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MANAGING TECHNOLOGICAL INNOVATION PROJECTS

A thesis
submitted in partial fulfilment
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—

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Abstract

Technological innovation is the whole process that turns ideas into income and is becoming strategically important for creating and offering customers new choice. Traditional project management is often used to deal with discrete parts of innovation processes and involves having substantially complete knowledge of all the inter-related activities needed for project achievement. Innovation projects, however, explore new ways to meet customer needs and it is prudent to frequently review output and benefits projections. Thus, traditional project management approaches do not appear to suit innovation projects. This thesis investigates how innovation projects might be best managed.

The innovation project management practices of seven R&D purchasers and providers (1995) and six successful companies involved in the electronics, food and forestry sectors (1998) in New Zealand were investigated. Twenty-three in-depth, partially structured interviews with project and programme managers explored how they were held accountable. Every manager considered their current project management arrangements could be improved and all were searching for alternatives. Their needs and desires were examined and a new generic approach called the Time-block Innovation Project Management System (TIPS) was conceptualised to meet current practice shortfalls. TIPS uses Microsoft Excel, a common spreadsheet software package as its implementation base.

TIPS differs from traditional project management in ten ways:

- TIPS recognises *achievement* not *activities*
- Project *achievement* goals are synchronised to the business calendar
- Projects always start *now* and always finish when *benefit (income) is received*
- Projects are monitored and controlled to *maximise* delivery of currently estimated *future benefit*
- All past project cost and effort is considered as *invested in new knowledge*
- TIPS projects are regularly *re-planned from a zero base*
- Each project is *uniquely ranked*

- Resource allocation is done by *empowered staff*
- TIPS acknowledges, quantifies and *standardises risk estimates*
- TIPS is *formatted for convenience* and practical use.

Original interviewees were presented with a description of TIPS (1999) for their comment on potential benefits and requirements for implementation. Most respondents thought TIPS appeared to have several advantages, but six specifically advised that TIPS would need to be demonstrated on “real” projects before their organisation would consider using it.

Finally, a three-month pilot trial was run (2000) implementing TIPS on three projects in each of one of the original R&D provider companies and electronics/manufacturing companies. Action research was used to simultaneously refine and implement TIPS, and to determine its potential usefulness and value to the companies. Participant managers indicated that project management information collected by TIPS was adequately comprehensive and very useful. Participants agreed that TIPS was better than existing arrangements at drawing early attention for corrective action. One-third of the participants thought TIPS might be better implemented in dedicated software.

One company, six project managers and five technical managers rated TIPS methodology very highly. The second company rated the value of implementing TIPS as moderate. Respondents considered TIPS could be implemented in their companies within 12 months.

It is recommended that TIPS’ user interface be improved and full implementation tried.

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My wife Daphne has been praying, loving and patient, not doubting my stewardship of time and effort.

My supervisors have helped develop my thoughts and transcribe them into words. Associate Professor Alan Langdon listened and discussed, Associate Professor Chris Kirk stretched me to achieve my original vision, Associate Professor Janis Swan made the thesis readable and Dr Conan Fee helped with embryonic formulation.

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The source of much of the contemporary thesis material came from the 36 executives, senior managers, programme managers and project managers who were willing to share their time, experiences and opinions. I also thank the 13 organisations involved with interviews and pilot trials for trusting me with sometimes confidential and sensitive information.

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Abbreviations and Glossary

Specific glossaries are referenced in some of the bibliographed texts. Topical bibliographies include: technology (MoRST, 1996b, glossary); innovation (Souder, 1987, p 2); project management (PMBOK, 1996, pp 157-171); and portfolio management (Cooper *et al.*, 1998, pp 21-22).

Activity. Element of work performed during a project. It normally has an expected duration, expected cost, and expected resource requirements. Activities are often subdivided into *tasks*.

Bar Chart. Graphic display of schedule-related information. In the typical bar chart, activities or other project elements are listed down the left side, dates are across the top, and activity durations are as date-placed horizontal bars. Also called a *Gantt Chart*.

BCR. Benefit/Cost Ratio.

Concurrent Engineering. Approach to project staffing that, in its most general form, has implementers involved in the design phase. Also called *simultaneous engineering*.

Control. Comparing actual performance with required performance, analysing variances, evaluating possible alternatives, and taking appropriate corrective action.

Crashing. Taking action to decrease total project duration after analysing alternatives for reducing the maximum duration for the least cost.

Critical Chain. The application of the 'Theory of Constraints' to the *Gantt Chart* (see Goldratt, 1997).

Critical Path. The series of *activities* in a *project network diagram* that determines earliest project completion. The critical path can change as activities are completed ahead of or behind schedule. The critical path is normally calculated for the entire project, but can also be determined for a *milestone* or sub-project.

CPM. Critical Path Method. A deterministic network analysis technique to predict project duration.

CRI. Crown Research Institute. A New Zealand government-owned research company.

EBIT. Earnings Before Interest and Tax.

Effort. The number of labour units to complete an activity or other project element. Usually expressed in staff-hours, staff-days or staff-weeks.

EVA. Expected Value Added. A proprietary method to estimate added value.

Event. An *activity* of zero duration.

ECV. Expected Commercial Value. Present value of net project benefit discounted for the time value of money and overall risk (including uncertainty) of successful completion.

Float. The amount of time an activity may be delayed from its earliest start without delaying the project finish date. Also called *slack*.

FRST. Foundation for Science Research and Technology. A New Zealand government-owned body to manage government supported R&D.

FTE. Full-time Equivalent.

Functional Manager. Person responsible for activities in a specialised department or function.

Gantt Chart. See *Bar Chart*.

Innovation. 1: Process to turn ideas into income. 2: Process to provide customers with new choice. 3: Description for processes (or an approach) that can (amongst other things) create improved or new technology. Innovation applies to every facet of human activity.

Invention. Way to provide a potential new alternative to meeting a need.

Line Manager. 1: Person organising a group making a product or performing a service. 2: A *functional manager*.

Management. Getting things done.

Matrix Organisation. Any organisational structure where the project manager shares responsibility with the *functional managers* for assigning priorities and directing individuals assigned to the project.

Milestone. Significant event in the project, usually the completion of a major deliverable.

Monitoring. Capture, analysis, and reporting of project performance, usually as compared to plan.

Monte Carlo Analysis. Schedule risk assessment technique that performs a project simulation many times to calculate the distribution of likely results.

NPAT. Net Profit After Tax.

NPC. Net Present Cost.

NPD. New Product Development.

NPV. Net Present Value.

NSOF. Non-Specific Output Funding. New Zealand government funding provided to CRIs for unsolicited but agreed R&D.

NVA. Net Value Added.

OST. Objectives Strategies Tactics. A system developed by Texas instruments to link corporate objectives with strategies and tactics (see Jelinek, 1979).

PERT Chart. Specific type of *project network diagram*. See *Program Evaluation and Review Technique*.

PERT. Program (Project) Evaluation and Review Technique. Probabilistic event-oriented network analysis technique. Used to estimate project duration when individual *activity* duration estimates have a high degree of uncertainty. PERT applies the *critical path method* to a weighted average duration estimate.

Polychronicity. Individual's ability to do and think about multiple things (*activities* or *events*) at the same time.

Project Network Diagram. Schematic representation of project activities and their sequential inter-relationships (dependencies).

Project Portfolio. Program of related projects. The relationship may be by common type (e.g., R&D, new product), by strategic intent (e.g., new market development, "cash-cow" product support) or may contain all innovation projects an organisation is undertaking.

Program (or Programme). Group of related *projects* managed in a co-ordinated way. Programs usually have an element of on-going activity. The words "program" and "programme" are used interchangeably in this thesis according to contextual origin.

Project. Temporary endeavour undertaken to create a unique product or service.

Project Management. Applying knowledge, skills, tools, and techniques to project activities so the project meets or exceeds stakeholder needs and expectations (on time, on budget and at or better than agreed quality).

RA. Research Association. An industry-funded research organisation.

RAD. Rapid Application Development. Processes developed during the 1980s and 1990s for controlled and fast production of software applications. The process favours timeliness (and by inference cost) ahead of functionality (quality). RAD uses *time-boxes* for calendar-based reviews.

R&D. Research and Development. Systematic investigation of phenomena, ideas, and problems, and application of the results to create theoretical constructs, solutions and technologies.

Resource Levelling. Any form of network analysis in which scheduling decisions (start and finish dates) are driven by resource management concerns (e.g., limited resource availability or difficult-to-manage changes in resource levels).

ROI. Return on Investment.

S-Curves. Graphic displays of cumulative costs, labour hours, or other consumables, with time asymptotic to the start and finish values on the Y-axis.

Scope. Sum of products and services to be provided as a project.

Simultaneous Engineering. See *Concurrent Engineering*.

Slack. See *Float*.

Stage-Gate Process. (“Stage-Gate” is a trademark of R.G. Cooper). Formal process, or road map, which firms use to drive a new product project from idea to new product launch. It is also called the new product process, gating process, or phase-review process. This process typically has multiple stages, with gates or decision points where Go/Kill decisions are made, and hence where many of the resources are allocated. It can be used in conjunction with the *project portfolio* approach to program management.

Stakeholder. Individuals who and organisations which are involved in or may be affected by project activities.

Task. See *Activity*.

TBG. Technology for Business Growth. A government-funded scheme to assist industry to employ researchers.

TDU. Technology Development Unit. The name given by a particular research provider to its specific commercial organisations.

Technology. Knowledge capable of practical application.

Technological Innovation. Applying innovation processes to create or develop new or improved technology.

Time-box. Construct used in *RAD* for packaging the work for review. Time-boxes are typically one week long. Activities planned for each box require completion, even at the expense of desirable functionality.

Time-block. *Work package* created for *TIPS*. Time-blocks can be one week (7 days), one month (30 days) or one quarter (90 days).

TIPS. Technological Innovation Project System/Time-block Innovation Project Management System. System to oversee the management of an innovation process.

TQM. Total Quality Management. Method implementing a quality improvement program within an organisation.

VA. Value Added.

WBS. Work Breakdown Structure. A deliverable-oriented grouping of project elements that organises and defines the total scope of the project. Each descending level gives more details of a project component. Project components may be products or services.

Work Package. A deliverable at the lowest level of the *work breakdown structure*. A work package may be divided into *tasks* or *activities*.

CHAPTER 1 – INTRODUCTION

Outside of a dog, nothing brings greater enjoyment than a good book. Inside of a dog, it's too dark to read - George Bernard Shaw.

1.1 Innovation and Projects

Innovation is about giving customers new choice and is now widely recognised as being a key element in providing businesses with sustainable competitive advantage (Quinn, 1985; Peters, 1990; Porter, 1990). More companies are innovating (Economist, 1999). They need to innovate effectively to survive and efficiently to endure.

Technological innovation projects create and introduce new products, processes, services and systems to business operations (Mills and Kirk, 1995). However, projects are traditionally managed using techniques originally developed in America and Britain in the 1910s (Gantt Charts) and 1950s and 1960s (PERT and CPM) for designing and producing aeroplanes, submarines, power stations and office blocks (Wren, 1979; Burke, 1999). Technique development was done for large, complex and inevitable projects at a time in history when the science and art of management was in its infancy and technological change was relatively dormant (Boone and Bowen, 1987).

During the past four decades projects have become a common means of introducing new and potentially risky products, processes, services, systems and ideas into organisations. Projects can be self-managed and isolated from normal operations. Project managers have the responsibility for project output and are accountable for efficient and timely delivery.

Projects have been characterised by tight scopes and intense resource management. A standardised body of knowledge and a number of professional institutes have emerged in the last decade (PMBOK, 1996). However, key strengths of traditional project management techniques, including the ability to optimise task sequences

and efficiently direct and manage resources to balance time, cost and quality constraints, appears to be much less useful for innovation.

The tasks, their inter-relationships, the resources and most of the technology used on traditional projects are well understood and can be essentially prescribed. However, modern technological innovation projects (particularly where new technologies, processes and markets are involved) incorporate novel solutions. Therefore rigid project prescription is not possible.

Traditional project management is used for discrete parts of the innovation process (Figure 1.1) whereas for technological innovation projects it is desirable to manage the whole process from idea to income generation. (Figure 1.2).

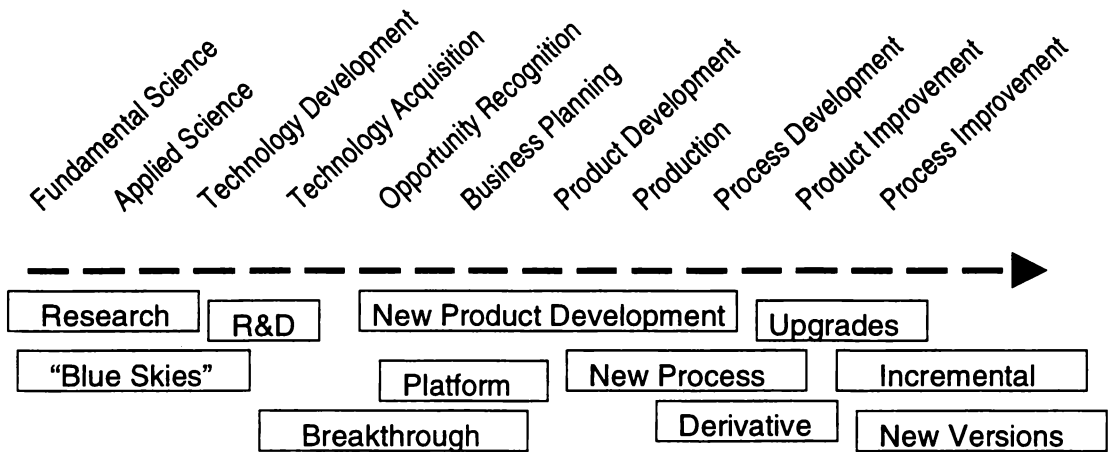


Figure 1.1. Traditionally Managed Innovation Projects

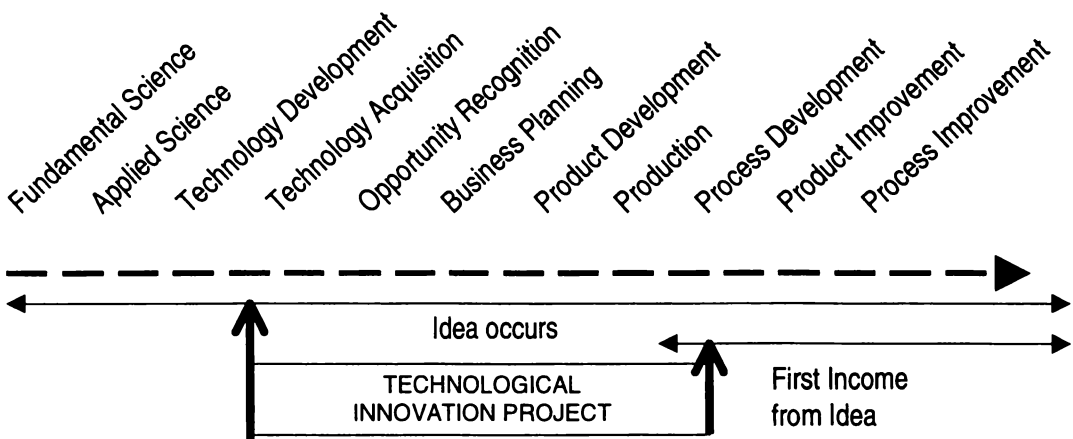


Figure 1.2. Scope of Innovation Project Management

1.2 The Challenge of Managing Innovation

Technological innovation project managers are faced with increased uncertainty in many dimensions including, specification, functionality, task sequence and suppliers. New technologies and market opportunities may even completely change the activities required to satisfy customers, generate the desired project output or optimise the prospects of profitability. Traditional project management techniques cope well with managing changes to resources and constraints but deal less easily with changes to tasks and scope. The importance of innovation projects to organisational survival and welfare, particularly in the last decade, has highlighted shortfalls in the capacity of traditional project management techniques to be effective.

The pace of innovation is increasing as businesses strive to be first to the market (Thamhain and Weiss, 1992). Practices that encourage more tasks to be done in parallel rather than in strict sequence have evolved to meet the need for speed. Examples are, technology shoot-outs (Quinn, 1985), strategic partnerships and alliances (Howarth *et al.*, 1995) and concurrent or simultaneous engineering (Kerzner, 1997). In spite of increased uncertainty and the need to apply inefficient parallel practices, more resources are being invested in innovation effort and greater accountability is required for innovation performance. There is consequently a growing need to be effective at innovation at the same time as being efficient through project management.

The innovation process has become a continuous synchronised effort rather than merely a collection of temporary endeavours (Cooper *et al.*, 1998). The need for organisations to conduct on-going innovation has transferred novel projects from independent isolation to routine operational necessity. Therefore, innovation project management needs to be integrated with regular organisational activity.

Bartlett and Ghoshal (1994; 1995a; 1995b) argue that organisations are in transition from operating in a framework that emphasises strategy, structure and systems to one promoting progress through purpose, process and people.

Traditional project management enables strategy to be implemented through systems and structures and admirably suits conservative regimes. Innovation, on the other hand, is a process that translates ideas into income through the endeavours of people. It is therefore important to understand how the people involved in making the innovation process happen currently cope with their responsibilities. Whether or not people perceive themselves as operating through strategy, structure and systems or through purpose and process, or some other paradigm, current practice needs to be identified before systematic improvements can be contemplated.

If business growth depends on capturing the benefits of successful technological innovation, then it is important for organisations to know:

- how innovation projects are managed
- whether traditional project management practices are still useful
- whether there is a more relevant model for managing innovation projects.

1.3 Aim

The research reported in this thesis was undertaken to investigate technological innovation management practices in New Zealand, to identify performance and accountability inadequacies and recommend how they may be appropriately addressed.

This research seeks to characterise the essential elements of a technological innovation project management process and recommend new or improved alternatives. While any new arrangements should be useful to organisations involved with innovation in New Zealand, it is also expected that the principles will be applicable elsewhere. Recommended changes should enable better and more timely decisions by R&D purchasers and providers, project contributors from all functional areas, and parties selecting and managing innovation project alternatives within organisations. Ideally the widespread adoption of a more useful system will help provide common understanding about project potential.

When considering changes to present practices, organisations are expected to consider their attitudes to (unrealistic) expectations. For example, that project output will always provide the best business solution and that project risk level always reduces with the passage of time and activity achievement.

An additional benefit sought from this research relates to motivation for project staff. There is a widespread and unjustified perception of failure when project schedule, output quality or financial return targets, as assessed by traditional project management techniques, are not met. This is exacerbated when regular updating of expectations from projects is neglected on the basis that insufficient project management resource has been allocated, too much unjustified effort is required or the revised plans will not change subsequent actions. In properly managed projects, failure should be rare if adequate attention is paid to updating prospective futures. The application of a more relevant management system for innovation projects should increase staff motivation by reducing the prospect of failure.

