negotiations centering on scope clarity and risk allocation, the RPA Board approved management's recommendation to enter into a contract with Citywest Luas Limited for the development

of Luas Line A1. In January 2007 the contract was signed with CLL, a special purpose vehicle set up by the Developers to implement Luas Line A1. This contract was also supported by robust security arrangements for the delivery of CLL's obligations as CLL had no assets of its own.

[REDACTED]

[REDACTED]

[REDACTED].

RPA maintained its position to proceed in a structured and gated approach to ensure that all issues and funding implications were resolved and that the DoT was briefed at key milestones. While this structured approach did affect key Transport 21 project commencement dates, it withstood considerable pressure from the developers and was supported by the Department. It also ensured that funding and other commitments were supported by robust performance security arrangements which, with the oversight of the Board have since stood the test of a failing property market and the deteriorating solvency status of individual developers.

2.0 Development Agreement and ancillary security contracts with CLL

The following is a summary of each of the main provisions of the agreement and a commentary on their effectiveness:

2.1 RPA Obligations

RPA's obligations under this Agreement were conditional upon:

- An enforceable Railway Order being made.
- Adequate arrangements for the funding of the Project being made within six months of the date of the Agreement.
- The consent of the Minister for Transport pursuant to Section 43(6) of the Transport (Railway Infrastructure) Act, 2001 in respect of the agreement with the Developer, within six months of the date of the agreement.
- These pre-conditions were achieved in a timely manner.
- Under the terms of the Agreement RPA was not required to submit the Railway Order application unless it had received assignments of bank guarantees to a total value of [REDACTED]. These assignments were achieved in a timely manner.

- Under the terms of the agreement RPA was responsible for the management and satisfactory delivery of the RPA works within 15 months of takeover of CLL's works. Under the agreement RPA had a right to inspect and comment on CLL's works. In consultation with CLL, RPA did this by putting in place a construction supervisory team with the remit to monitor and report on quality and progress of CLL's works with a clear benefit to CLL that it had access to RPA's expertise in delivering light-rail. This ensured that in the main the works proceeded in a satisfactory manner, that RPA had a full understanding of the infrastructure being provided by CLL and that there were no surprises.
- Under the terms of the agreement RPA was to guarantee that from the start of passenger services, trams would operate from Connolly stop on the Luas Red Line to the new terminus at Saggart at least every 15 minutes between 7am and 10am and between 4pm and 7pm on every working day and at least every 30 minutes at other times subject to any limitations that may apply from time to time for technical or safety reasons. Even with recent timetable changes RPA is delivering on this obligation.

2.2 CLL Obligations

- CLL was required to deliver a suitable Environmental Impact Statement to support the Railway Order application compiled by RPA.
- CLL was responsible for the management and delivery of its works within 18 months of an enforceable order with liquidated damages owing thereafter unless CLL could give RPA at least four months' advance notice of the delay (in which case RPA would be in a position to mitigate the cost consequences of delay). This clause, which was invoked, allowed RPA to programme its Systems Contractor's works with a degree of certainty. While the works were completed in time, transfer of shareholder property title did delay takeover. [REDACTED]

[REDACTED] RPA allowed accommodation for this in discussions with its follow-on Systems Contractor and ensured appropriate security was put in place with CLL until this issue was resolved.

- CLL was required to provide a 300 space Park & Ride to RPA at nil cost and this was delivered.

- CLL was required to transfer the land interests under its control that were required for the project to RPA at a nil cost. The transfer of other land interests, also at nil cost to RPA, was also to be provided by CLL. The transfer of all lands was a condition of takeover of CLL's works. In the case that the compulsory acquisition of lands by RPA was required, CLL was required to pay to RPA all costs including the full amount of compensation payable and all reasonable legal, valuer's or other costs associated with the acquisition.
- Under the terms of the agreement, CLL was to provide [REDACTED] to RPA for works to be carried out by RPA and to be paid on takeover of CLL's works by RPA. This was complied with.

In summary the agreement with CLL to manage the delivery of Railway Order application documents, civil works and land and also make a financial contribution to RPA works was a novel approach. The other benefits it delivered were the removal of the associated risk to RPA of works and land price escalation and the risk of cost increases arising from potential arbitration proceedings. There was also less risk attaching to this scheme than to a planning levy scheme (Docklands and Cherrywood extensions) in that the contribution was independent of development occurring and was 'up front', rather than over a prolonged period. As with the extensions to the Red Line (Docklands) and the Green Line (Cherrywood) this project demonstrated RPA's commitment to engage with the private sector with a view to delivering infrastructure in partnership with it and represented the best deal to date for RPA.

While the agreement allowed CLL to procure the project EIS through its own EIS consultants and to contract directly for the design and construction contractors and manage same, RPA had never adopted this approach previously. The quality of both the EIS and the works delivered by CLL shows that RPA does not have to do everything itself. Notwithstanding this, the agreement with CLL allowed RPA to review and comment on the EIS and allowed for a full design and construction review and approval.

This level of supervision and management is important in any future engagement with third parties on actual delivery of works.

From the outset the developers promoted a view that they could deliver faster and at considerable less cost than the public sector. However this view is not shared by RPA.

Progress was evident and while RPA did not have direct access to the Developer's costs we believe that the out-turn cost of their civil works were approximately 8% less than RPA estimates. The Docklands and Cherrywood projects were also completed at below RPA's estimates, reflecting the prudent but realistic nature of RPA estimation.

2.3 Security for Performance

The security structure put in place to support the Development Agreement is described as follows:

- CLL was required to put in place an assignment of bank guarantees (that it had in place to the value of [REDACTED] to RPA. These guarantees were not to reduce below the value of acquiring any land then owned by third parties (i.e. parties other than the principals of CLL) required for the project until such lands were transferred to RPA. Furthermore the guarantees could not be reduced below the CPO cost of acquiring these third party lands plus the additional [REDACTED] until that amount was paid to RPA on takeover of the Developer's works. This threshold was termed the Minimum Unutilised Balance (MUB) and was a key component of securing the commitments made by CLL to RPA on entering into the Development Agreement.
- CLL was required to procure a performance bond for at least 25% of the value of the works contract from its contractor and ensure that RPA could call on the bond if CLL's contractor was in substantial default under its contract. This bond and its assignment were delivered.
- CLL was to provide RPA with suitable collateral warranties, supported by professional indemnity insurance [REDACTED] from CLL's designers and CLL's contractor (professional indemnity cover of [REDACTED]), valid for a period of 12 years from the date of completion of CLL's works. These were delivered.
- In addition to these collateral warranties, the Contract required that retention monies of [REDACTED] be put in place in the event that CLL was liable for any defect in its works up to the issue of the Performance Certificate (which is three years from the date of their completion). After that date CLL will not be liable for defects in the work, but RPA will have access to the collateral warranties outlined above. This was delivered. A supporting security pack was put in place consisting of Debentures, Deed of Assignments (security over specified project

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related agreements and bank guarantees) and a Deed of Subordination (shareholders defer claims against CLL in favour of RPA).

[REDACTED]

3.0 Belgard Canopy

Following a tender process, RPA awarded a contract to BAM Rail Limited in July 2009. The scope of works comprised civil, track and overhead contact systems for the trackwork tie-in, the reconfiguration of Belgard stop including a canopy structure and two overground substations. The form of contract used was the GCCC Public Works Contract for Civil Engineering Works designed by the Employer. RPA was responsible for the detailed design, co-ordination and implementation of all of the required works with the exception of the canopy and the substation services. This was the first contract where RPA resources were used directly to develop the detailed design. The detailed designs in relation to the canopy and substation building (mechanical and electrical) systems were to be developed by the contractor in accordance with performance specifications provided by RPA. This decision was taken as it was determined by the project team that this risk allocation was appropriate given the innovative and specialist nature of the canopy structure.

The canopy was erected in July 2010. However in November of that year a section of the fabric element of the canopy was damaged during high winds and RPA's contractor removed the fabric completely the following day. The contractor's first proposal for the

replacement of the canopy was not accepted by RPA as it did not demonstrate that the cause of the failure has been addressed. The contractor has since proposed an alternative replacement fabric material and configuration and this proposal is now being reviewed by RPA. In principle this is acceptable to RPA with further design work required to demonstrate technical compliance with performance specifications.

[REDACTED]

[REDACTED]

4.0 Passenger Numbers

The system achieved its primary objective of delivering public transport safely and reliably. The commissioning and trial running went very well and there were no significant reliability issues when the system commenced passenger operations in July 2011. Safety approval was achieved in a timely manner from the Railway Safety Commission (RSC) prior to commencement of operations and the system has operated safely since operations commenced.

Patronage on the Citywest extension has been very disappointing and significantly less than forecast in the approved FBC. The FBC for the scheme forecast an additional 6.65 million passengers added to the Luas network in the future year of 2016. Working backwards from 2016 using a percentage factor this figure equates to an additional 4.85 million passengers in the opening year of 2011.

The future year passenger forecasts are based on landuse projections provided to us by the Local Authorities and at this time the Dublin Transportation Office (DTO). These

landuse projections were based on a significant increase of both population and employment being in place in 2016 in an integrated and sustainable manner adjacent to the Citywest extension. This quantum of development which are the basis of the passenger demand forecasts above are almost certain not to be achieved by 2016.

In advance of the Citywest extension opening the passenger forecasts were revisited to take into account a combination of more recent information regarding both existing and future landuse projections and experience on Luas to date. These forecasts projected an additional 2 million passengers at the Luas network as result of the Citywest extension. Based on the actual usage along the Citywest extension and Luas Red Line these forecasts have been projected downwards to an additional 1 million passengers added to the Luas network in 2012 which is very disappointing.

RPA has undertaken some qualitative analysis of the passenger numbers to date and has identified some plausible reasons why this has been the case.

When the FBC for the Luas Citywest extension was approved in 2008, passenger numbers on Luas were growing at more than [10]% p.a. and RPA was under pressure to add to capacity to meet that increasing demand. It was then expected that the projected maximum Red Line (Belgard to City Centre) peak headway of 4 minutes would be increased to a peak headway of 3 minutes with the commencement of operations on Luas Citywest. This significant increase in public transport offering would increase the forecast passenger demand. The current level of passenger demand on Luas does not justify this headway or the cost of operating this service. The resulting service pattern may not be sufficient to encourage a shift from private car.

This analysis has also indicated that some of the boardings on the Luas Citywest extension were probably existing Luas users as the passenger numbers at Cookstown, Hospital and Tallaght Stops on the existing Red Line have decreased after the opening of the extension with the largest decrease occurring at Cookstown stop.