Good innovation project management is vital to the welfare of organisations and must therefore not be left to the devices of ill-informed executives, outdated tools, and intransigent managers. This research therefore has as its final aim to draw to the attention of managers a means to properly attend the innovation process.

1.4 Scope

New Zealand is better known domestically for its ingenuity than internationally for its innovation where it ranks poorly against other developed countries (Economist, 1999). Innovation management in New Zealand is practised with limited resources and on smaller projects than in the US and Europe, where traditional project management tools were developed. However, many innovations done overseas are accomplished by initially small organisations. Therefore, doing this investigation in New Zealand makes it relevant to local need and provides opportunity for wider benefit.

While not a large or consistent producer of advanced technology, New Zealand is advanced as a technology user and exploiter (Darroch and Engelbrecht, 1998). Technological innovation is the most difficult type of innovation and represents a comprehensive challenge (Drucker, 1985). However, if a way can be found to better manage technological innovation, it would provide a potential template for other easier innovation types and for other types of projects.

Project management is by nature an integrative activity. Project managers do what is necessary to get a job done. Therefore this study must cover areas of significant influence on the role of project managers and include organisational behaviour, vision and strategy as well as the structure, systems, methods and tools of implementation.

Organisations significantly involved in innovation in New Zealand include R&D purchasers, specialist providers and companies, who service much of their own innovation needs. Within organisations the functional roles of R&D and marketing are pivotal for innovation success. The interaction between, R&D, marketing, engineering and production in the context of developmental operations also need to be explored.

A wide range of organisational ownership and purpose was desired to consider information from a wide perspective. Typical R&D organisations necessarily include examples from government, government-owned entities and industry bodies. Company structure types include public, private and co-operative ownership.

1.5 My Perspective

I am a professional mechanical engineer involved in the formal management of projects for 30 years. In 1969 I was a student apprentice responsible for updating magnetic tile/white board Gantt charts for the planned maintenance of boilers and turbines in a Central Electricity Generating Board thermal power station in England. I used similar but computerised CPM and PERT systems for the

construction and commissioning of electrostatic precipitators and ash handling plant for Huntly power station in New Zealand in the mid-1970s.

In the 1980s, I moved from managing power projects to managing agricultural research projects applying my project management skills to the R&D environment with mixed success. I always knew where the project team should have been but we did not always get to where I would like to have gone. Project management tools helped plan and project desirable outcomes but were not much help in managing people or achieving desires.

In the late 1980s and early 1990s in New Zealand, government R&D and private R&D there was an emphasis on realising tangible benefit on investment. Therefore, first as Leader of the Ruakura Engineering Development Group and then as Head of the MIRINZ Development Engineering Division, I was responsible for turning ideas into income. Traditional project management methods and tools formed the basis of my efforts to plan and control innovation projects and account for the expenditure incurred in doing so. Sometimes traditional tools worked, but often factors outside the project, outside my control and beyond my sphere of influence conspired to frustrate the otherwise responsible management of innovation projects. Traditional project management methods and tools appeared to be inadequate to achieve success.

In the mid-1990s, while working with the Technology Management and Innovation Unit at the University of Waikato, the opportunity was presented to write case studies of successful innovation projects from 5 different companies. The CEOs themselves had to approve the case write-up the emphasis inevitably revolved around their view of the process and their perception of why the innovation was a success. My role was, in one sense, a scribe for a storyteller and, in another sense a selector and controller of information type, and level and style of presentation (Abell, 1997).

Despite these many constraints five stories of innovation were assembled and approved. The stories tell of new products and new processes, company innovation

systems, ways of motivating people and integrating accounting measures with operations. The cases and their analysis were later expanded and published (Poulin *et al.*, 1998a; Poulin and Mills, 1998b). These two books included additional commentary on the perceptions and strongly held views of competent executives as well as formal academic strategic analysis. The analysis reflected the views of influential personalities and impositions of company cultures as well as concurrent financial realities expressed in company financial information. This taught me that innovation is an organisationally comprehensive affair.

A final influence, which ran in parallel to the main research period, involved preparing teaching material and interaction with mature company-based students as they explored issues during classroom interaction and in assignment responses for Masters degree level courses in Technology Management and Innovation. The students' own research revealed further information sources and helped identify issues that they, and the organisations they represented, found to be important.

1.6 Limitations and Key Assumptions

This thesis presumes that innovation can provide sustainable competitive advantage to organisations intent on growth and longevity. The term “innovation”, used in its generic sense, unavoidably involves the “application of know-how” (technology). In this work “technological innovation” emphasises the beneficial application of new knowledge, usually in tangible form, and includes new applications of old knowledge. However, for the sake of readability compound terms like “managing technological innovation projects” are sometimes shortened to terms like “managing innovation” or “managing projects”. Important distinctions with, for example “managing traditional projects” are, however, made explicitly clear.

The scope of this research is constrained to successful organisations working substantially in three industries important to New Zealand, specialised manufacturing electronics, food and forestry. The purpose behind this selection is to touch a range of industry types, generalised as small, fast and modern

(electronics), large and traditional (food), and finally, underdeveloped but growing (forestry).

This research does not purport to offer representative samples. A limitation of in-depth partially structured interviews, action research and involvement with pilot trials on actual projects is the number able to be done across the wide range of perspectives required to address this topic. Rather, the integrity of the research relies on the fact that each interviewee operates in the context of an indisputable reality, sufficiently cohesive to enable their role to be performed. Their realities are a mixture of fact and perception and are influenced by personal intrinsic values, circumstance and expediency. Likewise interpretation of the verbal and non-verbal communication at the interviews is perceived in the context of the interviewer's predisposition and needs. Effort has been made to present typical and significant contributions.

A further limitation of this research is the self-imposed restraint to establish a single cohesive solution able to be implemented within the scope of current organisational practice and with the presumption of compliance and co-operation of all managers involved in the innovation process. A presumption is also made that a solution, perceived as having benefit, is not rendered untenable by having unrecognised disadvantages.

A process to better deliver innovation was expected to emerge from the study of the literature and in-depth interviews. Validation by full trials of the technological innovation project system was the initially preferred output of this research. However, findings from the literature review indicated this desire was a difficult and unlikely prospect within the jurisdiction of this thesis.

1.7 Data Collection

Primary research information was collected through partially structured in-depth interviews and pilot trial site visits with project and programme managers. Innovation project and programme managers are busy people skilled at making

things happen through interpersonal interaction. Therefore in contemplating the collection of research material (data, information and knowledge) “face-to-face” interaction was considered more conducive and productive for gaining “in-depth” insight than solely a written survey. Further, although these managers are used to creating order from chaos and are able to cope with open-ended questions, a partially structured interview with pre-circulated guideline questions was selected to help constrain and manage the scope and depth of their responses during the initial research.

The in-depth interview and the action research approach does not question the validity of the data, because people report reality as they see it. However, the constituency they represent is more difficult to determine. Matters of policy and fact can be verified in a general sense by inspecting annual reports and official documents; these sources were reviewed for the organisations represented. Further, the positions held by interviewees also confer a level of authority on their responses although inevitably these were mixed with personal experience and opinion. Therefore, rather than attempt statistical representation of levels of management, functions, organisations, industries, sectors or nationalities, this research uses these labels as indicators of the perspective from which each individually valid contribution was gleaned.

1.8 Thesis Outline

Chapter 2 (Literature Review) introduces, classifies and reviews the literature on project management to establish an understanding of previously published work on technological innovation management through projects and to help formulate questions for this research.

Chapter 3 (Methodology) describes how new data, information and knowledge were collected for this research.

Chapter 4 (Findings) assembles and compares the results of the interviews, pilot trials and surveys.

Chapter 1 - Introduction

Chapter 5 (Discussion) compares, contrasts and discusses the findings of published work with the findings of this research.

Chapter 6 (Conclusion) compiles, consolidates and summarises new understanding and knowledge generated by this research. Future work to extend the research is recommended at the end of the chapter.

CHAPTER 2 - LITERATURE REVIEW

*When we try to pick out anything by itself, we find it is hitched to everything else
in the universe - John Muir*

2.1 Chapter Layout

This review investigates the process of managing technological innovation projects, overviews its components and explores its practices. These practices are intended to deliver growth and benefit to the organisations that use them and provide accountability to stakeholders for the resource they consume.

The review starts with a perspective on the principles and concepts embodied in the elements that make up the thesis title. Two subsequent sections explore in some detail the growing importance of innovation in business and then focuses on its most demanding form, “technological” innovation.

Technological innovation is addressed here in three categories, research and development (R&D), revolutionary innovation and evolutionary innovation. A linear view of these three processes might describe them as “awareness and creation of new profit potential”, “realisation of that potential” and finally, “extension of the potential”.

In practice the R&D function is a parallel activity within technological innovation, however, it is often perceived as being most evident during the initiation phase of projects. R&D provides highly creative contributions forming an innovation base. R&D involves researchers and marketers. It employs “discovery” and “fundamental- and applied-science” on one hand and, “need awareness and interpretation of market opportunities” on the other. An R&D project traditionally culminates in the report of new knowledge that indicates how it might be translated into tangible benefit.

Revolutionary or “break-through” innovation is a process starting when a tangible opportunity to generate profit from a novel concept is recognised and finished

when benefit is achieved. Innovation must eventually produce benefit of some description. Benefit is usually realised and recognised by producing direct or indirect profit to the owner.

New product development (NPD) is a business-centred activity that has accumulated a large and distinctive body of literature. NPD does not necessarily have direct genesis from R&D projects and its scope rarely extends beyond the onset of commercial production and product launch. NPD is reviewed here as a sub-set and within the context of revolutionary innovation.

Evolutionary innovation in this review includes profitable improvements, enhancements and support to extant income generators. These include product and process upgrades. Evolutionary innovation is regarded separately because of its distinctive feature of pace and its connection to the closing phases of the innovation process.

The prolific literature on project management is gleaned only from the perspective of general concepts and those elements that address dynamic and highly uncertainty environments.

Finally, a short review on the increasingly popular and relevant topic of project portfolio management is presented. This business-process ideally optimises project selection and usually regulates project pace. Portfolio structures and systems provide frameworks that oversee the translation of strategic intent into strategic implementation and should house decisions made by enterprise to best create and exploit competitive advantage. Project-portfolio management can be described as a means to optimise the potential benefit from investment in an orchestrated selection of innovation projects.

The relationships between chapter topics are outlined in Figure 2.1.

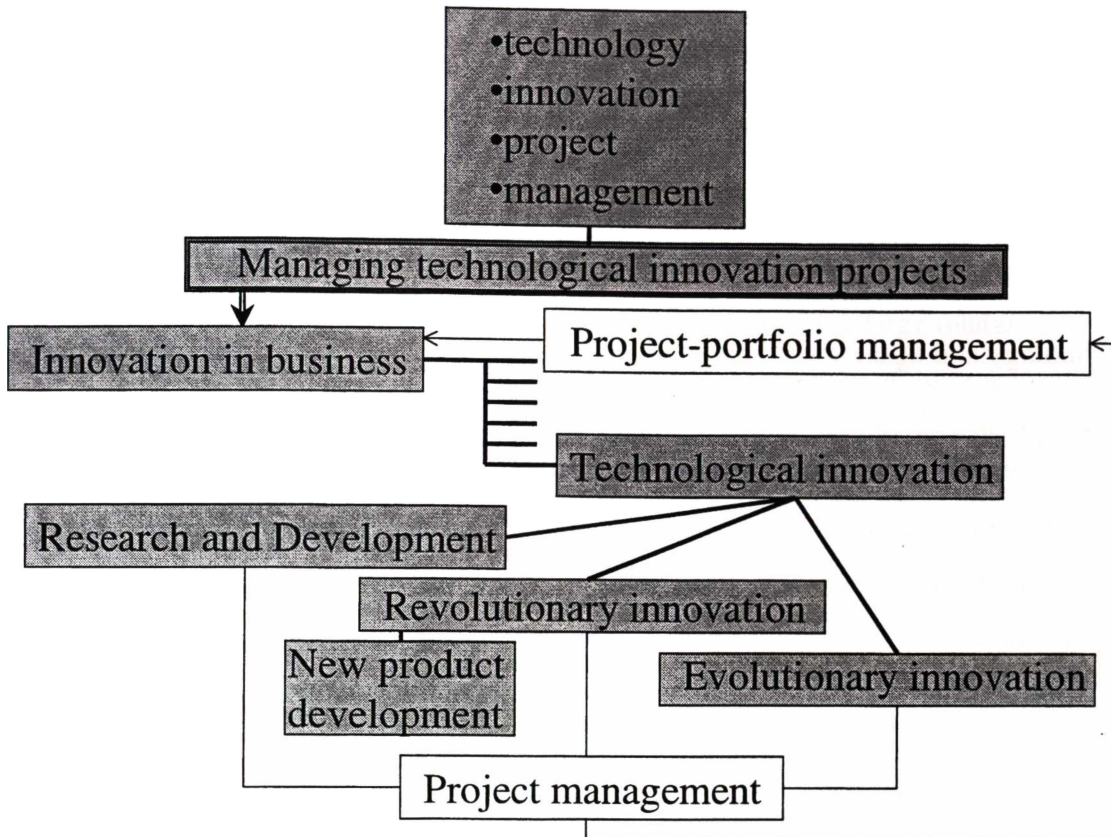


Figure 2.1. Literature Review Layout

2.2 The Need For Something New

2.2.1 An enduring problem

The challenge to improve the management of the innovation process is persistent and relates to the chaotic nature of the process. Over 30 years ago the consulting firm Booz-Allen and Hamilton (1968, p 13) identified problems with the organisation of new product development. Problems were associated with top management failures (81% of firms reported problems with organisation, 35% had poor control and follow-up, 26% had poorly defined objectives and 26% had inadequate business analysis). The most common organisation problems were, for 30% of firms their definition of responsibilities, for 28% working and reporting relationships, for 26% communications and 23% each with top management support and the size of the organisation. Booz-Allen and Hamilton, further

reported that “four out of five products failed because either the idea or the timing was wrong”.

Gruenwald (1985, p 11) reported little progress with the problem 17 years later, listing many different reasons for product development failure from his research in the US. He described the main contributors to the problem as poor planning, poor management, poor concept, poor execution, and poor use of research, poor technology and again poor timing!

Barczak and Wilemon (1999), marketing academics, interviewed 71 members of new product development teams to assess the effectiveness of the processes used by their companies. Only 50% thought their process was effective and the balance said the process was ineffective mainly because it was not used. Another revealing fact was that only 64% of staff understood the purpose of their new product development projects. The poor understanding was because projects lacked goals or the goals were not communicated. This study concluded there was still urgent need to improve the innovation management process.

The problem of doing innovation is evident even in successful companies. Bernaxo *et al.* (1999, p 130), who investigated the new product development process at the Materials and Controls Division of Texas Instruments, identified two challenges for the “enormous effort” required to stage innovation. Firstly, academics must find better ways to communicate to practitioners. Secondly, simple instruments must be developed to “solve the problems of implementing solutions such as stage-gate systems, project management, portfolio management, TQM or concurrent engineering”. However, Englund and Graham (1999, p 63) from Hewlett-Packard warn:

Any attempt at leading change in how an organisation links projects to strategy is bound to meet resistance. The concept receives almost unanimous intellectual support. Implementing it into the heart and soul of all people in the organisation is another story.

The efficient management of the innovation process is therefore a well-recognised, comprehensive and enduring problem. Potential solutions have been inadequate and difficult to implement.

2.2.2 Project management to the rescue?

Dinsmore (1998) describes the route from business planning to project implementation as a “murky journey through Never-Never land”. Project management techniques, seen to be so useful for co-ordinating large military and civil projects, do not appear to have helped much to solve innovation process problems. Project management tools have been developing slowly over the last 30 years. Frame (1994, p 5) lists many different reasons for the failure of tools to address innovation project problems and suggests that problems really stem from a narrow definition of what project management is about.

Shenhar (1999) has also been searching for ways to improve the contribution of project management tools to the problem of innovation management. He analysed 40 commercial and defence projects, 127 projects with quantitative data and a further 110 projects with both qualitative and quantitative data and found that 85% of projects over-run estimates. However, Shenhar too concludes:

Tools are never the problem and projects hardly ever fail because managers did not know how to use project management applications... there is a need to manage projects differently... project management should not be a mere implementation tool but rather fully integrated into the organisation at all levels

Although Thamhain (1999a) insists that help will come from better tools, able to handle “complex, non-linear and fuzzy problems”, the weight of opinion is that improving project management tools alone will not adequately address the needs of innovation process management.

2.3 Technological Innovation Project Management

2.3.1 Technology

Dussage *et al.* (1992, p 13) gives a fundamental and elegant Eighteenth Century definition of technology as “the study of techniques”, differentiated from art by the fact that “techniques” are transmissible. This is an important distinction when considering the unique contributions of creative people and artisans in the innovation process. In a context useful to this thesis Dussage also offers technology as being:

A process which, through an explicit or implicit phase of research and development (the application of scientific knowledge), allows for commercial production of goods and services.

He considers that an organisation should have a balanced technology portfolio, ranging from “emerging” to “obsolete” which transfers in due course from a “differentiated” to a “base” attribute of the firm.

Technology can thus be seen as essential to an organisation to help capture and secure benefits.

2.3.2 Innovation

Tushman and Nadler (1986) define innovation as simply “the creation of any product, service or process which is new to a business unit”. However, Burgelman and Sayles (1986, p 10) acknowledge the effort required, and so describe innovation as, “a company’s efforts in instituting new methods of production and/or bringing new products or services to market”. Gilbertson and Knight (1992, p 15) studied innovation in New Zealand companies and describe innovation more pragmatically as, “an attitude of mind or a leadership style which creates a culture where, ‘making things happen’ is a key phrase”. Stopford and Baden-Fuller (1994) agree and describe innovation as nothing less than “corporate entrepreneurship”.

Souder (1987, p 2) provides 11 definitions of innovation to make the point that a “lack of clear definitions has resulted in considerable arbitrariness in our concepts of innovation”. And Buckler (1997) amplifies innovation as “the whole spectrum of

activities necessary to provide new value to customers and a satisfactory return to the company or entrepreneur”. He describes innovation as requiring belief and support, and that it must be holistic. Levene and Goffin (1997) notes the Oxford English dictionary definition of innovation as simply “introducing something new”. In the business context innovation also has the potential to increase value to the shareholder or stakeholder.

2.3.3 Technological innovation

Karger and Murdick (1972, p 59) describe technological innovation as “any changed form of a product that has become available in a specified market within a specified recent time (typically, about a year)”.