Looking at the passenger numbers on a stop by stop basis along the Citywest extension have shown they are quite low in comparison with similar stops along the Luas network with the busiest stops being Fortunestown and Saggart Stops. These stops would be

expected to have the highest number of passengers as there is a reasonably high residential density in proximity to the stops albeit to the south of the line only (development to the North has not proceeded as envisaged). Based on the current population and based on our experience from similar stops elsewhere on the Laus network however it would have been anticipated that the actual passenger numbers would have been higher.

The low passenger numbers as discussed above are also due partly to the absence of the projected development in some instances and also partly due to the lack of integration of some of the development that has taken place, particularly in the Citywest/Fortunestown area as a consequence of the property market collapse.

Prior to the introduction of the Citywest extension it was anticipated that commercial development would have taken place on the land adjacent to Citywest Campus Stop. This development was anticipated to result in passenger flows on the Citywest extension to be in both directions similar to what has been achieved along the Luas Green Line at Sandyford. Comparing the passenger numbers alighting the stops between 8.00am and 9.00am at Sandyford and Citywest Campus shows that Sandyford stop has four times the number passengers alighting.

This development has not occurred resulting in the closest stop to the Citywest Business Park being quite remote and only connected via pedestrian link. This pedestrian link while not long in actual length and well within a reasonable walking distance is quite remote and really only provides direct access to a small cluster of offices in the Business Park. This coupled with the economic recession has also contributed to the low patronage at this stop with employment figures within the Business Park less than what was forecast in 2016 and even less than actual 2006 employment levels.

While disappointing, there is reason for optimism as developments continue in the Citywest area adjacent to the Citywest extension. It is expected that the undeveloped areas adjacent to Luas Citywest will develop when economic conditions improve given that development policy/appropriate zoning is in place, the existence of the Luas and its proximity to the city centre. The line serves an area where there is an objective to provide high density development and it is in a desirable location. There is, therefore a

high likelihood that development will commence as economic conditions improve and the necessary planning framework to allow development is in place.

RPA in conjunction with South Dublin County Council (SDCC) will be carrying out a personalised travel planning initiative in the coming year focusing on people in the catchment area of the Citywest extension. The aim of this initiative is to encourage a change of behaviour from current travel patterns to a more sustainable mode of travel for work and discretionary trips. We intend to target some of the residential estates beside both Fortunestown and Saggart stops as part of this study. RPA also intends taking specific initiatives to encourage people to use the Luas Park & Ride facilities during the summer, with a view to encouraging increased patronage over the medium term. As a result of the fragmented development that has occurred in the area the accessibility and attractiveness of Luas is less than ideal with circuitous walks required to access the stops. RPA is exploring options with the local authority and local landowners to improve the permeability and accessibility to stops as existing development is not in close proximity to Luas Citywest in some cases or not readily accessible in others or a combination of both.

In order to ensure confidence in our patronage and revenue estimates for future scheme appraisal, RPA has revised its model assumptions (including sensitivity tests) in light of the global recession, which has seen the Irish economy contract significantly over the period 2008-2010. It is assumed that the employment and population growth previously forecast for 2016 in the Greater Dublin Area will not now transpire until 2025, with these projections being consistent with the lower quantum envisaged by the Central Statistics Office (CSO) MOF1 Traditional forecast. The proposed methodology and approach on sensitivity tests are in line with guidance agreed with the DoT. By undertaking sensitivity testing it will demonstrate that the economic case for any proposed schemes is resilient and retains their value for money even assuming the most pessimistic demographic scenario of no growth in population and employment.

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Review of Board Strategic Role and Decisions

It became evident from an early stage that management of the front-end definitional stages of Luas Citywest was important to achieving a successful outcome particularly in defining the relationship with the Consortium and other key stakeholders. This was

particularly relevant in considering analysis of project success and failure criteria^{1 2 3} through a range of issues such as unclear objectives, changing sponsor strategy, poor project definition, technology difficulties, concurrency, inappropriate contracting strategy, unsupportive political environment, lack of top management support etc.

Table 1: Morris & Hough (1987) – Issues affecting success & mitigation on Luas Citywest

Morris & Hough (1987) identified the following issues affecting success:	
Issue	Luas Citywest mitigation adopted with private sector
Unclear project objectives	Formalised through Heads of Agreement and its evolution to full agreement.
Changing sponsor strategy	Developers required establishing a Consortium to act as a single point of contact.
Poor Project Definition	Early organisation objectives, scope & risk definition and allocation.
Technology difficulties	Early definition of requirements
Concurrency	Programme Management framework adopted.
Inappropriate contract strategies	Contract risk matrix, use of standard FIDIC terms supplemented by special conditions.
Unsupportive political environment	Early engagement and inclusion in T21
Level of top management support	Clearly demonstrated early.
Funding difficulties	Performance security structure (Bank Guarantees, Service Agreements, Performance Bond, Retention Monies and Security Pack.
Inadequate manpower	Early market engagement and organisation resource planning across T21 programme.
Geophysical conditions	Early geotechnical, slit-trenching & radar

¹ The Anatomy of Major Projects: A Study of the Reality of Project Management Morris and Hough (1987)

² What Causes Cost Overrun in Transport Infrastructure Projects? Flyvbjerg et al (2002)

³ Flyvbjerg (2005) Policy and Planning for large –infrastructure projects: problems, causes, cures

	investigations.
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Table 2: Flyvbjerg et al (2002) – Issues affecting Transportation project success & mitigation on Luas Citywest

Flyvbjerg et al (2002) identified the following issues affecting Transport Project success	
Issue	Luas Citywest mitigation adopted with private sector
Length of Implementation Phase	Risk exposure (construction & property) allocated, pre-conditions, thresholds and walk-away clause put in place regarding planning time frame and onerous planning conditions. RPA cash spend profile after CLL works substantially underway.
Size of Project	Complex with competence and experience within RPA taking lead.
Type of Ownership	Public/Private – Governance structure put in place (Project Board between the parties).
Recognition of the following: Research shows Rail projects susceptible to av. cost escalation of 45% while Transport projects 4.64% year on year.	Appropriate Risk Planning and modeling used throughout the project lifecycle.

The challenge that RPA successfully delivered was to the achieve RPA's objectives of technical compatibility, high quality, value for money (capturing at least 50% of the total capital cost), timeliness, flexibility and minimising process risk through agreement with the Consortium while also ensuring the scheme was in line with Government transport policy and met key stakeholder objectives. In relation to this particular scheme the Transport Policy maker (DTO), the Local Authority (SDCC), the majority of the landowners (both consortium and non-consortium) in the catchment area and the RPA

proactively cooperated in arriving at the optimum solution in relation to the essential elements of the scheme.

In order to manage this challenge, a negotiating framework was put in place to develop the relationship between the RPA and the Consortium while also engaging with key stakeholders in parallel. This was supported by risk and scope management processes that were agreed between the parties. This involved the development of a number of risk and scope management tools. These tools ensured that risk and scope allocation was confirmed in advance of RPA and the Consortium signing the Detailed Development Agreement supported by robust performance security provisions. These ensured the successful transfer of works, land and direct financing without cost to the Exchequer against the backdrop of a property market collapse and an economic recession. The Agreement also allowed RPA to scope the procurement of the remaining project works with certainty for procurement.

It is clear from the above discussions that the Board was actively involved in providing strategic direction in relation to the project through the provision of full support to Management in managing against defined project success and failure criteria and through developing, negotiating and varying commercial agreements. An example from the early definitional stages was a decision to negotiate an agreement with developers in order to achieve a high level objective of getting a contribution of 50% towards the capital cost of the project. There was also flexibility to explore different mechanisms to achieve this bearing in mind the realities that existed. Further examples were the decisions to vary the terms in relation to security held in lieu of third party lands (MUB) and their transfer as a condition of takeover (through provision of additional/alternate security). This rebalance of risk transfer assisted CLL's cash-flow position allowing the project to proceed while maintaining the fundamental principle that the Developers would be responsible for works, land transfer (directly or by CPO) and a direct financial contribution at no cost to the exchequer as initially agreed. These decisions by the Board reinforced Management's ongoing negotiating position with CLL and together with robust agreement terms and security arrangements put in place ensured a successful outcome for both parties.

The Board received the necessary reports and authorisation was sought for decisions according to project management procedures developed after completion of the original Luas lines. These achieved a correct balance of allowing the Project Manager and his team to get on with day to day management of the project while a strategic and corporate oversight was maintained by the Board. The reporting was of at high quality and there were no surprises as regards delivering this project within the advised programme, cost or quality and risk profile.

Frank Allen

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The contextual graph in Fig. 8 refers to Line C1, the Docklands extension

The Role of Attention in Fusing Situation and Activity

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Abstract. Performing, assessing and learning may be represented as embedded activities in contextual graphs, representing simultaneously the structure of a situation and the reasoning involved in both the actual and prescribed performance of the activity. We propose a model of practice-based organizational learning to support discussion of the role of contextualization in performance assessment, organizational learning, knowledge management, and decision support systems. We present results of ongoing research into the role of context in practice-based organizational learning at the strategic level in an organization responsible for the procurement of light rail public transport systems.

Keywords. Contextual Graphs, Context-based Reasoning (CxBR), Performance Assessment, 4Ps Model of Practice-based Organizational Learning, Light Rail.

Introduction

In this paper we address a real-world problem that arises in organizations charged with the planning and execution of complex infrastructure projects; how to leverage organizational learning from experience in long cycle projects where key members at the planning stage are likely to be no longer in the organization by the time the project is delivered. Many researchers in performance either avoid the problem altogether by reducing assessment to measurement by key performance indicators that appear as *deus ex machina* to guide the organization, or they divide the problem to conquer the parts for which their models are adapted without too much concern for a coherent overall conceptual framework [1]. Weick [2] proposes an interesting model relating performance to sensemaking in organizations and insists on the dialectic of organizations viewed as both loose (open systems) and coupled (closed systems) but he resolves the dialectic between choice and interpretation on the side of sensemaking. We believe that it is interesting to maintain both dialectics. Fusing situation and activity in contextual graphs allows different modes of acting, judging and thinking to be expressed in a uniform way while taking account of the salient circumstances. Related work by the authors includes context proceduralization and modeling [3,4,5,6,7] and a model of human decision-making that captures both diagnostic and look-ahead reasoning [8]. This paper extends our previous work with a model of practice-based

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organizational learning that supports the efficient acquisition of practical knowledge in organizations and helps organizations to leverage their lessons learned from experience.

Hereafter the paper is organized in the following way. Section 1 presents our ideas on practice-based organizational learning. Section 2 shows how to support practice-based learning in organizations. Section 3 presents results from the application of our ideas on practice-based organizational learning to a complex real-world problem. Section 4 concludes and indicates directions of future research.