The OECD (Eurostat, 1997, p 18) follows the arguments of Utterback (1987) and distinguishes between technological product and technological process innovation. It defines technological product innovation as “the implementation/ commercialisation of a product with improved performance characteristics such as to deliver objectively new or improved services to the consumer”. Technological process innovation, on the other hand, is “the implementation/ adaptation of new or significantly improved production or delivery methods that may involve changes in equipment, human resources, working methods or a combination of these”.

Technological innovation therefore may relate to a product, a process or a service.

2.3.4 Projects

Gilbreath (1986, p 12) describes a project as if it were a guided missile homing in on a target:

It has been designed, produced, aimed and fuelled for one purpose-to destroy the target. Once the missile strikes its objective, the missile and its reason for existing vanish altogether.

This singular view is typical of those who tend to isolate projects from other parts of the organisation and expect no ongoing obligation to customers. This contrasts this with the holistic view of innovation espoused by Buckler (1997) and Stopford and Baden-Fuller (1994). Gilbreath’s (p 26) perspective is cemented by his view

that normal business progression is “operations-project-operations”. A more ubiquitous view from PMBOK (1996), representing the current *de facto* authority on project management, defines a project as “a temporary endeavour undertaken to create a unique product or service”.

Kharbanda and Pinto (1996, p 15) on the other hand, use a definition of a project which transfers the focus from the endeavour to the people involved:

A project is an organisation of people dedicated to a specific purpose or objective. Projects generally involve large, expensive, unique or high-risk undertakings that have to be completed by a certain date for a certain amount of money, within some expected level of performance. At a minimum, all projects have to have well defined objectives and sufficient resources to carry out all the required tasks.

This definition presents an idealised picture of desired resource availability and emphasises the magnitude of the endeavour more than the uncertainty characteristic of innovation projects. It suits the environment for which traditional project management tools were developed. Burke (1999, p 2) prefers a more comprehensive but equally constrained definition of a project as:

An endeavour in which human, (or machine), material and financial resources are organised in a novel way, to undertake a unique scope of work, of given specification, within constraints of cost and time, to so as to deliver beneficial change defined by quantitative and qualitative objectives.

Projects are therefore viewed as isolated efforts with distinct boundaries related to tangible and prescribed outcomes, which are desirable, beneficial, and which provide no acknowledgement that the target might be moving.

2.3.5 Project management

Professional project managers are globally adopting the PMBOK (1996) framework to classify project management. Nine major categories identified are integration, scope, time, cost, quality, human resources, communications, risk and procurement. These cover a combination of topics described by Block (1998) as 20% science and 80% art. The art portion involves communications, trust, integrity, sociability, leadership and values - resisting description and defying boundaries.

PMI Today (1999) reports that project management definition was a source of strong contention in the 1970's and 1980's. Some equated project management with scheduling by PERT and CPM while others thought it was the occupation of the one person in charge of a project. All appear to agree, however, that it is possible to specify, plan, schedule and execute projects without paying much attention to the environment outside the project's own crisply defined and patrolled borders.

Cleland (1999) for example still uses a 1951 definition of project management:

[The management of] any undertaking that has definite, final objectives representing specified values to be used in the satisfaction of some need or desire.

However, the desirable “isolated” status of projects is difficult, if not impossible, to achieve. Even Cleland acknowledges that “most projects do not have a sharp beginning” (p 348). And at what point does a project manager know he or she has succeeded? Is success only measurable by performance against original objectives?

2.3.6 Summary

Managing technological innovation projects therefore involves the diverse dimensions of science, technology and art in the context of both normal business and a specific endeavour. The process should occur in a dynamic and chaotic environment with an orderly, measured discipline. The outcome has to be something new and useful. It has to meet real needs as well as sustain and benefit the innovators.

2.4 Innovation In Business

2.4.1 Economic origins

Innovation is an economic construct creating a temporary and legal monopoly until the arrival of competition (Schumpeter, 1934; Malinvaud, 1973, p 257; Urabe, 1988, p 3). A firm should therefore strive to improve its internal innovation processes and adjust to the external environment to maximise profit. Haour (1999) describes Schumpeter's work on ‘creative destruction’ as, “the interplay between

technology, growth and competitiveness”. Continuous innovation therefore provides sustainable competitive advantage.

Denison (1956) and Solow (1957) confirm real growth in the US economy from 1909 to the 1950s to be due to increased human capital of the workforce and technological change. Frater *et al.* (1995) investigating the factors that influence the interest and ability of New Zealand enterprises to innovate and concludes that technological change is responsible for most of the historical growth in modern economies.

Technological innovation is therefore accepted as an historical driver for company and national growth.

2.4.2 Continuing need for innovation

Macro studies

The need for continuing innovation effort is supported by Kanter (1983, p 38) who observes:

Recent business history is filled with the skeletons of companies that failed to innovate or even to recognise the need to adapt to obvious change

More specifically Kerzner (1997, p 51) describes business survival as depending on a broad spectrum of innovation:

Successful capital projects, new product development, customer expectations, efficiency and effectiveness, executive managers’ buy-in and internal competition.

The OECD (Eurostat, 1997, p 270) recognises the continuing economic importance of innovative products (goods and services) and innovative processes and advises:

At the macro-level, there is a substantial body of evidence that innovation is [still] the dominant factor in national economic growth and international patterns of trade. At the micro-level, within firms, R&D is seen as enhancing a firms capacity to absorb and make use of new knowledge of all kinds, not just technical knowledge.

Not only has the need for innovation remained but the pace of technological change is also seen by some to be increasing. Chorafas (1967, p 223) provides examples to argue this point. Photography discovered in 1727 took 112 years to apply whereas transistors discovered in 1948 required only 5 years. This evidence infers a natural limit. However, the topics, and their dates of discovery and practical application although tenuous and a convenience to the author make the point that individuals and organisations continue ever more energetically strive for innovation.

Micro studies

Traill and Grunert (1997, p xvi) conclude there is little evidence to relate the level of R&D to business success. The proportion R&D/sales in the food sector is very low at 0.5% compared to 12% for drugs and 8% for electronics. However, he shows that customer needs are indeed met through innovation activity.

Innovation is important to Hewlett-Packard which garners 60% of revenues from products introduced in the last 5 years (Matheson and Matheson, 1998) and is “obsessed with growth and innovation” (Haour, 1999). Matheson and Matheson also advise that Gillette and 3M also look to their new products for 25 to 35% of their revenues each year.

A study on 716 manufacturing companies each with over 300 employees, in 17 countries confirms there is a strong correlation between innovative and corporate success (Howell, 1999, p 32). Howell also quotes Dyson, the fastest growing manufacturing company in the UK as saying, “we cannot afford not to strive continuously for innovation”.

It is evident that to be useful, R&D outputs must be translated into profitable outcomes through consolidated organisational effort. However, novelty introduces complex, chaotic environments and interactions into organisations.

New Zealand situation

New Zealand is poor at innovation (Economist, 1999). New Zealand funds R&D to only half the level of comparative countries a relatively high proportion coming

from government investment (MoRST (1996a). However, a survey of 730 New Zealand exporting companies found that the government owned and substantially funded Crown Research Institutes (CRIs) provide the least important source of innovation (Frater *et al.*, 1995). New Zealand has a fragile innovation base since only 250 firms account for 90% of New Zealand's exports and only 70 firms account for 68% of the reported private sector spending on R&D (MoRST, 1996b, p 10).

Darroch and Engelbrecht, (1998) provide a snapshot of New Zealand's national innovation system using macro-economic indicators. They conclude that the innovation system is failing. Overseas owners of large New Zealand companies control too much innovative resource and small companies tend to have inadequate innovative resources. Further, New Zealand government support favours existing competitive strengths.

New Zealand studies show it to have a dysfunctional innovation system. Government supports CRIs who fail to significantly contribute to the innovation efforts of companies. The private sector companies are generally poor contributors to their own R&D efforts and do not work much with government funded researchers (Frater *et al.*, 1995). There is little evidence of healthy R&D and innovation partnerships or support systems to make internal processes and external networks efficient.

2.4.3 Character of business

Legendary companies

The top growth companies in the US are characterised by their ability to involve lower level (strata) employees in long range planning, seize opportunities when they appear and maintain an active, viable programme to encourage employee innovation and creativity (Karger and Murdick, 1972). These companies also have an "infallible sense of timing" for starting and closing ventures, have above average investment acumen and finally have an integrated product line with a programme of product development and acquisition to avoid both risk and merely temporary gain.

Drucker incisively identifies the proper allocation of scarce resources: capital and performing people, as essential, since they convert into action whatever information management has about its business. “They determine whether the enterprise will do well or do poorly” (Drucker, 1995).

Legendary companies are said to have vision and purpose that is memorable and inspirational (Collins and Porras, 1998). Success comes from recognising the power of “and” (embracing partnership and co-operation) rather than falling to the tyranny of “or” (singular selection in decision making).

The advice from these three prominent commentators to those who seek legendary status for their companies stretches from being exemplary vision-marketers to having acumen in primary resource allocation. This range of skills is found from the top through to the lower levels of management. Therefore cohesion of purpose and competence in implementation is needed throughout the organisation.

Systematic entrepreneurship

Drucker (1985, p 50) defines innovation as systematic entrepreneurship derived from seven sources, four from within the enterprise and three from without. He exhorts his readers to look inside their industries for the unexpected event, incongruities, innovation based on process need, and change in industry or market structure. Opportunities arise outside from changes in demographics, changes in perception, mood and meaning and finally new knowledge (scientific and non-scientific).

Science-based (technological) innovation is glamorous but, Drucker warns, “the least reliable and least predictable”. It is the most challenging kind of innovation. It is hard to manage, takes a long time and is expensive. It is not surprising, then, firms are reluctant to undertake the innovation trail unless they have good processes to realise a return. For this reason governments, including New Zealand’s, endeavour to support R&D where the benefit is evident but less appropriable, and the risk is high.

A decade later Drucker (1995) still says “every organisation, not just businesses, needs one core competence: innovation”. Drucker is also frequently quoted in the literature as saying:

Because its purpose is to create a customer, the business enterprise has two, and only two, basic functions: marketing and innovation; (everything else is cost).

A business plan is recognised as the passport for entry into the idea development queue. It harnesses concepts and provides the metrics and language to which business can comfortably relate (Stevenson *et al.*, 1994; Timmons, 1999). It helps frame creativity.

Technological innovation therefore, provides a significant and fundamental challenge to organisations. An important milestone is reached in its development when an innovation can be described in an appropriate business plan, but early work may require government support.

Does organisation size matter?

Successful innovation often comes from small companies and causes growth, but are they advantaged by size? Quinn (1985) argues organisational size need not be of concern provided that big companies act like small ones in the innovation process. He argues big, legendary companies thrive because they have efficient innovation processes. Top management and implementers “sing the same song and harmonise”.

If small company size influenced innovation, New Zealand might be in a favourable situation since international comparisons shows the average size of New Zealand manufacturing plants to be 15% and 18% of Sweden and US respectively (Frater *et al.*, 1995, p 173). New Zealand however, has a much higher rate of new start-ups. Tom Peters advocates small businesses for the purposes of innovation since they produce four times more innovations than middle sized firms and 24 time more than large firms (Kharbanda and Pinto, 1996, p 24).

Grunert *et al.* (1997, p 19), however, present arguments both for and against the benefits of small company size to improve innovation success. Flexibility and fleet-footedness of small companies are balanced by access to capital and markets for larger ones.

No overwhelming evidence was found in the literature to support organisational size as advantaging the innovation process.

2.4.4 Business environment

Integration

Souder and Sherman (1994) think there should be an organisationally integrated approach to managing new technology development. They see technology as a “resource of profound importance for corporate profitability and growth”.

Effective management is vital. Graham and Englund, (1997, p 5) consider that the key element for creating an environment for successful projects of any type are a strategic emphasis for projects and cementing linkages into “upper management territory”. Diab (1998) suggests ways for this to happen. All three writers advocate against the traditional project isolationist view.

Trust and co-operation

Modern management writers consider trust and co-operation are good business practices (Kanter, 1983). However, Gilbreath (1986, p 45) rejects trust as a tool between projects and the parent organisation:

Both parties (projects and corporate) benefit from objective performance criteria carefully and intelligently applied to the project. Any success in reducing the natural reliance on trust will benefit the project.

This belief is to be expected in the project isolationist view. It is valid for routine projects and may lead to efficiency. On the other hand, depersonalising the process may lead to communication problems. Clear borders require precise transactions and are ideal places to post metrics for monitoring project health. However, there are no clear borders, especially at the “fuzzy-front-end” of the innovation process. In contrast, Prather and Gundrey (1995, p 89) describe nine workplace dimensions that support creativity and innovation; challenge and involvement, freedom, idea

time, idea support, conflict, debate, playfulness and humour, trust and openness, and risk-taking.

Thamhain (1999b) surveyed 62 project teams from US, Australia, New Zealand, Mexico, Brazil and Europe between 1992 and 1995 to identify the human factors involved in making the stage-gate process work effectively. The 17 key success factors identified that all required “an environment conducive to mutual trust, respect, candour and risk sharing”. Indeed Kerzner (1997, p 195) observes a change in project management practice over the past 20 years, validating informality. He says four elements are essential: trust, communication, co-operation and teamwork. This evolving style uses checklists rather than policies and procedures. Success of informal project management depends on culture not budgets. Company growth does not necessarily destroy the informal approach. However, some senior managers still believe, “What has not been written has not been said”.

Kerzner (1997) limits his enthusiasm by insisting that communication with senior management needs to cover only 3 topics, “Where we are today, where we will end up and the problems that involve senior managers” and these should not need to take more than a sheet of paper to express. Further, the problem with middle managers in informal systems is that “They meddle”.

The way people work together is changing and important for successful innovation. Howell (1999, p 32) surveyed 716 manufacturing companies in 17 countries and concluded:

Companies that pursue a corporate culture which is highly conducive to innovation in the form of opportunities to foster creativity, open discussion groups and decision-making structures are more successful innovators than those which attach little importance to this type of participatory framework... Innovation is influenced by internal processes and management alone and is unaffected by external influences.

To achieve an efficient environment across the innovation process is likely to involve a variety of seamlessly co-ordinated management styles and processes. The trend is toward arrangements that rely on trust and informality.

Individual contribution

Babcock (1991, p 19) summarises the work of engineering management pioneers as to how to “maximise the return from human resource”. Taylor and Gantt among others derived efficient work and process methods but, additionally, the positive perception of contribution from individual workers has been found to be very important (Hawthorne experiments). Renewed attention to individual contribution is advocated by Bartlett and Ghoshal (1995) who emphasise purpose, process and people.

Good managers help generate good contribution from staff. David Packard, (1996, p 10), reflecting on the successful Hewlett-Packard philosophy comments:

If an organisation is to maximise its efficiency and success, a number of requirements must be met... select the most capable people... a high level of enthusiasm. Coupled with this, individuals should be treated with consideration and respect... Bill and I have placed great faith and trust in H-P people.

Henshall and Henshall (1998), from Auckland University, are working on how individual contribution can be measured. They have developed a knowledge capital index, a measure of strength of the linkage between the competencies held by individuals and the capability of their organisation.

The specific contribution of an individual and their relationship to the firm and the innovation process is important. It is no longer considered appropriate to manage people as a bulk resource to be indiscriminately allocated and levelled.

2.4.5 Strategies

Strategy and culture

Clark and Scott (1995) describe the normative model for strategic management as encapsulated in the triplet “where are we now, where are we going, and how do we get there?” Strategic planning is the traditional preserve of executive

management and typically has a 3 to 5 year horizon... but not in every industry. Kevin Roberts (Waikato, 1998) the world-wide CEO of advertising firm Saatchi and Saatchi, argues against long term horizons and suggests that a company's success is "inversely proportional to the amount of strategic planning" that its managers do and is "inversely related to its distance from the consumer". He advocates a 100-day "to do" list prominently displayed by senior managers.

Poulin *et al.* (1998a, p 9) point out that the definitions of strategy, and culture, are interesting because:

the term strategy can be substituted for culture, and *vice versa*. For if strategy is about planning for and moving towards a vision of a desired future, culture is the embodiment of past strategies. The point is that strategy and culture can and do influence people in the organisation, for better or worse.

Strategy is therefore important since it will influence tomorrow's culture and work environment. A frequent and regular review of strategy or purpose is more effective in delivering innovation appropriate to current customer need.

Resource planning

People and their intangible contributions are becoming important resource considerations to innovative companies. Human resource recruiters in New Zealand expect a trend toward the employment of more managers who have a consultative style that is suited to the co-operative and collective decision-making processes common in fast innovation environments (Boxall, 1990, p 241).

Hall (1993) identifies the role of intangible resources in sustaining competitive advantage. In a US national survey of 95 companies across a broad range of industries he found the top three intangible resources were company reputation, product reputation and employee "know-how". However, resource is squandered unless opportunity is given to exploit and share knowledge. Chakrabarti's (1997), book review relating to innovation and knowledge companies noted that Western models of innovation expenditure are only adequate to meet innovation project requirements rather than to feed the organisational learning spiral.

The management of innovation projects should therefore consider strategic benefit to be gained by coincidentally growing the organisation through the provision of adequate human resources. Put another way, tight control of the human resource is short-term thinking.

Product strategy

The selection of product innovation projects must be done in a context wider than intrinsic benefit. For example, Oxenfeldt (1959, p 338) offers advice on new product pricing strategies:

- Get as much profit as you can
- Set price to discourage competitors
- Recover development costs within a set period
- Set a price to yield your regular “rate of return”
- Use your product to enhance sales of the entire line rather than the specific product itself.

Further, O’Conner (1964, p 269) concludes there are three considerations beyond generating immediate return when considering product development, “to protect your present position, to reach beyond the competition and thirdly, to enter new fields and achieve a broader base”. Porter (1990) identifies these considerations to resolve into only three generic competitive strategies, cost leadership, product differentiation and market differentiation. Each strategy can be enhanced through technological innovation.

Consequently, Foxall and Fawn (1992, p 198) argue that, technological, marketing and strategic development cannot be separately treated: because of their behavioural nature and links in the process of innovation, they form a continuum. Technical superiority and sound design are the most important factors for customers of new technology products (Beard and Easingwood, 1993, p 141), therefore supporting the view that product strategy formulation should include input from senior staff in technological as well as marketing functions.

The market pull/technology push myth

Voss (1984, p 141) looks at the market pull and technology push dichotomy for innovation. Both “market need” and “technology” stimulated innovation exists in

his view. A review of eight studies concluded that “market need” accounted for between 66% and 90% of innovations. Innovation responding directly to the market, the company mission (strategic alignment) and production needs predominated.

Steinhofler (1986, p 261) looked for patterns of innovation processes in 200 projects by small and medium-sized Austrian firms and concluded that the most successful projects are based on market-oriented ideas where only 2% failed commercially.

Innovation projects, often starting with speculative or curiosity-driven R&D, are funded with the prospect of eventually satisfying market needs. The stimulation of new technological capability merely contributes to the process.