1. Practice-based Organizational Learning

“Organizations store knowledge in their procedures, norms, rules and forms. They accumulate such knowledge over time, learning from their members” [9]. Situations [10] in which Organizations find themselves may be expressed as Problems to be solved. If performers in the organization are faced with a task for which there is no procedure, they create a Plan that proceduralizes the context [4]. They commit to the Plan [11] and use it to guide their action [12]. Over time, the organization finds itself with more than one Practice that effectively realizes the task and may express preferences for some Practices using Performance Assessments based on indicators [13] that in turn may be characterized by Performance Assessment Types [14]. Learning from experience may be expressed in Lessons Learned and characterized by Lessons Learned Types [15]. Lessons learned are leveraged when Practices, in de-contextualized form, are elevated to the level of Procedures that prescribe behavior in future confrontations with similar Problems.

Figure 2 illustrates the spiral relationship among the three activities performing, assessing performance, and practice-based learning. Practice-based learning requires effort, represented by the ascending spiral staircase, attention, and memory. At each step attention is focused on one of the three activities; performing may involve unconscious learning, assessing may include learning from mistakes. As long as memory continues to function the spiral of learning continues to higher levels of abstraction (in signs), incorporation (embodied in skills) and implementation (in tools). The accompanying Table 1 shows how we propose to model each of these activities.



Figure 2. The Practice-based Learning Spiral

Table 1. Modeling the Practice-based Learning Spiral

Activity	Model	Representation formalism
Performing	Context Modeling [5,6]	Contextual Graphs [5]
Assessing Performance	Performance Assessment Maturity Model [14]	
Practice-based Learning	4P's Model of Practice-based Organizational Learning	

Figure 3 takes a closer look at each of the three activities. The arrows with full lines represent the primary flow of control; the arrows with dashed lines represent feedback. We draw attention to the compatibility of our framework with some well-

known organizational learning models, for example the single-loop/double-loop [15] model.

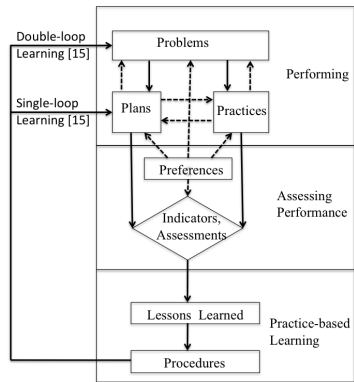


Figure 3. Elements of a framework of practice-based organizational learning

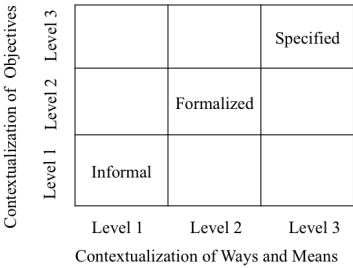


Figure 3a. A two-dimensional performance assessment maturity model [14]

Figure 3a shows how performance assessment compares a plan represented in prescription mode and the corresponding practice represented in performance mode. Note that depending on the level of the management activity (strategic or tactical), the graph will represent strategic objective-setting assessment (contextualization of objectives) or tactical implementing assessment (contextualization of ways and means). In both cases, the comparison may be direct, in the one graph using annotations, or indirect using one graph for each of the two modes. These graphs may be used to calibrate a performance assessment maturity roadmap for the organization and determine its performance assessment maturity level using the two-dimensional model shown in Figure 3a. What is original about Figure 3a is the fact that the dimensions of function and behavior are considered in a synthetic manner in the representation of performance. Here again, the focus of attention fuses situation and activity; attention grasps the problem and the solution, alternating between attending to the problem from the solution, and attending to the solution from the problem [17].

We model practice-based learning in organizations as a process of contextualization, de-contextualization and re-contextualization as shown if Figure 4 and the accompanying Table 2. This process is superimposed as circular movement on the unidirectional ascending movement in Figure 2. Problems, Plans, Practices, and Procedures, are important organizational codes [9] and it is their transformation through contextualization, de-contextualization and re-contextualization that constitutes practice-based learning (hence the name 4P’s model). As the focus of attention halts on a step in Figure 2, what it attends to is expressed in Figure 4. The illustrated clockwise movement of the focus of attention corresponds to the direction of performing, assessing and learning; the counter-clockwise movement of attention also makes sense as the direction of understanding [16].

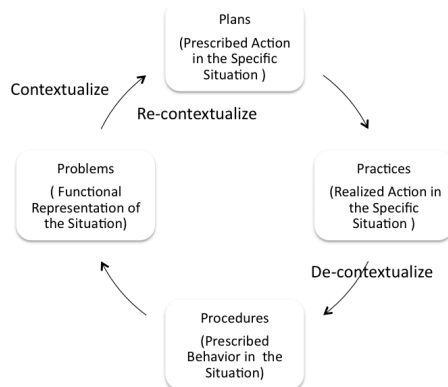


Figure 4. The 4P's Model of Practice-based Organizational Learning

Table 2. Practice-based organizational learning as contextualization, de-contextualization and re-contextualization of organizational code expressions

Process:	Definition:	Organizational Code Transformed from:
Contextualization	Fusing of a realized or projected action and a specific situation; as an activity unfolds, the evolving focus of Attention Fuses Activity and Situation into a Practice.	Problems to Plans (in look-ahead mode) Problems to Practices (in performing mode)
De-contextualization	Abstraction from lessons about Practices in specific situations to new Procedures that prescribe behavior in more general situations	Practices to Procedures
Re-contextualization	Specification of the Procedures, as Plans to deal with the Problem in a new specific situations	Procedures to Plans

Some noteworthy epistemological commitments we made in constructing this model are discussed below.