Forecasting

Forecasts are sometimes wrong but Rassweiler (1959, p 72) advises:

Difficult though such forecasting may be, however, customer response must be predicted in order to plan product strategy.

Twiss (1992a) provides a comprehensive argument for technology forecasting, sometimes done for decades ahead. The process integrates strategic planning with product and process planning, R&D with marketing functions and faces management with quantitative risks and qualified uncertainties to help decision-making.

Forecasting has its detractors who point to the poor record of past predictions as testament to a failed concept. However, technology forecasting can provide a useful platform to compare future options for companies. Technology forecasts provide a useful context when considering project selection and pace. Scenario planning, another forecasting tool for strategic thinking (Schoemaker, 1995), helps compensate for the usual decision-making errors of over-confidence and tunnel vision.

Cotter (1997) advises successful organisations consider three kinds of futures; predictable futures, uncertain futures and intuitive futures. In his opinion future successful organisations will need to be “simple, small, speedy and strategic”.

Organisations, then, may constrain themselves to a very limited planning horizon (100-days) or to an imagined and distant future (decades). Legendary companies do both (Collins and Porras, 1994).

2.4.6 Structures

Strategy and structure

King (1985, p 10) discusses company structure hierarchy directly relating to, mission, objectives, strategy, goals, programmes, projects and resource allocation and notes that “interdependence between these last three is in any case inevitable.” However, Kerzner’s world (1992, p 75) is structured into discrete systems starting from the universe and focusing down to global, company, organisational and employee levels. Missing in this model is the now common industry system (Poulin *et al.*, 1998a). In Kerzner’s model project management is constrained to the organisational system and therefore does not provide the desired linkage to the rest of the organisation required for innovation.

Skilbeck and Cruikshank (1997) explain how traditional company structure attends to three categories. Global, strategic and operational matters have parallel responsibilities found at corporate, business and operational levels. Edosomwan (1989) too characterises business functions into three parts, R&D that creates, manufacturing which produces and marketing which sells. Whereas the OECD (Eurostat, 1997, p 28) describes only two distinct major categories of skills in innovative firms: strategic and organisational [structural].

The literature indicates a trend toward less structural categorisation and Bartlett and Ghoshal (1994; 1995a; 1995b) contend that structure is less important than process in any case. Hierarchical and organisational division of responsibilities appears to be breaking down in favour of co-operative consensus.

Company structure

Mintzberg (1979, p 25) views the strategic apex and the operating core of the organisation being substantially supported by and linked through marketing functions. The visualisation provided by Mintzberg, identifies on one hand a support techno-structure seeking to standardise (quality systems) and on the other, the R&D structure which seeks to destroy norms and innovate, both mediated by the marketing function.

Ten years later Mintzberg (1989, p 197) suggests that innovative organisations might require an organic structure, an operating “ad hococracy”. This type of temporary structure is not efficient, but is effective. Strategy formulation proceeds incrementally, “continually nibbling”, as Roberts (Waikato University, 1998) advocates:

Any process that separates thinking from action, planning from execution, formalisation from implementation, would impede the flexibility of the organisation to respond creatively to its dynamic environment... In the innovative configuration it is the environment that takes precedence.

Innovation and its associated projects are now considered the lifeblood, if not the main product of organisations. An “innovation assembly line” may be as important as a “product assembly line”? The traditional relationship between R&D and marketing in company structures propounded by Mintzberg (1979) is therefore too rigid and his organic model (1989) may be too loose.

Structures for change

Schoonhoven and Jelinek (1990, p 235) discuss observations in the British electronics industry in 1961 which lead to the conclusion that “organic management” best-served innovation because it was adaptable to unstable conditions. This provides for ambiguous reporting relationships, unclear job responsibilities and consultative decision making based around the task-expert. This was a forerunner of the, “unstructured, loosely coupled, amorphous ‘ad hocracies’” predicted by Toffler (1970) and Mintzberg (1989). Schoonhoven and Jelinek did not find the “shambles” they were expecting when they investigated large electronic companies in the US. They conclude:

Without meticulous co-ordination and control these [large electronic development] processes simply will not be successful (in the long run). But [she noted] these firms do re-organise frequently.

Prahalad (1993, p 40) suggests that value creation requires bridging of the performance gap and the opportunity gap. The former is bridged by upgrading quality, reducing costs, shortening cycle time, simplifying logistics, reducing headcount, increasing productivity, providing good administrative systems and making good portfolio choices. The latter by growth, new business and market development, strategic direction and resource leverage. He continues:

The next challenge for management is: How do you connect individual employee's motivation and contribution with customers through a transparent process inside the company, where everyone understands what the shared aspirations are and how the various businesses interlink with each other, and the logic for nesting individual products and new initiatives? Growth is the agenda...dramatic growth will not take place if the focus is on the technology; it will take place when we focus on the organisation, with the technology as part of it. Dramatic growth requires a radical rethinking of current management paradigms.

An innovation project management system would usefully address these issues.

Where does innovation fit?

Edosomwan (1989) describes innovation as inter-functional and one of three types, radical, incremental or system and Ait-El-Hadj (1991, p 124) makes the observation that:

Innovation separates clearly from R&D. Innovation calls on many sources... innovation becomes the business of the entire corporation.

Quinell (1997) proposes an organisation-wide parallel stream structure whereby traditional management is used to manage the present and project management is used to manage the future [innovation]. However, this arrangement only amplifies some of the shortfalls of traditional project management already been identified. Likewise, Lendrum (1998, p 68) is enthusiastic about the need for innovation but unhelpful in describing a mechanism for its implementation.

Innovation is more than a pervading culture and is too important not to be cultivated. Traditional project management in hierarchical structures is inadequate.

Project types in companies

The literature provides little guidance about how innovation projects relate to other types. Lock (1992, p 3) categorises organisational projects into four types; civil, manufacturing, management and R&D, acknowledging:

research projects may not be amenable to strict project management. However, some form of control must be attempted... Expenditure can be controlled to some extent... the research itself may be outside the scope of project control methods.

Also unhelpful is Cesen (1997) who classifies the project types emerging in Slovenian companies into two categories, external and internal. However, innovation occurs in each category.

Influence of structure on innovation success

Booz-Allen and Hamilton (1968, p 20) concluded that new product development success required top management, marketing and R&D to work closely together. Further advice comes from an empirical analysis of 88 innovation projects by Schewe (1994) made to determine how firm-related and project-related variables contributed to the success of innovations. Above all, he found that success is determined by the “capabilities” of the firm rather than any project-related dimension.

Howell (1999, p 32) reports that, “the more effective innovators use fewer people across a greater number of departments”:

We have learned a lot in recent years about the importance of early involvement of a wide range of functions in the product development process...It also depends on the nature of the innovation... A minor improvement to an existing product doesn't need the same cross-functional project team as a radical new concept.

These findings suggest that innovation (like quality) is the business of the whole organisation and although involvement with key functions is required for

breakthrough innovation, less involvement can be expected on incremental change projects.

R&D and marketing

Luther (1982, p 2) describes the elements of a corporate marketing planning process in a complex schematic. The schematic acknowledges linkage between manufacturing personnel, the strategic plan and corporate objectives and indicates a weak link between the marketing plan and the manufacturing plan. However, there is no reference to new product development or R&D activities, plans or personnel.

The nature of co-operation between marketing and R&D in the design of technologically advanced products by 10 firms in the UK is reported by Bonnet (1986, p 117) who concludes:

All too often, the effectiveness of the co-operation is limited by the type of information which is exchanged; marketing provides a commercial reassessment about the new product idea and R&D, on the basis of this assessment, proceeds to develop or to cancel the product project... Although the need for an early integration of the R&D and marketing function to design and develop new products has been widely discussed in the literature, it seems that, in practice, manufacturing firms have rarely implemented this integration.

Gupta and Wilemon (1990) also studied the R&D and marketing relationship in a study involving 83 technology based companies and found evidence that:

successful product innovation hangs on close R&D/marketing relationships, especially in technology based organisations. However... linkage problems are common and, when not overcome, failure is usually the result.

The study showed that 60% of R&D directors thought that things had improved over the last 5 years (18% said it had deteriorated). The need for integration was reported as pressing because of the emphasis on new products, change in corporate culture, increased competition, product complexity and customer sophistication.

In most companies the marketing department drives R&D (Kerzner, 1992, p 487). In some companies marketing directly controls R&D budgets and executives contend that projects should be cancelled when:

R&D costs cause product costs to be excessive, when ROI arrives too late and also when the competition is too stiff and development is not worth the risk.

Metz (1996) helpfully identifies five best practices for integrating technology and business planning from a two-year study of 50 companies. The first step is to establish a structured process for technology planning then foster active involvement between R&D and other functional areas within the organisation. Top management commitment and buy-in from all functions must be ensured. Finally, R&D and business units must be held accountable for measurable results. The literature has yielded confirmation of the need for innovation project management and a survey of the problems. Commitment and accountability across functions are required but arrangements to ensure this are not evident.

Behaviour within the structure

Burgelman and Sayles (1986, p 56) compared timing sensitivities experienced by research departments and business operations. Businesses need to react to external events whereas research departments continue at about the same level and even pace throughout the year. Innovation processes that span this dichotomy therefore need to accommodate the imperatives of both these worlds. Incompatibility problems can be superseded “if you are working in a “great groups”” according to Bennis and Biederman (1996, p 196). However, Buckler (1997) identifies three different and essential micro-cultures that need to co-exist within an organisation; the “fuzzy-front end” with its high tolerance for ambiguity and uncertainty, the product delivery process where urgency and teamwork prevail and “operations” that require predictability, order and financial accountability.

Verganti (1999, p 372) investigated 18 Italian and Swedish companies in the vehicle, helicopter and white goods industries to see if making decisions (fixing the project specification) early was advantageous. He concluded that the important thing was not the choice to make decisions early or late but rather the capability within the firm to carry out a given approach. Fixing the specification early may not therefore be a pre-requisite to innovation success although it is required if using traditional project management techniques.

Thoms and Pinto (1999), return to the argument to dealing with timeframe sensitivity and suggest the temporal skills of polychronicity and time-warping need to be honed to help facilitate multiple and planned future activities. A mind suited to viewing projects in a variety of timeframes also helps develop realistic perspectives for decision-makers.

Organisation structures and the relationships and behaviours they induce play an important role in efficient and effective administration of the rites of passage of technological innovation. A capable and co-operative crew appears to be more important for the voyage than a prescribed route on an old map.

2.4.7 Processes

Project management processes

Processes linking projects to other organisational activity are reported by Bowers (1988, p 157), Howard and Rai (1994) and Kerzner (1997, p 109), who asserts that project management can integrate with all recently introduced processes in achieving excellence. Kerzner cites the examples of TQM (1985), concurrent engineering (1990), self-directed teams (1991), employee empowerment (1992), business process re-engineering (1993), life-cycle costing (1994) and risk management and change management (1995).

Matheson and Matheson (1998, p 71) identify five best practices [managed through processes] related to projects as: to fully resource projects, evaluate projects quantitatively, focus in on factors that create value, evaluate and plan all projects and agree on measurable and clear goals. They found six best practices for R&D portfolio management were; to evaluate the R&D project portfolio, balance innovations and incremental improvements, manage the “pipeline” [innovation process], balance against strategic objectives, hedge against technical uncertainty and finally, manage and prioritise different R&D projects.

Far from enjoying traditional independence and isolation, projects have become more integrated with business operations and other projects through portfolio

management activities. Integration requires a consistency of approach at project business interfaces.

Product development processes

Nelson *et al.* (1997) identify how product development processes should integrate. They propose that product portfolio management processes serve both corporate operations and strategy management, stage-gate processes are used to develop individual products and day-to-day delivery be supplied by project management processes.

Nelson further describes a very tidy sub-division of processes within the product development path. Three stages are proposed which respond to the findings of Buckler (1997). The first stage is described as the innovation sub-process, characterised by openness and concluding with a business plan. The second stage is the development itself, characterised by velocity [speed with direction] and concluding in a launch plan. The last stage is market value generation, where order prevails.

Simons and de Klerk (1997) also present an elegant but clinical systems approach to product development. It integrates with strategy through “an extensive framework of simple interrelated models” with extensive checklists. Linkages are shown between resource, constraint, product, TQM, business, process and management models. Their arrangements would, however, only suit very highly disciplined organisations.

Reporting processes

Walters (1959, p 113 suggests there are only three types of reports:

Before the fact, after the fact and during the fact. The first two are easy, the last is vital.

In his analysis he identifies three requirements; keeping the sponsor happy (and *vice versa*) in respect of, priority, objectives and direction; keeping people in other parts of the company informed and thirdly, the difficult task of keeping corporate management informed. Walters advocates weekly activity reports acknowledging:

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[Written and oral reports] take time and cost money, [but] we are convinced that it is a great deal cheaper than research in the wrong direction or providing the solution to a problem that no longer exists.

A simple system of project reporting used at 3M covered technical progress, accumulated costs, the planned program and the cost of the planned program (Wachholz, 1959, p 303). Every six months management did a project review and decided to either terminate or continue. If projects continue, decisions were made to maintain, increase or lower the level of funding.

Chorafas (1967, p 121) discusses the need for reporting at a more generic level and accepts that reports may be, “verbal or written, formal or informal”. More reliable technology has reduced the need for some instructions altogether (Jelinek 1979, p 5).

Bill Hewlett of Hewlett-Packard advises, “you can’t manage what you can’t measure [and report]”, and “what gets measured gets done” (House and Price, 1991, p 93). However, the quality of the measurement may not be of concern providing it is consistent (Martin, 1984, p 1990).

Note here that reporting and writing was in the past a distinct skill and function rather than a routine that may now be highly automated. Reporting tends to be part of an upward information flow, relating to accountability and often with content that is not durable. Priority setting for projects may be done, but poorly communicated down through the organisation (Kerzner, 1992, p 489). Here the information flow is downward and needs to be dynamic. Most downward formal information flow is durable, such as orders and policies. Project priorities are likely to be less durable and highly politically sensitive, which may account for disinclination for transmission.

Kerzner (1997, p 159) recommends that project managers report high-priority projects to senior management and maintenance projects to lower and middle management. But this neatly gives project managers the problem of judging priorities for resource allocation across a wide variety of project types! In practice,

this arrangement inappropriately shifts responsibility for project priority assessment away from senior management.

Alignment and concurrency

Texas Instruments developed a system called OST (Objectives Strategies Tactics) to formalise their innovation processes and align it with business processes (Jelinek, 1979, p 69). OST linked corporate and business objectives with strategies and tactics, however it took 7 years to implement. The long implementation time was thought to be because the system was, “non-intuitive”. Fundamental to OST was the need to set milestones for each quarter. The milestones could be “any measurable parameter” suitable to the project and were required to be “definite and discrete”. A rank order of projects was assigned. Normally projects were funded for a year but could be reviewed as frequently as quarterly.

Unfortunately, a comprehensive arrangement is required for innovation but it is not easy to do (Bray and Perry, 1994, p 23; Kanter, 1983, p 156). The latter quotes Gene Amdahl who advises:

I think it's impossible to really innovate unless you can deal with all aspects of a problem. If you can only deal with yolks or with whites, it's pretty hard to make an omelette.

A universal, comprehensive, integrated and efficient innovation process cannot be readily prescribed or implemented. A process to serve innovation needs to be flexible yet consistent, intuitive and simple, relevant at multiple levels and respected by multiple disciplines.

2.4.8 Systems and methods

Communications

Behaviour

Potential for creativity is maximised by consideration of communications that do not violate the basic needs of individuals (Maslow, 1943, p 115). However, leaders are not good at ethical communications according to Huey (1994):

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Ninty-five percent of American managers today say the right things. Five percent actually do it. That's got to change.

Four barriers to communication in the project environment, physical, intellectual, psychological and political are identified together with a golden rule to adhere to commitments, “always follow through” (Boedecker, 1997).

Kerzner (1997, p 209) describes the problem of communication researchers perceive:

When a researcher talks to a researcher there is 100% understanding, when a researcher talks to manufacturing there is 50% understanding, when a researcher talks to sales there is 0% understanding. A project manager has to talk to them all!

An additional problem for innovators is described by Weintraub (1998, p 38):

Most cultures throughout human history have not liked creative individuals. They ignored them or they killed them. It was a very effective way of stopping creativity.

He says creative people are “odd” and thought to be “impulsive, non-conformist, make up the rules as he or she goes along, like to be alone and tend to not to know their own limitations”. The least typical traits perceived in creative people are “being practical, dependable, responsible, logical or sincere”. Therefore appropriate communication with innovators must be a carefully considered when designing a process.

Formality

Documentation in general has five very useful functions (Chapman, 1994, p 119):

- People tend to think more clearly if they commit thoughts to paper
- Communication is greatly enhanced...supported verbally and graphically
- Staff turnover is reduced, thereby reducing risk
- As a reminder and refreshment to commitments and
- Extension across projects capturing important corporate knowledge.

Chen (1994) promotes written monthly reports to project stakeholders as effective tools for communication and management. The essence of the reports should be to allow readers to “quickly grasp the pulse of the project”, identify issues and

propose an action plan and take less than 10 minutes to read. A guide to report content is offered by Ahmed and Alderman (1986, p 151).

The Internet

Communication is the “number one issue” for all companies involved in the new product introduction process regardless of size and type of industry (Bayyiget *et al.*, 1997). Companies who had implemented the Internet and intranets saved time which could be used to reduce the product development cycle time. However:

Face to face contact is still the best means to relay information to other people at times due to body language inflection and other intangibles. In small organisations this is often an essential part of their development, However as companies grow larger, the sheer number of people make this an impossible task. The result is a need for a centralised set of standards with which to communicate to the whole.

Web-site-based communications were found to be even better than emails or phones for some project management requirements (Kalluri, 1999).

Informality

Mintzberg (1979, p 49) emphasises the importance of informal communication:

60% of the face to face communication in organisations was directly related to the tasks in hand. Most work just cannot get done without some informal communication.

Only following formal processes, leads to breakdown.

Dealing with risk and uncertainty

Uncertainty

The problems of accommodating technological uncertainty are introduced but not resolved by Morris and Hough (1987, p 216) and Szakonyi (1988, p 4), the latter suggesting the arbitrary figures of 10% to 15% be added to costs to cover this problem!

Complexity and risk

Dynamic complexity, which is non-predictable and non-linear, needs to be accommodated according to Senge (1990) but he does not suggest how. Project complexity has the dimensions of size, variety, difficulty and change according to

Frame (1994, p 23). Shenhar (1999, p 383) includes complexity alongside uncertainty and pace as the three dimensions of project risk. Each can be described at various generic levels, for example pace could be regular, fast competitive or “critical blitz”. By this means a risk profile can be established for a project.

Risk types

Bright (1964, p 460) provides a comprehensive discussion of technological innovation risk. Five areas of risk are identified, “technical (scientific, engineering and production), marketing, interference (for example through regulation), timing and obsolescence (both technical and market). This is significant since he allocates risk for elements throughout the innovation process, rather than bundling them into the two generic categories of “technical” and “market” popular with later authors, notably Cooper (1993) and Cooper *et al.* (1998). Technical and market risks are present together throughout the process and are not tidily partitioned. The problem of subjective risk assessment still remains, although Bright identifies the characteristics of project team members that help mitigate risk. Risk is reduced by, “curiosity, persistence, determination, downright stubbornness, discontent, antagonism toward the *status quo*, passionate enthusiasm and blind belief”. The faith, courage and attitude of project team members therefore must be considered in innovation project risk assessment and decision-making.

Five types of risk in the R&D process at the corporate level are related to, research, time, technological advancement, quality and market according to Grunert *et al.* (1997, p 10).

Frame (1998) identifies seven categories of common risk sources. They are technical risk, incompetent staff, regulatory changes, changes in the “players”, actions of competitors, environmental (socio-political) traumas and poor time and/or cost estimates. Failure from inadequate risk assessment is high. He quotes one study where only 16% of 8000 information technology projects met all (time, cost and quality) constraints, 34% were “total washouts” and the rest were euphemistically described as being “in recovery”.

Risk analysis

Risk can usually be analysed on one of three dimensions, duration, cost or performance (Chapman, 1994, p 107). Duration risk is the easiest. Chapman suggests that one dimension is selected and the other two “traded-off” against it. Chapman notes that not all risk factors need to be known in detail. In part this can be reconciled by the dilution of individual factors, particularly in high risk projects where “expectations and targets may differ by a factor of 2 or more” (p 112).

Hulett (1996) discusses the practical application of risk analysis methods on schedules including the common problem of assessing project completion time where parallel tasks with similar duration and risk level interact (converge). He recommends using a three-step approach, first create a CPM schedule, then gather risk information and finally simulate the network using a Monte Carlo approach (see also Gump, 1997). This is useful when all tasks are known but problematic for innovation projects where unknowable events can be expected.

MacLeod and Petersen (1996) presents an elegant method of merging CPM and PERT probability estimates and using the information to trade-off the cost of adding resources against the reduced risk of completing on time. Only two completion time estimates are required per activity rather than the traditional three time estimates, common in PERT analysis and a robust beta probability distribution curve is used.

Risk modelling by computer during the planning stage of new product development projects is advocated by Pascale *et al.* (1998). The process should be part of regular corporate planning although he acknowledges the process is complex and iterative and does not produce a single date by which a new product might be ready, contrary to the preferences of many managers.

In review, Durrenberger (1999) explains the benefits of the “three duration estimates” method of calculating activity times. However, he points out the reasons Monte Carlo simulation methods are better for estimating traditional CPM/PERT networks. Problems arise when a new critical path occurs due to overrun on a key

activity. The variances of activities on the new path are required to accurately determine risk. Since there are often lots of potential new critical paths it is normally better to simulate duration variation of each activity over the whole network many times to improve estimates. This approach is sensible only as long as no totally unexpected activities are anticipated.

Therefore while a convincing case is made to use Monte Carlo method for assessing risk in traditional projects, the uncertainty over future activities in innovation projects suggests an alternative approach based on duration estimations may be most useful.

Risk management

Estimates for innovation project costs and duration are reported by Martin (1984, p 201) where 88% incurred cost overruns and 68% time overruns. The point in the project at which estimates were declared is not provided.

At the marketing end of the innovation spectrum Burgelman and Sayles (1986, p 68) comment on the ability to assess returns:

It is highly unlikely that even the most skilful market analyst can estimate the future size of the market for any significant innovation at the early stage of the development cycle.

This difficulty in making good estimates has called for desperate measures. The advice from Szakonyi (1988, p 6) is to:

form a contingency fund from say, 15% of the budget. Although if one admits he has a contingency fund some people will want to rely on it... it is still useful as a backup in case one's plan is not precise. The best thing to do is to make everyone who wants to dip into the contingency fund feel that he is less successful for having to do so.

So much for open communication! This advice is all the more ironic since in his preface Szakonyi points out:

the most likely causes for an R&D project going off track are changing conditions or outside influences that make the initial requirements no longer valid.

Lauden and Lauden (1994), set out strategies for controlling projects according to project structure, technology level, size and degree of risk. Risk containment strategies proposed by Murray (1998) fall into one of four categories, risk reduction, risk monitoring, risk protection and risk transference. They warn failure to articulate a vision of organisational risk management will result in lack of senior management acceptance of risk and inadequate resource allocation.

It appears there is no easy way to deal with high levels of risk and uncertainty but methods are available for risk assessment if things go to schedule. When schedules change, so must the risk assessment. Pragmatically, “unlikely” situations need to be handled as they occur. It is not surprising that innovation project success as measured by adherence to a schedule prepared at an early phase is low.

Planning and scheduling

“Catch 22”

As early as 1959 Quinn (p 175), warning against “over-planning”, advised that “planners should not plan in any more detail than they expect to control”. However, detailed planning is difficult to resist since it is a pre-requisite to scheduling. Planning is, “the art of stating how something should be done”, whereas scheduling is the, “art of fitting a plan to a timetable” (Chorafas, 1967, p 151). Allosch (1986, p 8) describes the basic dilemma for innovators as, “the need for planning is high at the start, when the details of the process are low”. In fact, Boone and Bowen (1987, p 28) describe management pioneer Henri Fayol’s rules for business planning, which includes, “plans must be compulsory”.

Szakonyi (1988, p x) moderates the need for innovation planning little saying:

Unless a project manager thinks clearly in the beginning about how an R&D project will lead to useful results, serious problems are assured.

And Cleland (1999, p 56) acknowledges that as the project lifecycle progresses [for new product development] continuous re-planning is necessary. Early plans (and consequently schedules) are recognised as unreliable and yet are frequently used to demonstrate non-compliance for contract and for success measurement.

Colwell (1999), an architect for the Pentium II microprocessor-chip development at Intel, provides an interesting consequence of the planning dilemma as he describes the four and a half-year (stated as 18 quarter) project. His experienced team regularly made “best estimates” of the remaining effort required for project completion. Not only were the estimates a factor of three too small at commencement but the estimate was little better than 50% of the actual level half way through the project! This example shows how difficult it is to estimate effort and perhaps how technologists are optimistic. In this case the project end date was essentially fixed by trade show date commitments and it was economic to add more resources, although this itself caused unscheduled communication and office-space problems. Colwell advocates clear goals and common formats and the need to adjust human and financial resources if a fixed delivery date is essential.

Plan features

Mechanisms to optimise the planning process have been widely investigated in recent years. Wysocki *et al.* (1995, p 97) advise that from the outset each project should have an “overview statement” in preparation for plan development. The statement should have five elements; definition of the problem or opportunity, the project goal, project objectives, success criteria and, assumptions, risks and obstacles. They quote Doran’s overworked acronym “SMART” to describe his essential characteristics of project objectives to define the scope; Specific, Measurable, Assignable, Realistic and Time-related.

Nukalapati (1997) advocates the need for a resource allocation system especially where resources are scarce. He regards it a strategic activity linked to portfolio analysis to ensure that the most important projects get priority. However, he reports some serious shortfalls in an implementation of this kind of system in a very large company when using Microsoft Access, a relational database.

“Work packages” are planning and controlling constructs made up of activities related to the achievement of a specific goal but according to Raz and Globerson (1998), little research has been carried out on work package definition. Raz and Globerson suggest that WBS planning should be done in as small a work-package

as possible to increase cost and schedule estimate accuracy. Accuracy is also improved by making the work packages even in size. A size limit is reached where interdependence between packages becomes significant or where significant contingencies are loaded on to each package. Work packages are best managed if only one person is responsible. Monitoring and control is made easier by recording full completion of a small work package rather than by assessment of percentage completion of a larger one. Internal cohesion of work packages should be high and if not, further breakdown should be considered. Another reason for increasing the number of work packages is to isolate high-risk elements for specific focus.

The problem of planning optimal resource allocation for IT projects is addressed using simplified mathematical techniques derived from operational research studies (Carbno, 1999). He assumes that increasing resource levels can speed projects up but costs more money and that delay also incur costs. These constraints can be modelled for each project and an optimal solution identified. For multiple projects optimal allocation is said to occur when the resource used for each project is in proportion to their individual optima.

Scheduling

Provided communications are effective there should be no reason why professional artists or artisans should not be able to perform on command Badenoch (1964, p 50). The presence of an “immutable end date” is advocated to assist performance (Morris and Hough, 1987, p 229). This should be considered in the light of the more recent “time-box” concept (section 2.6.2).

Morris and Hough (1987) urge caution when there is overlap of design and production and concludes that concurrency “invariably leads to project overruns”. However other authors discard this ideal as fanciful. Rich (1989, p 10) describes the Lockheed Skunk Works philosophy and includes “tight scheduling” as a requirement:

Give yourself less time than what you think you will actually need. You will miss a few deadlines, but on balance you will come out ahead.

Goldratt (1997) theoretically justifies the Skunk Works philosophy. He uses the theory of constraints to identify bottlenecks and provides buffers in the schedule. Time allocation for the buffers is harvested from each activity by scheduling only half the “pessimistic” time estimate. However, Goldratt has earned some detractors since he also advocates against multi-tasking and insists that once started an activity should proceed to conclusion. Goldratt’s approaches become impractical when detailed task descriptions are unavailable and unique resources are required for other work in the organisation during a project.

Ibbs *et al.* (1998) looked at the consequences of starting projects before all design was completed (“fast-tracking”). They found a small but insignificant increase in the overall number of changes required and that fast-tracking was a valid option for owners and project managers to consider even for traditional projects.

Planning and scheduling innovation therefore appears to be useful when given continuous, diligent and dynamic attention.

Budgeting

Budgeting strategies

Wachholz (1959, p 304), a controller for 3M recommends to spend as much on new products as enhancing new ones but does not say how much should be spent.

Goslin (1967, p 73) gives seven common ways to plan product project budgets:

- As a percentage of company gross sales or capital invested
- As a percentage of company profits
- As a percentage of the contribution of research to profits
- On a project basis
- Using a growth-rate standard
- By following or leading a competitors investment strategy, or
- On an amount determined yearly.

He concludes that the most successful strategy is a combination of “on a project basis and an amount determined yearly”. However, not all companies are so transparent. Burgelman and Sayles (1986, p 10) report that in one company they investigated, “safe” projects were formally funded and high risk ones, consuming up to 10% of researchers time, were “bootlegged” (hidden).

Expenditure on R&D is very dependent on industry maturity at 1-2% of sales for mature industries and 15 to 20% for high technology industries (Balachandra, 1996), Japanese companies having the higher values.

Kameoka and Takayanagi (1997) have developed a mathematical model of the value of corporate technology stock. R&D value depreciates with time but is realised as it progresses through to sales when incorporated in a product. The model was used to determine the value of the stock under different regimes of input (investment). The best option was to concentrate investment to rapidly build the value of the stock at an early stage. The stock achieves a high residual value and even though depreciation does occur, the retained value is higher than for the case of constant, incrementally increasing or intermittent investment. It is therefore better to give attention to fewer innovation projects and see them through to fruition as soon as possible.

Smith and Barker (1999) warn about the use of Benefit/Cost Ratio (BCR) as a projected measure of value. Problems can arise if it is not remembered that BCR is only a relative figure. BCR is based on the assumption of a constant risk-profile, that is not the usual case for innovation projects. Care must also be taken if it is used in portfolio analysis if there are project interdependencies if, for example, an essential pre-requisite project is not selected.

Budgeting practices

Leermakers (1959, p 100) of Kodak says that usually an annual budget was proposed and approved for R&D, a fixed dollar amount for “experimental effort”, still common today. Little has changed since the 1959 practices of the Rand Corporation (Bright, 1964, p 22). Expenditure is expressed in two ways based on sales percentages amounting to:

1% on basic research
3% on applied research
26% on product development and
70% on product enhancement.

or,

1.9% on blue skies research
3.2% on long range research (5-10 years before final products)

6.4% on the search for new knowledge in anticipated areas
9.6% on updating standard products and
78.9% on developing tailored solutions to customer orders.

Karger and Murdick (1972, p 91) quotes Mr R.C. Dale, an executive from Nashua, in describing a prudent innovation investment strategy:

Spend the first research dollar because you are in business and the second to improve the existing product. The third dollar should be spent to round out the product line and the fourth to diversify while maintaining a thread of continuity. The fifth dollar should be spent on pure exploratory work and the sixth to diversify into a new field.

Accounting practices for handling R&D expenditure in company accounts have been compared and little difference to financial information occurs if R&D costs are expensed immediately or capitalised and spread over 4 years (Goodacre *et al.*, 1993, p 317). The former is preferred since it is considered “more neutral”. Using this approach R&D expenses are considered as “sunk” and accounted for all in the same year.

Expenditure of 6.6% of sales is committed to R&D at the very successful 3M company and all technical staff can spend up to 15% of their time on projects of their own choosing (Coyne, 1997, p 50). Gillette is reported as spending 2.2% of sales on R&D, “twice as much as the average consumer products company” (The Economist, 1998).

Innovation project budgets appear to be relatively fixed in size and spread strategically across innovation types. There is advantage in taking projects through to completion early, which suggests doing fewer projects faster. Project selection and project-portfolio management is therefore paramount. Project costs are sensibly accounted for (sunk) in the same year as they are incurred.

Monitoring

Senior management should be involved in monitoring new projects and “be prepared to shoulder difficult decisions themselves” rather than load project managers (Davis, 1989, p 236). However reporting processes are difficult for New

Zealand managers, who show a high level of operating “outside the rules” and a low level of “innovation process monitoring” (Shane, 1994, p 296).

Gaynor (1996, p 46) discusses project monitoring and says there is “no magic formula” for success... “risk [luck] is a factor” but “success is increased through a disciplined methodology and an emphasis on integrity”. To this end the Project Management Institute (PMI, 1997b) has published a book of more than 150 standard forms for traditional project monitoring and control. However, the emphasis is on recording, reporting and getting approval rather than empowerment, trust and speed. Project standardisation is of benefit even for small projects (less than US\$50,000) (Inman and Milosovic, 1999).

Some monitoring formalisation appears to be beneficial but its benefits will need to be clearly evident before New Zealand managers can be convinced to change their practices.

Controlling

Purpose and importance of control

The purpose of control is to reduce costs (Kharbanda and Pinto, 1996, p 49), therefore appropriate innovative solutions that exceed projected costs are traditionally unacceptable in principle. However, this is a “western” trait (Pullin, 1998) and in practice “control mechanisms” ranked only twelfth out of thirteen factors to consider when implementing a new project system (Jiang *et al.*, 1996). This contrasts with the views of Hanif and Nobley (1997) who advise that schedules, which allocated tasks to named individuals, must be updated regularly (weekly) otherwise they are relegated to mere reports. The weekly update cycle is considered the backbone of the project management system for Intel, driven from the bottom up.

“The purpose of [monitoring and] control is to predict what might happen in the future” (Cleland, 1999, p 326). However, this presumes a future that looks essentially the same as it did when the project started. More useful for innovation

projects is the capacity to influence what might happen in the future to optimise benefit.

Prospect of control

The level and application of innovation project control is of enduring concern (Simmons, 1959, p 55):

The secret of steering between the dangers of too much control and too little control is, unfortunately, a proprietary item. Inherent in the character of management, it is a secret that a successful organisation need not worry about losing, since it defies description.

There are two types of scientific thought, systematic and intuitive (Bright, 1964, p 120). The systematic thinker uses empiricism, guided empiricism or omphaloskepsis (deep meditation); the first two processes can lead to serendipitous discovery. The intuitive thinker on the other hand delivers through a flash of genius or a scientific hunch. “Unfortunately”, he says, “none of these appear predictable or much able to be controlled!”

The literature provides a wide range of advice for control application. Karger and Murdick (1972, p 96) conclude that control levels can be minimised by employing administrative and financial people in support of technical people rather than in control of technical activities, but this is an uncommon occurrence. To stifle innovation Kanter (1983, p 101) advises “control everything, make sure people count anything that can be counted, frequently”. However, Szakonyi (1988, p 13) advises, “the more one pushes the state of the art, the more one should plan to control the R&D project”.

Practice of control

Peters, (1992, p 183), looked at the control conundrums in the project environment at David Kelly Design:

There is a perceived lack of control in accounting performance...but failures were found to result from a breakdown of partnership and trust. In all cases reviewed, control (accountability) outstripped that found in traditional bureaucracies because project structures aimed members at tasks and kept deadline pressure high in a team orientation. It was made clear that

individuals must take the initiative. Customers were real and close at hand. Feedback lurked at every corner. Members were required to have something to brag about and subjective evaluation schemes directed attention to qualitative issues...The most effective teams set 3 or 4 inescapable due dates for specific deliverables.

Bart (1993) interviewed 29 business unit managers in ten large companies about how they controlled new product R&D projects. He found they used informal control regimes with R&D projects. However, business unit managers always compensate reduced formal controls with “high amounts” of informal control.

Three types of popular project control methods have been identified and their relative frequency compared; analytical (13), process-oriented (12) and people-oriented (5) (Thamhain, 1996). Popularity is not, however, synonymous with effectiveness. Management often overlooks three important aspects of control tool use. Firstly, lack of integration with the business process, secondly the impact of project performance on the firm’s customers is rarely considered and thirdly, the impact of change on individuals is often poorly managed or outright ignored. Thamhain concludes with recommendations for the introduction of new control tools including; team involvement, pre-testing and senior management support.

Rautianen *et al.* (1999) investigated controls to manage objectives, goals, metrics and mechanisms at four organisational levels, strategic, process, projects and individual. Need for an individual level for the framework was decided after early interviews identified its importance. The primary issue appeared to be management at the early stages or “fuzzy front-end” of projects. “Most projects are launched without a clear, defined target, if one is to believe the responses in the interviews”. Rautianen *et al.* found, however, that most companies view the concept of control very narrowly, “we make project plans and compare progress to the plans at regular meetings”.

The control of change

The three elements of change are, “the stone, the splash and the ripple” (Gilbreath, 1986, p 232). Humphreys and English (1993, p 123) conclude that a useful unit of

change control (splash and ripple) is the “work package”, which produces an identifiable or measurable result.

The level of change resistance needs careful consideration (Frame, 1994, p 71). If change is permitted too freely then whimsy might rule. Frame therefore argues the need for distinction between good and detrimental change.

Summary

Control is required and should be applied in a form to suit the size and complexity of the project. If control metrics relate to the schedule, then the most up to date schedule should be used. Control should effect progress toward clear goals rather than provide data to describe the difference between the original schedule estimates. A useful unit for change management is the “work-package”.