1.1. On representing practice-based learning in contextual graphs

As an activity is unfolding, learning is tacit (embodied) [17] until a breakdown propels a concept into our focus of attention; we chose to remember the new concept as a parameter of the activity (enriching our theoretical model) or as a characteristic of the learning situation (enriching our practical model) [20]. The new concept may be completely new, requiring a restructuring of our model to accommodate it, or it may be just a new value for a concept already in the model, in which case, the value is assimilated [21]. Figure 5a brings together these two ideas on content and process of learning. In this paper, we are concerned with the representation of practical learning, in particular the concepts characterizing the learning situation and their novelty either as new contextual elements or new instances of already known contextual elements.. Figure 5b shows that practice-based lessons learned may be conveniently segregated by management level. Figure 5c shows, for a strategic activity, and Figure 5d, for a tactical activity, four novelty types of practice-based organizational learning depending on whether the situation and/or of the practice is new. We are concerned with the new situations as the discovery of new practices is a matter of domain specific learning and outside the scope of this paper. Each time a new CE or a new instance of a CE appears in a contextual graph, it may be classified by one of the four novelty types, by people familiar with the organization's history and the domain of activity.

Content of learning	Theoretical	New Value for a Contextual Element	New Contextual Element
	Practical	New Value for an Activity Description Factor	New Activity Description Factor
		Assimilation	Accommodation
		Process of learning	

Figure 5a. Typology of lessons learned

Management Level	Strategic	New Value for a Contextual Element in an Objective Setting Activity	New Contextual Element in an Objective Setting Activity
	Tactical	New Value for a Contextual Element in an Implementing Activity	New Contextual Element in an Implementing Activity
		Assimilation	Accommodation
		Learning process	

Figure 5b. Strategic and tactical lessons learned

Strategic Situation	New	Discovery of a new strategic situation in which a known practice also works	Discovery of a new practice that works in a new strategic situation
	Known	Confirmation that a known practice continues to work in a known strategic situation	Discovery of a new practice that works in a known strategic situation
		Known	New
		Actual Practice	

Figure 5c. Novelty types of practice-based organizational learning for a strategic activity

Tactical Situation	New	Discovery of a new tactical situation in which a known practice also works	Discovery of a new practice that works in a new tactical situation
	Known	Confirmation that a known practice continues to work in a known tactical situation	Discovery of a new practice that works in a known tactical situation
		Known	New
		Actual Practice	

Figure 5d. Novelty types of practice-based organizational learning for a tactical activity

Actual Practices for dealing with a specific situation may be known or new specifications of a generic procedure; learning is discovery of new practices that implement the procedure. Specific Situations may be either known or new specifications of a generic situation that call for an existing or new procedure or practice. Learning *sensu stricto* is discovery of new situations although senior management we have interviewed emphasized the importance of including known situations where things went well in lessons learned.

1.2. On case-based and practice-based learning

Contextualization is the process of proceduralization of context into a Practice [4]. It is the process of externalizing [18] knowledge associated with Practices through specification of the context of the situation i.e. selection and instantiation of contextual elements enabling *recognition of* the situation, and functional organization of the knowledge for cause and effect *reasoning in* the situation. Selection of contextual elements (parameterization) is the stable level of contextualization and as such is associated with Case-based Learning; specification is the dynamic level [3] and is associated with Practice-based Learning. Functional organization is context-based reasoning (CxBR) with integrity and inference rules; integrity rules involve reasoning *about* the situation used in classification problems, diagnosis and case-based reasoning (CBR); inference rules involve reasoning *in* the situation used in prognosis, look-ahead, scenario-based reasoning (SBR) and “what if?” analysis [6, 22]. The structure of the knowledge and the reasoning associated with the actual and intended performance may be fused in a contextual graph [17]. De-contextualization is the reverse (internalization) process. Re-contextualization emphasizes the circular nature of the process.

In section 3 we show how we used these theoretical constructs in a real-world application, where senior management of a large organization discovered the advantages of using contextual graphs to more effectively represent their knowledge and reasoning, in a way that suggests better context management. This methodology is supported by the system architecture proposed in the next section.

2. Supporting Practice-based Learning in Organizations

In addition to the conceptual tools developed in section 1, we present some information system components in this section. Formal representations of context may be used to

support organizations in their effort to improve the representation and assessment of their performance and leverage their lessons learned. First, by supporting the building of organizational experience resources in a focus-oriented experience repository. Members are able to do things (individually or collectively) that accomplish organizational objectives using their knowledge and the organization's resources. As they perform effectively the procedures and practices used may be formalized. The resulting stock of experience represented in the procedures and practices of an organization is one of its most valuable resources. An artifact that supports this process is a knowledge acquisition tool capable of simultaneously acquiring knowledge about the situation and the activity. Second, by supporting members' access to organizational learning resources. To the extent that it is accessible, the organization's experience may be consulted by newcomers to the organization and novices and accelerate their learning. A contextual graph reader may support this process.

Figure 6 illustrates the architecture that we propose for a practice-based organizational learning management system. The three essential elements are the practical knowledge acquisition tool, the focus-oriented experience repository and the contextual graph reader. The key functional characteristics are shown for each of the components.

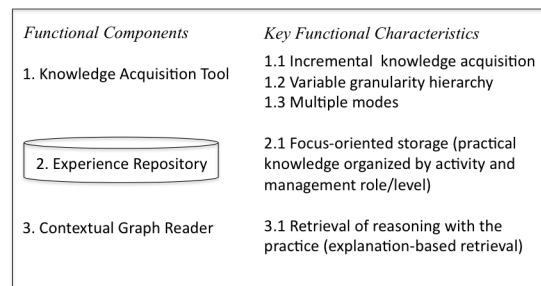


Figure 6. Architecture of a practice-based organizational learning management system

In the next section we present results demonstrating the feasibility and utility of our approach.

3. Results: Practice-based Organizational Learning in a Light Rail Project

In this section we present results from the application of our ideas to understanding and supporting practice-based organizational learning in a complex real-world situation. We have previously published results for tactical level route selection for light rail public transport. Here we present the results for the strategic level. Senior management has engaged with the researchers and their continuing support and interest constitutes a first validation of our research. The results presented here concern the strategic lessons learned by the organization following a tramway extension project in a European capital city.

3.1. Research Protocol

Our research consisted in documentary analysis, preparatory interviews with senior management and a workshop with the participation of both technical staff (transport planners and project managers) and senior management of the organization, followed up by numerous clarification discussions and formal written confirmations of our results. During the workshop we introduced the participants to the contextual element concept and demonstrated the acquisition of context in a real project using the contextual graph representation formalism. Later we transcribed into contextual graph format the lessons learned by senior management on a completed project. The source document was a 17-page high level post-completion review of the project addressed to the board of the organization by the chief executive. The researcher transposed the report into a chain of evidence table with five input columns populated directly with narrative from the report (activity, focus of attention, actual practice, evaluation of actual practice, and lesson learned) and three output columns (name of contextual element, specific value of contextual element, type of learning novelty) to be validated by the interviewee. The graph along with the chain of evidence table from the source to the graph formed the basis of in-depth discussion of practice-based learning with the most senior technical manager who validated, for each of the 25 lines of the table, 1) a contextual element with a specific value corresponding to the practice evaluated as a lesson learned, and 2) the type of learning (new situation, new practice or both). The contextual graph representation not only reflected accurately the lessons learned described in the board memo but it stimulated the recollection of further lessons learned. The final contextual graph was richer in contextual elements and instances of contextual elements than the original memo, in other words there were more lessons learned. Management validated this utility. The research project will continue in the form of action research, as the organization would like to use the contextual graph approach in preparing their next post completion report. What we did is summarized in Table 3.

Table 3. Research Protocol

Item	Action
1	Collect and represent in a contextual graph, data on the strategic activity (i.e. governance of the selected light rail infrastructure procurement project) and its main decision points; the organization's actual practice, its assessment of outcomes, its representations of lessons learned, its assessment of the novelty of the situation and /or practice
2	Analyze the data using our models of practice-based organizational learning and performance assessment maturity
3	Present the results to the organization's strategic management for validation

3.2. Research Results

We transcribed the management report into a contextual graph that had 7 activities and 25 lessons learned. The fact that we could isolate the contextual elements necessary to represent the strategic management practice demonstrates that complex strategic activities including project governance and objective setting may indeed be represented using the contextual graph formalism. Table 4 lists the activities in the graph and indicates the number of lessons learned by activity.

Table 4. Number of strategic lessons learned by activity

Activity N°	Activity name	N° of Lessons Learned
1	Defining the project	1
2	Setting governance objectives	2
3	Setting program objectives	8
4	Setting risk and contingency objectives	1
5	Setting cost objectives	11
6	Setting quality objectives	1
7	Setting funding Objectives	1

As an example, we discuss Activity 5 “Setting Cost Objectives”, with its 11 lessons learned, shown in Figure 8.

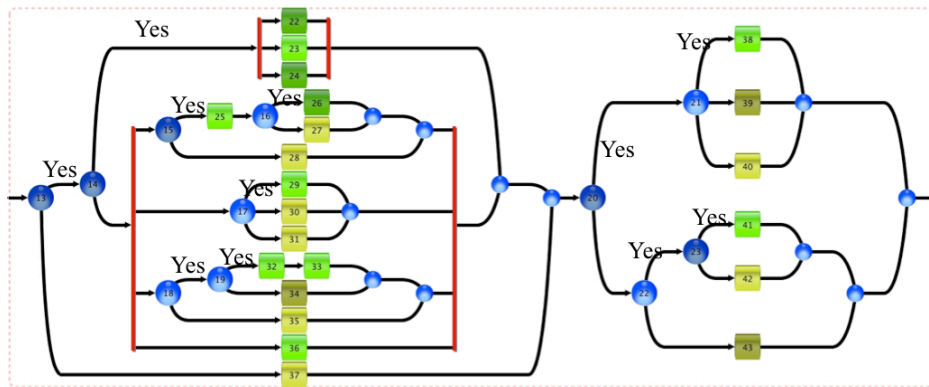


Figure 8. Detail of strategic contextual graph - activity n° 5 and its 11 lessons learned

Table 5 shows the contextual elements (CE) and the associated lessons learned. We will consider the CE N° 16 in Table 5 to continue this example. This CE corresponds to a moment when the focus of attention was at a decision point labeled “New bridge over S dock”. The contextual element N° 16 in Table 5 is labeled “Design changes close to the procurement stage accepted?” and it has a specific value of “yes” meaning that in this project a design change was accepted close to the procurement stage.