Accountability

Individual accountability is linked to reward systems by Kerr (1975, p 414) in his work entitled, “On the folly of rewarding A, while hoping for B”. He advises alterations to reward desired rather than undesired behaviour. This suggests accountability might therefore be improved by rewarding outcomes rather than reporting performance. This is useful for innovation projects and more productive than advice from Szakonyi (1988, p 16) who provides four reasons for traditional project reports:

- to track estimates of progress
- to make situations visible to all
- to protect oneself and
- to keep higher level informed.

Peters (1992, p 166) looked at the practices of “liberated companies” and describes inconsistencies and aberrations, “project models seem untidy...but they are the ultimate accountability model”, “the project leader changes from time to time” and “the project scheduler updates resource allocation but is always out of date”. On accountability in projects Peters comments, “real customers breed high accountability, almost automatically”, “teams are accountable to each other ... [creating] interdependence”, and “self accountability is induced through the project

configuration”. He suggests that none of these three accountabilities show their face in normal hierarchies.

In describing the practices of David Kelly Design (p 171) Peters notes:

In many respects each of the David Kelly Design designers are entrepreneurs in their own right. There is an engineering manager who, if necessary can help sort out scheduling hassles. He keeps a spreadsheet that more or less tracks what people are up to. In practice he is rarely called upon.

Peters concluded resource (people) allocation was, “nightmarish” and that no formal schemes work. Rather, natural selection occurs:

The basic idea is that everyone is responsible for filling their days with useful projects... and you must complete the projects you accept.

Projects at David Kelly Design were between 1 week and 1 year duration.

Accountability requires responsibility and authority (Kerzner, 1997, p 81) and accountability (in a matrix management environment) has changed. In the 1960s accountability rested firmly with line managers, in the late 1960s it had swung to project managers and returned to partial sharing in the 1970s and 1980s. In the 1990s accountability is perceived to be a fully joint responsibility.

At the pragmatic level Pickard (1997), a CEO, demonstrates his sense of personal accountability by keeping a one-page integrated spreadsheet to summarise cash flow for his company. The balance sheet, income statement and cash flow are shown on a monthly basis. The purpose is to have a simple dynamic report to assess the health of his company and provide a degree of comfort and confidence in the path being tracked.

Summary

Systems and methods are now becoming integrated into the process of innovation to provide direct relevance to the organisation and customer. Accountability within the context of innovation projects has been transferred to empowered individuals

and therefore systems and methods are of less significance for control but increased significance for monitoring progress.

2.4.9 Trends

Individual empowerment

Management and leadership philosophy has moved toward individual empowerment and away from traditional command and control (Cleland, 1999, p 486). New world philosophy provides for: consensus and consent, facilitation, maximum decentralisation, empowering people, team execution of management functions, dispersed leadership and exercises *de facto* (influential) authority. Enterprises should be participative and collaborative. Staff should be self-motivated, adaptable to change and be multi-skilled. And management should trust people and lead rather than direct (see also Peters, 1989, p 278 and Lendrum, 1998).

Accessing innovation

Alliances and partnering are now commonly regarded as useful vehicles to access innovation. Howarth *et al.* (1995, p 172) conclude their investigation of strategic alliances in Australia with some pointers to the future:

The excesses of the 1980s with their focus on rapid growth and quick returns have been replaced by an ideology that recognises the benefits of sustainable growth and long-term relationships... Many organisations are no longer large enough to carry out their own R&D. Many are also no longer prepared to take the risk of going it alone... We believe that trust is critical to strategic alliance success... [for many in the Asian region] it has [even] replaced the need for formal contracts... we invite you to take up the challenge.

However, Doz and Hamel (1998, p 28) prefer the term “enlightened self-interest and mutual interest”, a concept that drove British diplomacy and foreign policy in the nineteenth century, in contrast to “trust” when discussing partnerships and strategic alliances. They see trust as an “idealistic but perhaps hollow” concept.

In a more general sense there are three other ways in which firms can improve their access to innovation (Haour, 1999). Firstly, by providing capital to entrepreneurs they are not hindered in their endeavours by the parent company. Secondly,

companies can buy and sell innovation projects within a “distributed innovation system”. And finally:

At a minimum, it is necessary to put in place a small senior team dedicated to scanning and gathering intelligence on business/technology trends and scouting worldwide. This team must be closely articulated with the “product-or innovation council” or “technology cell” which steers key innovation projects within the firm, aligning business strategy and technology.

New arrangements for managing innovation projects should therefore sensibly be useful between partners and potential partners by using a common and easily understood language.

Ready for change

Growth in R&D expenditure has been fuelling change (Karger and Murdick, 1972, p 89). The total R&D expenditure in the US for the period from 1772 to 1926 was \$2 billion. The annual expenditure in 1972 alone was \$27 billion.

The capacity to thrive on change is also recognised as hallmark of successful New Zealand companies today (Birchfield, 1995-1999). Although venture capital is scarce in New Zealand the complex factors used in new business funding decisions have been standardised, and a simple tool for their analysis found to be useful (Cunningham, 1997).

Technological innovation in Asia is also seen as in its infancy (Haour, 1999):

Asia is characterised by a keen entrepreneurial spirit. So far, however, this energy has been channelled into sectors such as real estate, banking and trade, not technological innovation.

Tools useful for the expanding and changing innovation process are required. There is a widespread recognition that innovation project outcomes are vitally important. Processes must be efficient and effective to beat the competition but the true goal is a continuous flow of profitable innovation. Tools must suit the needs of the users at all levels of the organisation and be easily understood by partners. Traditional project management tools do not meet innovation project management needs and new ways to work together are required.

2.5 Technological Innovation

2.5.1 Introduction

The scope

In his book, “Research, Development and Technological Innovation”, Bright (1964, p 22) identifies four categories of endeavour related to enterprises: basic research, applied research, product development and product application. Karger and Murdick (1972, p 59) suggest five degrees of change (types of innovation): Major, minor, step (with the same function), nascent (with a new function) and breakthrough. Together these categorisations still form the basis of recognition of innovation types although no cohesive standard has emerged.

Betz (1987, p 50) provides a helpful model showing distinctions and linkages between science, technology and the product development process. Industrial research is focused on the achievement of a marketable end product whereas scientific research may be seen as an end in itself. Technology, however, feeds on the fruits of scientific research and plays a major role in enabling industrial research. The question raised by this model is whether scientific research and industrial research projects require different management arrangements.

Roberts (1989) and Tidd *et al.* (1997) provide overviews and reading lists in the field of managing innovation, the latter using the sub-title, “integrating technological, market and organisational change”. Marketing texts “fail to cover the specific issues related to innovative products and services”, although a few texts address the specific problem of marketing high-technology products. Tidd concludes with the plea for organisations to take a strategic approach to innovation.

Janszen (1997) helpfully differentiates between the innovation process and the product creation process. The former includes products, processes and services as well as including related activities external to the company.

The process

Managing professionals in innovative organisations is difficult since account must be taken of their motivations. Allen (1988, p 5) compared responses between scientists and engineers. When asked if it was very important to them to be able to help the company to increase its profit, only 28% of scientists agreed compared with 69% of the engineers. Likewise, when asked if it was very important for them to work on projects they themselves had helped originate 75% of scientist agreed compared with only 32% of the engineers.

Barriers to innovation identified by a group of corporate managers, entrepreneurs and a panel of innovation experts in New Zealand (Gilbertson and Knight, 1992, p 15) are:

- low incentives for idea champions
- creative people are squashed and controlled
- top management are short-term oriented
- accountants and lawyers have too much influence in management
- high personal risk if innovation fails
- limited incentives for organisational entrepreneurs
- problem of institutionalising attitude change
- decision-making too centralised, and
- a reluctance to invest in “problem-oriented training” as opposed to courses

There is a need for a more interactive system whereby firms can acquire, adapt and develop the technological knowledge and skills necessary for competitive advantage (MoRST, 1996b). Linkages between firms and science and technology resources are also a problem.

As the innovation process proceeds the tasks encountered tend to move from the unpredictable and complex to the predictable and simple (Gordon and Bush, 1997). Therefore different skills will be seen as more useful in different parts of the process. Integrators may suit early stages whereas problem solvers are more useful later. Managers should not expect individuals to be suited for involvement in the total innovation process. Chiesa *et al.* (1998, p 66) also provide a comprehensive analysis of the innovation process in the context of recommending an audit process.

Thomke and Reinertsen (1998, p 28) advocate the need to allow for product change at any point in its development cycle. Verganti (1999) supports them. Progressive lock down of specifications and making piece-wise commitments rather than binary choices is a pragmatic requirement. This incremental and dynamic approach aligns with the views of Kanter, Drucker and Peters but is philosophically different to the basic tenets of traditional project management.

2.5.2 Research and development

R&D scope

The scope of R&D and its relationship to innovation is unclear and no dominant definition is evident. The distinction between research and applied research (development) is, however, clear to O’Conner (1964, p 269):

Basic research is any planned search for unknown facts and principles of general validity without regard to commercial objectives, whereas applied research is any planned investigation with the intent of utilising known phenomena or substances to accomplish a particular objective.

Kerzner (1992, p 89), however, recognises R&D in three categories pure, basic and applied research where the R&D phase concludes when revenue is generated. Innovation is not mentioned. In contrast the OECD recognises R&D as comprising:

creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications.

However, there is considerable difficulty reported in identifying a border between “R&D” and “innovation” (Eurostat, 1997), which suggests a further process between R&D and income generation.

R&D people

Good researchers are not necessarily aligned to the purposes of organisations. The top 7 motivations for scientific creativity in companies is reported by Goslin (1967, p 106) noting that personal financial success was not a prime motivator:

1. Desire to solve problems (68.6%)
2. Personal gratification (64%)
3. Desire to win prestige (64%)
4. Desire to advance financial position (42%)
5. Desire to advance in title (14.3%)
6. Desire to win in competition (12.4%) and
7. Gaining special benefit (4.8%).

Unfortunately those who might champion R&D through an organisation are distributed throughout the firm but they are not necessarily good judges of an innovation's potential benefit to the firm (Markham *et al.*, 1991). Matheson and Matheson (1998) advocate that managers should hire the best staff and maintain expertise, protect intellectual freedom, maintain connections with research organisations, share an integrated view of the R&D portfolio and empower R&D managers.

R&D process

Dr. Mees of the Kodak Research Laboratories (Leermakers 1959, p 105) advises:

Research is a gamble. It cannot be conducted according to the rules of efficiency engineering. Research must be lavish of ideas, money and time. The best advice is, "Don't quit early, don't trust anyone's judgement but your own, especially don't take any advice from any commercial person or financial expert and, finally, if you really don't know what to do, match for it. The best person to decide what research work shall be done is the man doing the research. The next best is the head of the department. After that you leave the field of best persons and meet increasingly worse groups.

Although R&D managers and researchers have attempted to measure R&D process effectiveness for over 30 years, there are still no methods that are widely accepted for doing this (Szakonyi, 1994, p 100). Casler (1997) and Iyigun (1999) have assembled and implemented formal integrated R&D systems for individual organisations but no comprehensive and generic processes have been reported.

R&D reporting

Howard (1955, p 54) describes a "common sense" approach to reporting at Sylvania Electric Products. Fundamental research was reported every three months and everything else monthly. Reports were done on all projects bigger than took up

20% of a scientist/engineers time over a three-month period and on any critical project. Likewise Quinn (1959, p 175) provides advice on reviews:

Unless all aspects of research are reviewed at least annually and carefully re-planned to meet modified needs of the sponsoring concern, top managers will find that proper research integration cannot be maintained. Re-evolution of detailed experimental plans is, of course, part of the day-to-day job of research administration.

Glasser (1982, p 27) also advised that R&D should be reported in writing each month and projects reviewed after each phase (at 3 to 6 month frequency).

However, Burgelman and Sayles (1986, p 58) quotes a highly regarded research scientist as declaring:

Written constraints, statements of objectives, milestones and so on are all dysfunctional... people are optimistic. Attention will be paid to what has not been done rather than what has been accomplished... management systems... are failure-oriented.

R&D status can be done verbally in 5 minutes at weekly or bi-monthly meetings (Kerzner, 1992, p 490). Since communication is often seen as a problem Kerzner also suggests the R&D department provides an excellent proving ground for the introduction of project management to an organisation! In contrast Bishop (1992) observes:

R&D organisations have earned a reputation for not having a “sense of urgency” in accomplishing work and making technological progress.

He reports on the attempts made by the AO Smith Corporation to overlay some engineering discipline on to developmental efforts concluding that it is better to break tasks into 3- or 4-month blocks so that a quarterly report can be made. As each task is written, a “criterion for success” statement should be added. The effort to report to the extent of providing full explanation of actions and consequences of experimental findings is high. This makes frequent R&D reporting an inefficient process.

R&D project problems

Work on existing products and processes can be decided on a direct financial cost/benefit basis (Leermakers, 1959, p 98), but for new products and processes it is generally:

impossible to predict effort required to complete a technical investigation in an unfamiliar field... any project to which a definite formula for evaluation can be applied is not in the research category.

R&D projects are fundamentally problematic because they are “one [type] of the broad range of projects where a pre-known sequence of activities and their correlation may not be known in advance” (Muller, 1990, p 122). Muller’s solution was to consider mathematical simulation techniques, which unfortunately further widens the gap between theorists and practitioners.

Kerzner (1992, p 484) is sympathetic:

Very few people in an organisation truly understand the R&D environment and the problems facing the R&D manager. We continually ask the R&D project manager to achieve an objective that even science fiction writers haven’t thought of, and that requires technology that hasn’t been discovered yet... The R&D environment might very well be the most difficult and turbulent environment in which to manage a project.

True R&D projects present special challenges for project monitoring in their trek across unexplored territory (Khahbanda and Pinto, 1996, p 18). They continue pragmatically, “There is, however, a difference between granting engineering leeway for discovery and writing the equivalent of a blank cheque”.

There is difficulty in selecting R&D projects and planning, scheduling and controlling them. The people involved are a truly curious breed, often poorly understood by managers. R&D project management processes are often insensitive to the effort required to report information and to its consequential quality.

2.5.3 Revolutionary innovation

New products

The ideal product is described by Wade (1959, p 129) as, “cheaper, not re-useable and habit-forming”! More specific formal objectives are, however, recommended by Simmons (1959, p 56). Searching for ideal product is, however, pointless since Phillips *et al.* (1997), declares the “product” is dead. High-tech products are often marketed before the specification is finalised (if it is finalised at all) and frequent upgrading is also prevalent, therefore products are virtual rather than tangible. This presents problems if project managers are required to wait for complete specifications before planning.

Hoban (1998) classified new products into 6 categories described as, classically innovative, equity transfer, line extensions, clones, temporary and conversion items. The classification was used to debunk the myth that only 5% of new products succeed in the market. His research showed 33% of new products were successful, 42% were still being distributed but in decline and 25% failed. Market research and internal R&D provides most new product ideas while product quality and understanding consumer needs provided the strongest positive influence.

New products are important sources of new business but their precise specification may not be available during the early phases of the process.

Product planning, selection and review

Goslin (1967, p 122) confirms that progressive phases of the product planning system increase the reliability of existing information. Product concepts that match existing perceptions are acceptable for incremental improvements but radical concepts are more difficult (Pascale *et al.*, 1997; Adank and Earle, 1998). Radical concepts are also likely to need commitment to new resources acceptable to top management. Top management involvement in evaluation is therefore more important for radical product concepts.

NPD process

The most important factors in speeding prototypes to production are; planning, decision and acceptance of responsibility, and co-operation (Schmidt, 1959, p

240). In fact, leading companies now pay as much attention to the process of new product development and introduction, as to the products themselves (Hoban, 1998).

In New Zealand product development arose from the food industries of the 1960's and has followed US trends in recent decades. Adank and Earle (1998) describe the process in four stages, product strategy, product design and development, product commercialisation and launch, and finally, post-launch activities. Detailed formal descriptions of the stages of product development are available (Cleland, 1999, p 53).

NPD best practices

ISK Biosciences Corporation uses a stage-gate system to help manage risk and add “discipline” to the NPD process (Kerzner, 1997, p 47). Heavy reliance is placed on software (Microsoft Project) to help develop the aggregate plan and assess resource availability versus capability. The benefits claimed are: reduced cycle-time and lower costs, realistic plans with greater potential for meeting development time frames, better communication about what is expected from workgroups and when. And finally, feedback about lessons learned on the project.

However, Baxter *et al.* (1997) argue that the current product development process using stage-gates in combination with networking and concurrent activities could extend product cycle-time rather than shorten it. He considered that interaction complexity in a multiple project environment is inadequately considered.

Baxter studied a software development company where 13 projects (ranging between 8 to 14 months) all overran their duration by 100% on average (range 70% to 283%). Individuals are given high autonomy in selecting the projects they work on and it was found that project populations are very fluid. If the population gets high, especially when a number of tasks are occurring together, confusion and delay occurs. Concurrency was observed to operate on functional, task and individual planes simultaneously. Smaller and simpler projects were recommended.

The three “best practices” found by Tabrizi and Walleigh (1997) were, tracking progress and sustaining urgency, developing early prototypes and finally, using development partnerships. They found only a few of the 14 organisations they investigated maintained a disciplined process for measuring adherence to schedule in the earliest stages of a new platform [revolutionary] project. Most firms operated under crisis management leading to late product launches. A useful tool was a measure of the product priority from the customer point of view. Three categories were used, “must have”, “should have” and “nice to have”. This customer interaction creates promised delivery dates, which drives product development teams. Another useful practice was holding weekly meetings until product definition was firm and a delivery commitment made then.

Stage-gate and aggregate planning using project management are overview rather than detail management tools and have been found useful for NPD processes. Customer interaction to finalise specifications using iterative development methods is preferred. Unconstrained individual autonomy and long project duration provides for inefficiency.

NPD in New Zealand

New Zealand exports 50% of its production compared with only 13% from US firms (Souder *et al.*, 1995). In New Zealand only 31% of the firms effort goes into new product development compared with 49% for the US although product obsolescence is higher in the US. New product development is said to take 6 to 12 months in both countries. A significant difference is the US inclination to share plans with suppliers, a practice seldom reported in New Zealand.

Souder *et al.* (1995) compare the proficiency of firms from 6 countries in high and low certainty markets (pp 31 and 45). Small firms in the US and New Zealand are relatively sound performers in both market types although the less proficient New Zealand firms are only 75% as successful as their US counterparts.

NPD in New Zealand is less well attended to and is less successful than global benchmark countries of US and Japan. Stage-gate and other disciplined NPD

processes are available but not always used. Existing processes may be unnecessarily complex and extend product cycle time although this may not matter if New Zealand does not have industries requiring short cycle times. NPD processes in New Zealand need to be made attractive so they will be used.

2.5.4 Evolutionary innovation

Is there need for speed?