Table 5. Lessons learned and associated CE in Activity 5: Setting Cost Objectives

N°	Context Elements:	Lessons Learned:
13	Contract Strategy?	Allow separation of contracts and watch interfaces managed by [Organization]
14	Cross project procurement?	Allow cross project procurement and watch interfaces managed by [Organization]
15	Infrastructure items on critical path?	Separate contracts and start early
16	Redesign close to procurement?	Avoid redesign close to procurement
17	Costing re-measurable contracts?	Allow sufficient risk amount
18	Utilities diversion?	A separate contract with a large risk amount
19	Material with long supply lead time?	Avoid separating material and works
20	Property issues?	Compare negotiating to Compulsory Purchase Order (CPO) at full cost
21	Access to land contested?	Negotiate license
22	Full costing of CPO process?	Add CPO risk to estate agent estimates
23	Avoiding CPO process?	Negotiate before Railway Order [planning permission for light rail infrastructure] if possible

The performance assessment indicates, “There were no major interface issues with other contracts that led to increased costs and the new bridge won two architectural awards”. But the lesson learned indicates, “Design changes close to procurement stages of a project will lead to extra costs and should be avoided if possible”. It seems on the face of it that this project was lucky. Further explanation by the management reveals the “rest of the story”. What is of interest here is that more contextual elements were elicited that enrich the specification of the situation and render the learning from the experience more practically useful.

Our results are summarized in Table 4. The first two results support the claim to feasibility of the contextual graph approach to representing and characterizing lessons learned. The last two results support the claim to utility of contextual graphs for leveraging learning and increasing learning incrementally.

Table 4. Research Results

Item	Results
1	<i>Strategic lessons learned may be represented as evaluated practices in contextual graphs. Acquisition of contextual elements is feasible.</i>
2	<i>Lessons learned may be characterized by type according to the novelty of the situation and/or the practice. For each lessons learned it was possible to say whether the situation was completely new, corresponding to a new contextual element or whether it was a new practice in a known (generic) situation, corresponding to a new instance of a contextual element. The novelty of contextual elements is a historical fact and can be determined by reference to the evolution over time of graphs.</i>
3	<i>Lessons learned may be leveraged using contextual graphs that explain the reasoning behind the practice as an evolution of the focus of attention through a sequence of uniquely specified situations.</i>
4	<i>Transcribing a report into a contextual graph may reveal additional lessons learned.</i>

The first result is the feasibility of representing lessons learned using contextual graphs, even for a complex strategic activity like the procurement of public transport infrastructure. Since lessons learned are ipso facto evaluated practices what is interesting in item 1 is the demonstration that in a real-world complex project it is feasible to isolate the salient contextual elements needed to represent the strategic management practice.

The second result is the feasibility of classifying lessons learned using our typology of practice-based organizational learning. Each lesson is associated uniquely with a specific situation and an actual practice and management had no difficulty in answering whether the practice, the situation or both were new for the organization. This is a matter of factual evolution over time. If no new contextual elements are appearing over time, this could be due to a phenomenon like theoretical saturation [24] but perhaps it indicates a need to revisit the trade-off between exploration and exploitation [9]. In either case the contextual graph and its evolution are useful practice-based organizational learning management tools.

The third result is the utility of contextual graphs in leveraging lessons learned. Contextual graphs can be used to reconstitute the situation as it evolved in practice and so explain why the practice evolved as it did. This represents value-added compared to the current practice in the organization in leveraging lessons learned.

The fourth result concerns the utility of incremental acquisition of knowledge about the situation as discussed in the example above; this is typical of the contextual graph representation formalism, which allows new elements to be accommodated or

new values to be assimilated in the model without having to reorganize the whole knowledge structure.

4. Conclusions and Future Work

In active engagement with senior management of the organization responsible for light rail public transport infrastructure in a European capital city, we demonstrate the feasibility and utility of contextual graphs to represent learning from experience at the strategic level in the organization. To do so we developed a theory of practice-based organizational learning that complements our views on representation of performance as task and practice [5] and our model of performance assessment [14]. We note here that the degree and type of contextualization exhibited in a contextual graph of an activity may be used to calibrate the formalization of practice dimension of a performance assessment maturity roadmap. Our theory consists in four original contributions, 1) the practice-based learning spiral and associated modeling and representation techniques, 2) the elements of a framework of practice-based organizational learning, 3) the 4P's process model of practice-based organizational learning, and 4) the typology of practice-based organizational learning novelty. We presented the results of ongoing research that support our claim that the role of attention in fusing situation and activity goes some way towards addressing the problem of representing diagnosis, prognosis, prescription and performance in a uniform way that is compatible with the behavioral and cognitive theories of thinking.

Ongoing work in our current research project will demonstrate how to calibrate the maturity roadmap, link strategic and tactical contextual graphs. We are engaged in studies organizations with responsibility for light rail infrastructure in two countries and will consider cultural context, both organizational and national, in a future cross-case analysis. Future work will elaborate a functional specification for a practice-based organizational learning management system for complex strategic organizational activities and projects.

This research constitutes a contribution to the development of a new paradigm in computer science and information systems applicable to organizational learning, performance assessment, knowledge management, and decision support systems.

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