Evolution innovation tends to be less risky than R&D or NPD. The compliance with traditional project management criteria is considerably better. However, a common and distinctive feature in this work is rapid project pace.

It is estimated that companies lose 33% of after-tax profit when they ship 6 months late as compared to losses of 3.5% when they overspend the product development budget by 50% (House and Price, 1991, p 92). However, Smith and Reinertsen (1994, p 500) concluded that speed to market is not always the critical factor. A key consideration is the speed of growth of the market. In a slow-growth market a 6-month delay may reduce profits by around only 7%. However, an increase of 9% in product cost can reduce profit by 22% in a high-growth market but as much as 45% in a slow-growth market. Therefore, it may be worth extra expenditure to accelerate the development of products destined for a high-growth market, although evidence is not strong (Levene and Goffin, 1997).

The costs of accelerating projects is described by Kharbanda and Pinto (1996, p 60), who concludes that every 1% decrease in schedule (planned time allocation) typically costs an additional 1.5% to 2% of the budget.

Janszen (1997) used computer simulations to show that being first to market was advantageous when high market share was important to strategy but otherwise product quality was more important than speed. Clearly there is no advantage in being slow or inefficient and project management is seen as having a role in reducing wastage (Fern, 1999).

Dealing with speed

Smith and Reineretsen (1994, p 500) regard milestone designation as more important than detailed schedules for product development, on the basis that “by when” is more important than “by whom”. Further, they advise not to use monitoring and control systems that will disempower people since:

Well-trained people armed with information and the means to choose and implement appropriate approaches, can out-perform most systems in a fast-changing environment.

Covey *et al.* (1994, p 33) however warns:

Some of us get so used to the adrenaline rush of handling crises that we become dependent on it for a sense of excitement and energy... We feel useful. We feel successful. We feel validated. And we get good at it... People expect us to be busy, overworked. It's become a status symbol in our society – if we're busy, we're important; if we're not busy, we're almost embarrassed to admit it.

An innovation project management system therefore needs to set the appropriate sustainable pace and give individuals enough flexibility to respond to the market.

2.6 Project Management

2.6.1 Introduction

Scope

Galbraith (1968) foresaw “the imperatives of technology” driving the increased use of project management in businesses. Project management is regarded not merely a technique, but rather as a philosophy which can be used by management of any organisation, at any level, and for any function (Gupta, 1985). Mazany (1995) who describes the contribution of project management to the challenge for the America's Cup provides a local example.

Meredith and Mantel (1995) include creativity and technological forecasting as adjuncts to traditional project management topics reflecting the broadening context of project management across and beyond the organisation. Typical project

management effort currently involves project initiation 4%, planning 36%, execution 25%, control 28% and closing 7% (PMI Today, 1998).

Projects in the organisation

The OST innovation process system at Texas Instruments recognised projects as occurring in 3 aspects of the organisation; operations, growth and resources (Jelinek, 1979, p 69). Innovation projects can be categorised simply by whether they are within or across functional areas (Rubenstein and Ginn, 1985, p 173), however Wheelwright and Clark (1992) advocate 5 categories; derivative, platform, breakthrough, company R&D and industry partnership R&D.

The defining three elements of traditional project management, time, cost and specification are qualified for innovation by Kerzner (1992) and Barkley and Saylor (1994, p 35). The four qualifications are; acceptance by the customer/user, minimum or mutually agreed scope changes, no disturbance to the main workflow of the organisation and no change to the corporate culture, only the first of which appears to suit modern innovative organisations. Further, Barkley and Saylor view project management as dealing with current needs in contrast to Quinell (1998) who expects it to deliver the future.

The differentiating categories suggested by Shenhar *et al.* (1997a) relate to whether project outputs are “tangible” or “intangible” since the former requires effort by “craft” and the latter “intellect”. Projects are viewed as flexible and helpful to organisations (Kerzner, 1997, p 3) but do not infer a dominant paradigm.

Success

Barnes (1990, p 5) proposes two laws for project managers:

1. All decisions are directed toward achieving the project objective
2. Only the remaining work in the project can be managed.

And advises:

If you are halfway through a project it is not clever, masculine, foresighted or respectable to be still on the original programme.

Barnes' emphasises a pragmatic view of the future often overlooked in the effort to supply data to management system mechanics. Success requires both discipline and management of the project between now (project current status) and the end (when the best outcome has been reached). The discipline of applying systems *per se* gives a higher level of success than *ad hoc* innovation (Cooper, 1993; Milosovic, 1997).

An empirical study of project success factors for 448 projects done in Germany attributes 59% of the variance to eight significant factors (Gemuenden and Lechler, 1997):

- top management support
- project leadership
- project team capability
- team participation in decision-making
- information/communication flow
- effectiveness of planning and control
- conflict level and
- the extent to which project goals change.

Suitable dimensions for strategic success are proposed by Shenhar and Wideman (1997b):

- project efficiency
- impact on the customer
- direct business and organisational success and
- preparation for the future.

Success can be determined by considering either the process or the product (Baccarini, 1999).

2.6.2 Tools

The toolbox

Gilbreath (1986, p 63) catalogues 130 reasons for project failure. He argues that without project management tools poorer performing staff are prone to failure although high performing staff will usually succeed. Gilbreath (1986, p 124) advocates the “folded map” concept for incremental planning where progressively

more detailed and sophisticated tools are used for imminent activities. He characterises “a good process” [tool-set]:

A good process is goal oriented, founded on objectivity, is singular, lean and simple. It must produce identifiable results and be necessary. Finally a good process must reward compliance.

Projects with ill-defined goals and/or methods of achieving them can be classified for specific tool selection (Turner and Cochrane, 1993). Complex problems may require sophisticated tools. For example Wang and Han (1997) describe a model with 290 variables and 168 constraints which generated for decision-makers “a satisfying selection of options”. On the other hand some tools are just inadequate or are still under development. For example Pither and Duncan (1998) review ISO Standard 10006, “Quality Management-Guidelines to Quality in Project Management” but does not recommend its adoption citing among other things some poorly conceived guidance where new technology and uncertainty are concerned. A broad range of unsophisticated tools is useful even on small projects (Fuezery, 1998; Fox, 2000).

Two tools particularly relevant to innovation projects are, PERT and Time-boxes.

PERT

PERT was originally recommended only for large projects (over US\$1 million) (Badenoch, 1964, p 48) and required (at that time) significant computing capacity. For smaller projects Badenoch preferred plans to meet “concrete, measurable” milestone events which might occur at frequencies between once a day and once a month. He suggested, “Close-in” planning should be done in “very considerable detail” and equates it with, “commitments by people, rather than desires by planners”.

Levin and Kirkpatrick (1966) provide a helpful distinction between the intents of CPM and PERT before they became indistinct as modern project management software developed. CPM was used for projects that had been done before. It was used to achieve minimum project cost commensurate with the completion date requirement and cost of expediting work. PERT was intended for planning and

controlling non-repetitive projects (more akin to the needs of innovation). It is a method of scheduling and budgeting resources so as to accomplish a predetermined job on schedule. Levin and Kirkpatrick (1966, p 147) estimated that over 100 other methods of planning and controlling were used and describe about 30 of them.

By 1968 (Booz-Allen and Hamilton, 1968, p 12) PERT was described as:

a successful tool for planning and controlling the development, testing and commercialisation of new products. New product planning is the third largest user of PERT and the fastest growing one.

Karger and Murdick (1972, p 31) report that by 1971, PERT had become the highest ranked operational planning tool whereas it was ranked lowly for strategic planning. PERT was the overwhelming preference of R&D project managers (Dougherty *et al.*, 1984, p 51). PERT usage claimed is 16% for basic research, 27% for applied research and 40% for engineering development projects.

However, those opposing PERT claimed it too sophisticated, inflexible and expensive. For example Martin (1984, p 207) correctly advises that PERT cannot deal with alternative processes and process changes easily. Major rescheduling is required. PERT development is still active (Jenzarli, 1997) using advanced techniques in artificial intelligence and statistics known as “belief networks” and Gibbs sampling.

Time-boxes

A rapid (software) application development process (RAD) was proposed by James Martin (Mimno, 1991). A significant feature is the rigid limits on development time. If time is running out then software functionality development is specifically compromised so that a working product is finished within a specified “time-box”. A further feature can be summarised as “doing the hard bits first” (Gomaa, 1993) which is also incorporated into the recent CPM modification known as the Critical Chain approach (Goldratt, 1997). Chaudhuri (1998) gives a modified version of the “time-box” approach and calls it the “30-60-90-day” approach for planning IT projects.

Software purchasers generally operate with tight time constraints and inflexible budgets (DSDM, 1999) but often succumb to the desire for increased functionality (scope creep) as the full consequences of system development are recognised. “Time-boxes” allow for time and resources to be fixed and functionality is provided to the extent that these constraints permit.

“Time-boxes” are typically fixed at between 1 and 6 weeks. The total duration of projects using this method is normally less than six months because new technology and new requirements are likely to obsolete projects after then. Where greater functionality requirements are essential a new project is started. Hung (1999) describes “time-boxing” as “setting a deadline by which a business objective must be met”.

Problems arise when essential work has not been completed within the time-box and no specific provisions are evident to cope with unexpected external change. However, the concept of a nominated phase-completion date helps to “nail one corner of the triple constraint to the floor”. It also requires the mutual acknowledgement of management (clients) and project staff that unknowable effort or unknowable functionality cannot be provided with knowable cost.

Tool use

Spreadsheets are a widely accepted tool, used and understood throughout the management hierarchy. Clark and Scott (1995) found spreadsheet modelling was the most popular of 40 management tools for both situation assessment and strategic analysis. The most popular tool for strategic implementation was “project management” followed by spreadsheets.

Most project management tools are based on personal computers accessible across an organisation through networks. The steps required to migrate project management tools across to a network environment should include tests of the network system as well as the extent to which the tools are in use and common in the organisation (Lientz and Rea, 1998, p 142). There is recognition of the lack of value to companies by expanding access to little-used tools.

A recent survey on project management tools in 180 projects from 42 companies covered: tools used, tool popularity and tool value (Thamhain, 1999a, p 364). Firms were asked about 23 contemporary tools. Companies were familiar with fifty percent of the tools but only used 28% of them on average. The most used tools were, computer software, deficiency reporting, benchmarking, stage-gate process and core team approaches. The most popular tools were schedule tracking, project definition, project review, budget tracking and core team approaches. However, the most valuable were, project definition, status assessment, design review, recovery wave planning and schedule tracking. Thamhain concludes (p 364) that:

There appears to be an opportunity to design project control systems which integrate both (1) the need for more team autonomy and self-control, and (2) the desire for more sophisticated and meaningful project tracking. The linking pin often comes in the form of visibility, recognition, risk sharing and mutual trust...

Call for new tools

New tools are required if project portfolio management is to be used to integrate projects into businesses (Levine, 1999). Levine observes a shift in the use of tools from individual to multiple projects and suggests as useful an ability to add and subtract projects for “what if” analysis. Resource allocation may need to be influenced at a higher level in the organisation. Levine suggests a further required attribute is the need to “slice and dice” information (for balancing “strategic buckets”, product and market types for example). In his view the features of an ideal tool would include, electronic time-sheeting, good access to project data, integration with corporate accounting systems, earned value computation capability (for very large projects), “slice and dice” capability, mid- and high-level resource loading and budgeting and risk assessment.

It is widely recognised that new project management tools are needed to improve integration with organisations and to assist them directly in achieving their purpose.

Problems

Large projects are reported to have only a 20% success rate (Schnaars, 1989) and reported failure rate is high in general. This may indicate that success measurement

is biased either toward failure or that project expectations are unrealistic. Other common complaints have been reported (Kerzner, 1997, p 77) including:

- Scope creep in every project and no way to avoid it
- Completion dates are set first [when] detailed plans are not available
- Projects emphasise deadlines not quality
- Senior managers are still date driven instead of requirement driven
- Not everyone is involved in project change decisions
- There are hidden agendas and politics
- No funding for laboratory equipment
- Budgets and schedules are not co-ordinated
- Juggling schedules on multiple projects is almost impossible
- Sometimes information for reports is filtered because we fear sending negative messages
- A lot of caving in on budgets and schedules-trying to be a good guy all the time is a trap.

Learning from the successes and failures of past projects using review tools is not widely practised and not seen as a helpful (Matheson and Matheson, 1998).

Project tools are necessary, plentiful in supply, variable in their usefulness although commonly fail to meet the needs of the innovation process. Tools imply the prospect of order and control, features attractive to traditional business managers. Yet many tools measure the wrong thing, are too complex and are ignored.

2.6.3 Factors affecting project performance

People

The advantage of projects promoted to small organisations is the ability to handle one-time activities with the minimum disruption (Kerzner and Thamhain, 1984, p 7). However, project priorities and competition for resources may still interrupt routine business, long-range planning may suffer to meet short-term needs and shifting people in and out of projects may interrupt training of new employees and specialists. Projects can also attract the inefficient use of time by individuals (Gilbreath, 1986) and the problem of managing people when schedules overrun is common enough to be specifically addressed by Davis (1989, p 236).

The natural calendar-related variation of individual attention and energy levels is recognised although is rarely accounted for in resource allocation and optimisation (Kerzner, 1992, p 367). Project performance is also affected significantly by,

communication, motivation, adequacy of resources and product value (Sicotte and Prefontaine, 1997). A further factor is project continuity. Tharnhain (1999b) advises that for each day a project is stopped, three days are required for recovery.

To account for the need to deal with inevitable routine commitments Englund and Graham (1999) pragmatically recommend that no more than 50% of a person's time should be allocated to projects. This level of allocation suggests that higher proportions of time, commonly used in the planning process, is unduly optimistic and the accuracy of the resource optimisation processes common in traditional project management is somewhat pretentious.

Measures of success

The “judgement of the marketplace” is the easiest and most useful measure of success for an innovation project (House and Price, 1991, p 95). Aids to plot the course of projects on their journey into the marketplace have been proposed but are difficult to implement (Howard and Guile, 1992, p 61).

An alternative to assessing success is to ignore the traditional measures that represent failure! Kruglianskas and de Quieroz (1997) investigated project management practices in 12 Brazilian and one German telecommunication companies. Few cases under study used scripts for preparation of project plans, since these instruments were seen as being both unnecessary and inconvenient. From the point of view of the interviewees the projects were effective because they satisfied their customers however, the projects “had a rather small adherence to the time and cost goals they had been set”.

Reflections

One could conclude that innovation project performance could really only be effectively measured against the benefit it brings to the firm. But what of the many projects halted to enable resources to be applied to more favourable prospects? Did those projects under-perform? Does it matter if they did? If a steady flow of money is coming to the innovation programme, surely it is more important to know that the overall project-portfolio brings a favourable return rather than attempt to assess performance of individual projects, which may have been only partially

completed? Is it not more appropriate to align staff with their responsibility to the success of the total project-portfolio?

It has been reported that adjustment to schedule and budget to keep pace with current expectations is difficult, and practically impossible. Effort expended in assessing actual expenditures against outdated schedules is meaningless and conveys the impression of failure because scope creep always works against meeting constraints. The expectation and high probability of failure is not conducive to the self-actualised free-flow of creativity desired of innovation project staff by companies. If staff and companies are not well served by traditional project management tools used for individual innovation projects, can project-portfolio management tools help?

2.7 Project-Portfolio Management

2.7.1 Introduction

Project-portfolio management is a dynamic decision process, whereby a business's list of active new product (and R&D) projects is constantly updated and revised (Cooper *et al.*, 1999). In this process, new projects are evaluated, selected and prioritised. The portfolio decision process is characterised by uncertain and changing information, dynamic opportunities, multiple goals and strategic considerations, interdependence among projects and locations.

Portfolio analysis has become a popular concept in the last decade (Levine, 1999) although it requires organisational dedication and discipline to fully implement.

2.7.2 Portfolio dimensions

Management issues

Management finds difficulty in relying on formal processes for innovation projects decision-making (Simmons, 1959, p 56) even though comprehensive and sophisticated analysis is used (Glasser, 1982, p 174). Less rigorous guidelines like those provided by Kanter and Fonviele (1987) for the continuing development of a

new product, (a continuing need, measurable internal support for a project and evidence that the project might work) are more appreciated.

The key issues facing senior management in making decisions is to ensure that the project-portfolio is, “innovative, aligned, valuable, balanced and optimal” (Menke, 1999). Menke suggests management concentrate on consideration of three primary portfolio dimensions, cost, time and value. The portfolio should be aligned to business needs and objectives for strategic fit at a low cost. Resource levels and allocation need to be intensively managed through the “pipeline” [project execution] therefore a time [schedule] based process is required. Finally a value-based approach is required to consider synergies between cost, time and risk. Fine-tuning of a portfolio is required once worthwhile projects have been identified.

Key dimensions

The complexity of portfolio assessment is evident from the diverse dimensions/factors and criteria reported in the literature. Management reluctance to trust analysis entirely to automated logical processes is therefore not surprising. Some examples are presented in this section.

Four key portfolio analysis criteria selected from a study of 50 R&D projects were, probability of technical success, continual existence of anticipated market, government regulations and the availability of raw materials (Balachandra, 1985, p 111). Twelve discriminating variables for success were also identified:

- probability of commercial success
- top management support
- top management commitment
- effectiveness of the project leader
- commitment of project staff
- whether the project leader was also the project champion
- stage in the product or process lifecycle
- frequency of plan revision
- rate of new products introduced
- alignment with corporate goals
- internal competition
- number of product end uses and
- chance events.

The author suggests that evaluators first check the validity of the four key criteria, then look at the 12 discriminators. If more than 9 factors are positive, proceed with the project and if less than 6 are evident, terminate. Balachandra (1996) extended his work to compare the factors influencing the decision to terminate R&D projects in four countries (US, Germany, Japan and UK). He looked at a pool of 310 projects and 27 factors. Sixteen factors proved to be significant and explain between 82.5% and 95.5% of the cases.

Two groups of key dimensions for portfolio analysis have been identified by Cooper *et al.* (1998, p 188). The first group includes:

- market segment
- product lines
- project types and
- technologies.

The second group lists:

- strategic fit
- inventive merit
- durability
- reward
- competitive impact of technologies
- probabilities of success
- R&D costs to completion
- time to completion and
- investment required.

Matheson and Matheson (1998, p 98) select two graphical presentations found to be helpful in portfolio analysis. The first graph plots probability of technical success against the expected commercial value (NPV given technical success). The second is a plot of cumulative expected value (NPV multiplied by the overall probability of success) against cumulative expected further costs. The second plot is made by sorting projects in order using the ratio of “expected value/expected cost” and plotting the highest ratios (best value) first.

Eight categories of factors currently used for project-portfolio reviews (examples in brackets) are reported by Cooper *et al.* (1999). Financial models were the most popular but strategic models produced the best portfolios:

- financial models and indices (NPV)
- probabilistic (Monte Carlo)
- options pricing theory
- strategic approaches (strategic financial buckets)
- scoring models and checklists
- analytical hierarchy approaches (expert choice)
- behavioural approaches (Delphi) and
- mapping/bubble diagrams.

The lack of a dominant model suggests that organisations wishing assistance from this approach will need the flexibility to identify and use innovation project factors of particular significance to their circumstances. The summary graphs suggested by Matheson and Matheson may provide a useful introduction to new users.

Useful dimensions

Knowledge of the actual project cost is not useful in setting product prices (Oxenfeldt, 1959, p 338) although the ratio of expected cost and expected return is useful in selecting and prioritising projects. However, Scranton (1964, p 277) asserts without justification that management must have available information on actual costs as compared to estimated costs.

Expected Commercial Value (ECV) (Cooper, 1993, p 186) is a recommended dimension since it incorporates the expected NPV from future sales, the costs to complete development and probability of technical and commercial success. Matheson and Matheson (1998) suggest that “expected NPV” is the strongest measure of innovation project success adding that risk calculation should be done in a consistent and repeatable way. They also recommends developing a business case for every project to verify the integrity of projected costs and income.

2.7.3 Processes

Procedures

Establishing a project-portfolio process is not easy (Perelle, 1959, p75). Cooper (1993, p 190) identifies a basic two-stage process for project selection decision

making. If the project is a bad one, kill it. If it is a good one, give it a priority. Proceed if the priority is high and hold if the priority is low. Archer and Ghasemzadeh (1996a) advise a three-stage process for project-portfolio development. First, project data is pre-screened and a portfolio model to suit the organisation is developed. Secondly, individual projects are evaluated, screened and a portfolio selection made. The final stage is to balance and adjust the portfolio.

Knutson (1999) recommends that portfolio management become a four-step formalised process: solicitation, selection, prioritisation and registration. She recognises only two types of project, strategic and bottom-up. The project become “legitimate” only after the first three phases are complete. The final step (registration) should incorporate some form of automation for data access by senior management.

Projects can be more easily compared if there is a common set of supportive data and descriptive factors (Englund and Graham, 1999, p 59). They suggest a summary chart that lists strategic category, priority, head-count and timeline information. The chart can be updated quarterly or as changes occur and should be available on-line in a shared database.

Project-portfolio methods should be realistic, truly used to make go/kill decisions and be effective (Cooper *et al.*, 1999). At the same time portfolio methods must be user friendly, efficient, easily understood by management and fit management’s decision-making style.

Ranking

Baker and Pound (1964) describe over 80 different models to help management select projects but note, “unfortunately few (if any) of these models are used in practice”. Intuitive models are, however used, including, “track record”, “squeaky wheel” and the “white charger” (the direct influence of a project leader of team). In spite of these failings, (p 199):

If consistent estimation models are used for all projects, it should be possible to set up overall rankings with some confidence. The robustness of these rankings can then be subjected to some simple sensitivity analysis to see how they are maintained in the face of variations of outcomes that may obtain in practice.

R&D programs are recommended set by corporate management and individual projects set by researchers through peer group evaluation (Martin, 1984, p 180).

Stevens (1996) reports that over-commitment of development capacity is common and insidious, suggesting the length of the ranked list of projects be reduced. As a corollary, value-added work (work that makes progress) was said to peak at 70% when an engineer is working on 2 projects at a time reducing to 40% for 3 simultaneous projects and is just 15% when working on 7 projects. (c.f. Goldratt, 1997 who advocates single-tasking).

Systematic ranking of all projects is essential if a link is to be made from strategy to implementation (Dinsmore, 1998). However, Englund and Graham (1999) advocate grouping projects in “strategic buckets” and then prioritise projects within those groups. “Not active” projects should be listed separately to discourage proponents from casually reactivating them.

Automation

Madey and Dean (1985, p 17) demonstrate on a selection of 40 to 60 projects the prospect of using multiple-attribute utility theory and multiple-choice objective optimisation for portfolio analysis. The procedure could “conveniently” be applied up to 20 times a year if required. As well, a linear project prioritisation model suited to rigid and rigorous environments like navel shipyards has also been developed (Leachman and Boysen, 1985, p 43). However, both these approaches would require specialist attention and be too inflexible for most innovation projects in most organisations.

A more accessible approach is presented by Archer and Ghasemzadeh (1996b) who describe the prototype of a software program that integrates project data from a spreadsheet through to a program that translates the data into “bubble diagrams”

on a personal computer. The matrix dimensions used for the bubble diagram are, “time to complete” and “risk level”. Ghasemzadeh and Archer (1998) have developed the concept further and some local company interest is emerging in Canada.

Project ranking appears to be useful, and simple automated tools are being developed to help management make decisions.

2.7.4 Problems

There is no mathematical formula that can be employed consistently to give a numerical answer as to the intrinsic value of a product or a project in its early stages (Harris, 1964, p 115) even though many checklists have been provided over 50 years. Likewise Chi and Chen (1997) looked for rules to determine the simple task of when to stop a project if completion time was uncertain and there was salvageable value and concluded “it is not easy and there is no unique solution”.

A recent list of common barriers to implementation of project-portfolio management (Matheson and Matheson, 1998) identify short-term focus, perceived difficulties in measurement (including uncertainty) and organisational boundaries.

2.7.5 Practice

Clear Communication (New Zealand) has a very diverse project portfolio and a scoring system used for classification rather than ranking (Ozalins, 1997). The first three steps in the management process are described as aligning, planning and balancing. Four project types are defined, new, enhancements, replacements or maintenance/support. Projects are scored (0 to 3) for strategic fit and benefits (positive factors) and, technical risk and business risk (negative factors).

Cooper *et al.* (1999) measured portfolio performance in 205 firms using six categories:

- the right number of projects for the available resources
- avoiding pipeline gridlock (getting projects done on time)
- high value portfolios
- balanced portfolios (long/short, high/low risk across markets and technologies)

- alignment with business strategies and a
- spending breakdown that mirrored business strategies and strategic priorities.

They concluded that benchmark firms (41.8% of his sample) did well in all categories. A formal, explicit portfolio management method yields better portfolio results... much better than an informal, undefined process. Financial models are used in 77% of firms, 64.8% use business strategy models, 40.6% use bubble diagrams, 37.9% use scoring models and 20.9% use checklists. Most benchmark firms use both financial and strategic models. However, financial models yielded the poorest portfolio performance results because they produce portfolios of poor value projects with too many projects for the available resources, so generating gridlock. Strategic models yielded the best results. Scoring models were best for high value projects and bubble diagrams best for portfolio balancing.

Project-portfolios are being used increasingly by generally larger companies and their benefits are being assessed. Performance or success is ultimately to do with increased shareholder wealth. If a prime factor in company welfare is indeed benefit from innovation then efficient means to manage the projects that deliver it must be sought and made to work.

2.8 Summary and Conclusions

2.8.1 The main message

The literature points to the continuing importance of innovation for organisational growth and development. Economists and many others identify technological innovation as an important wealth creator. However, producing or acquiring technological innovation is recognised as often difficult, risky and costly.

Optimally, the innovation process must be efficient and effective, however it is subject to unknown and unknowable influences, so neither the process nor the outcome, can be prescribed in detail from the outset.

Projects isolate new and specific endeavours from the routine operations of business. The technological innovation process is usually managed within organisations as a discrete entity in the context of a project or programme to contain and control exposure to uncertainties.

Traditional project management tools were designed to prescribe and optimise activity-sequence, to allocate responsibility for execution and to provide monitoring and control systems. Projects are usually undertaken on the basis of awareness of technological options, knowledge of customer need and a good understanding of the nature of competitor response; but these conditions do not all apply to technological innovation. Currently available project management tools therefore have limited applicability and usefulness.

The importance of innovation processes has been promoted to rival routine production and operations as organisational core functions and capabilities. A tangible end product may no longer be the prescribed purpose of an innovation project. Rather, the purpose may be to exploit an idea, or its derivatives, in whatever way maximises benefit to the organisation. In project terms, the specific endeavour may be to maximise benefit rather than necessarily produce a prescribed product.

Management can only affect future events. Technological innovation project management tools therefore need to include those that provide measurements that help compare project status, future cost and potential benefit between alternative projects. There is no purpose or gain in comparing current status with originally conceived prescriptions since the way to maximise benefit will likely be unknowable at the start of a project or even a good way through.

If the foregoing is true and if these needs are real then it is argued here that those technological innovation project managers, and those accountable for expenditure of resources in this area, will be dissatisfied with traditional prescriptive project management tools.

The innovation process is often iterative and divergent. Also the creative people whose skills innovation extensively calls upon are unique and often resist compliance to imposed structure. Once selected, traditional projects would usually be expected to proceed to completion. In contrast innovation projects, particularly ones subject to influence from new technologies and fickle market needs may become irrelevant overnight and are much less durable. Project-portfolio analysis and management has therefore rapidly evolved to help keep businesses focused on efficient allocation of resources.

Therefore, technological innovation project structures, systems and tools need to be updated to:

- Maintain better integration with organisational processes
- Deal with poor quality information from the onset
- Generate metrics useful for assessing project portfolios
- Be simple to understand and use at all organisational levels
- Be commonly understood enough to share with partners outside the firm
- Engender co-operation by individuals
- Encourage individual and corporate creativity for conjoint benefit and satisfaction.

2.8.2 The New Zealand situation

This literature review indicates that New Zealand may be less advanced than other nations in encouraging and performing technological innovation. New Zealand has relatively low private sector R&D investment, has some technologically innovative companies but generally poorly performing enterprises and a relatively high ratio of government/company financial support to encourage innovation.

New Zealand uses overseas technology extensively. It has developed its own technologically sophisticated processes (e.g. chilled lamb and soft butter) to contribute advantage to export products (New Zealand exports most of its primary production). New Zealand technology has also been adopted overseas (e.g. electric fences and whiteware). New Zealand can therefore be considered a mature trader in the global marketplace.

The problems and practices of managing technological innovation projects in New Zealand have not been significantly addressed. This is due to a lack of sustained attention because of low national priority and consequent lack of resources.

However, the problems faced by innovators in New Zealand are not different or less difficult than those found elsewhere. Therefore attending to the urgent need to improve the management of technological innovation projects in New Zealand should be done in the expectation that any enlightenment may have global application.

2.9 Research Aims

This research sets out to identify and verify potential improvements to the process of managing technological innovation projects.

The specific objectives are to:

1. Understand how technological innovation projects are currently managed
2. Assess what project accountability is both required and desired by R&D purchasers, R&D providers and significant successful companies
3. Identify where structures, systems and tools (collectively called techniques) currently employed do not meet required or desired levels of accountability
4. Assemble techniques into an integrated system that might better serve technological innovation project managers and the organisations they serve
5. Report on the reaction of managers to the proposed system
6. Provide direction for further study and both encourage and facilitate improved practices.

Chapter Three describes the methods employed to meet these objectives.

CHAPTER 3 – METHODOLOGY

Except during the nine months before he draws his first breath, no man manages his affairs as well as a tree does – George Bernard Shaw

3.1 Overview

This study uses iterative, action-research (Bright, 1964; Honey and Mumford, 1992; O'Brien and Hart, 1999) approved by the University of Waikato Human Ethics Committee. The approach is shown in Figure 3.1.

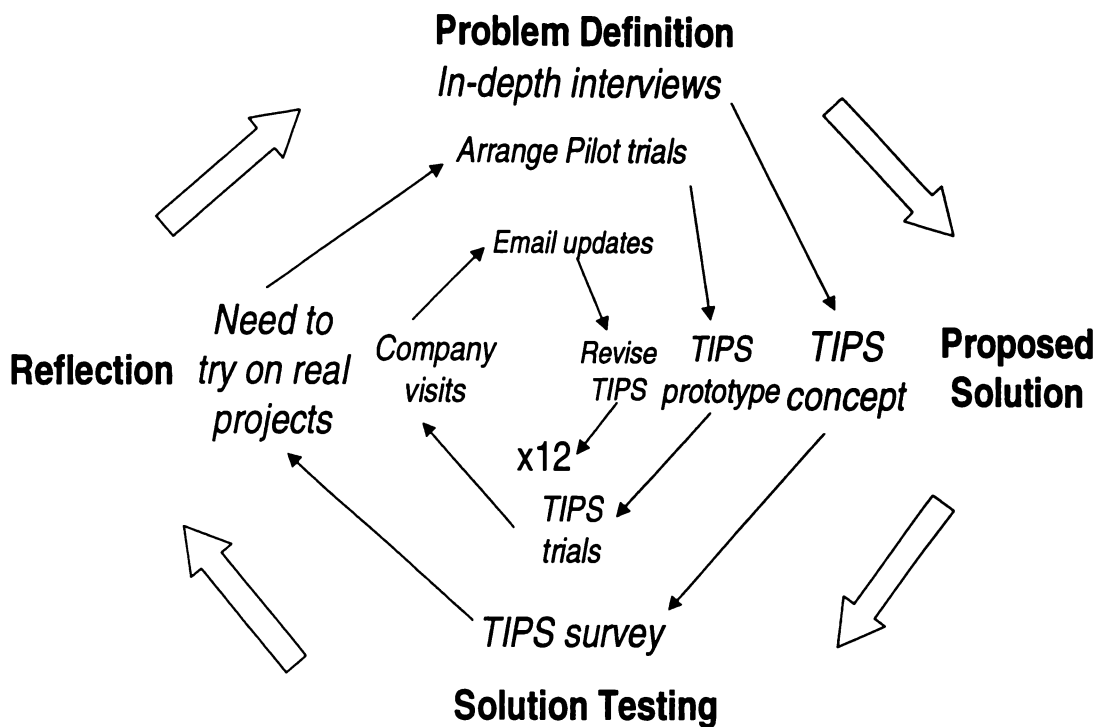


Figure 3.1 Iterative Action Research Approach

Representatives from four R&D funding organisations, three R&D provider companies and six successful companies were asked how they currently managed technological innovation projects and to identify the nature of perceived inadequacies. A system called TIPS was created and developed to integrate project management tools to address the reported shortfalls. The principles of TIPS were presented to academia and relevant professional bodies for reaction, comment and tuning (Mills and Kirk, 1995; Mills *et al.*, 1996; Mills *et al.*, 1999). An operational outline of TIPS was offered to the original interviewees for reaction and comment on implementation issues (Mills *et al.*, 2000). Finally, a three-month pilot trial was

run to simultaneously further refine and implement TIPS on a total of six projects in two of the initially interviewed companies in the latter part of the year 2000 (three with an R&D provider and three with an electronics/manufacturer) (Mills, in press).

Primary data was collected using partially structured interviews. The responses were considered to be valid and representative of the reality experienced by the interviewees. The number of interviews was selected to provide examples of organisational size and type. Organisation and interviewee designations are presented in Tables 3.1 and 3.2.

Table 3.1 Organisation Types and Size

Organisation Type	Designation	Turnover (NZ\$m)	R&D Expenditure (NZ\$m)
R&D Purchasers	P1	Not Applicable	259
	P2		7.6
	P3		2.5
	P4		1
R&D Providers	R1	87	70
	R2	44	38
	R3	10	7.2
Electronics Companies	E1	50	2
	E2	20	1
Food Companies	F1	2500	5-30
	F2	1000	5-30
Forestry Companies	T1	3000	Not Available
	T2	480	10

Source: Annual Reports, Birchfield (1995-1999) and interviews.

3.2 Introduction

3.2.1 Industry selection and representation

Primary production generates the bulk of New Zealand exports but some sectors are in decline and others are immature. New Zealand manufactured exports (including electrical machinery and equipment, which represents 3% of export income) are growing and have doubled in the past 10 years. All these sectors need attention paid to the improvement of innovation processes.

Table 3.2 Organisation and Interviewee Descriptions

Organisation Description	Organisation Designation	Interviewee Designation	Interviewee Description	TIPS Survey Response
Government R&D purchaser	P1	P1Ua	Policy Manager	Yes
		P1Ub	Programme Evaluation Manager	Not Available
Primary industry R&D purchaser	P2	P2U	Executive Director	Not Available
Agricultural industry R&D purchaser	P3	P3U	Secretary/Manager	Yes
Agricultural company R&D purchaser	P4	P4U	CEO	Yes
An agricultural Crown Research Institute	R1	R1U	Executive Manager	Not Available
		R1L	Product Development Manager	Yes
An industrial Crown Research Institute	R2	R2U	Divisional Executive	Yes
		R2M	Section Manager	Nil
		R2L	Scientist	Nil
Primary industry research organisation	R3	R3U	Director	Not Available
		R3M	Divisional Head	Not Available
		R3L	Section Head	Yes
Private electronics/manufacturing company	E1	E1M	Engineering Manager	Yes
		E1L	R&D Laboratory Manager	Yes
		E2	Operations Manager	Yes
Private electronics/manufacturing company	E2	E2L	R&D Manager	Yes
		F1	Company R&D Manager	Yes (Substitute)
International food company	F2	F1L	Project Manager	Yes
		F2M	Site Engineering Manager	Yes
Public forestry company	T1	F2L	Project Engineer	Yes
		T1M	Research and Technology Manager	Nil
Public forestry company	T2	T1L	Technical Analyst	Yes
		T2M	Strategic Research Director	Nil
		T2L	Project Executive	Yes

Source: Interviews and surveys.

R&D organisations substantially involved in electronics/manufacturing, food and agriculture were selected because they represented 48 % of export income (Statistics New Zealand, 1999) and reflected a significant proportion (31%) of government spending on R&D (MoRST, 1997a).

Six companies, two each representing the electronics/manufacturing, food and forestry sectors were selected. Forestry was included to provide an example of what is generally considered to be an emerging, but immature, industry in New Zealand and one that is being pressured by investors to be “innovative” and “add value” to their primary products prior to export. Wood and paper products exports represents 9% of New Zealand’s export income.

3.2.2 Primary data collection and analysis

Existing information

The size, location and general scope of the body of literature available on managing technological innovation projects was initially surveyed in 1995. Relevant data sources were subsequently scanned to identify important and topical issues and solutions or approaches recommended for dealing with problems.

During 1999 published works were systematically gleaned for the results of research and the advice of practitioners in those particular areas of the topic that were unresolved or contentious. The major topics reviewed were business innovation, technological innovation, R&D management, new product development and project management.

New information

Partially structured interviews, a brief postal questionnaire and an industrial pilot trial were used to collect new information. In-depth interviews (Johnson, 1986, p 238) were selected since the sample size was necessarily limited by the small total population of significant R&D purchasers (n=17) and limited number of providers in the selected sectors (n=10).

The partially structured, in-depth interviews were based on pre-circulated guideline questions to get high quality information, rich with incidental insight from each individual. The contextual information and detail in this form of face-to-face interview can lead to a good understanding of the current status. Pre-circulation was used to allow the subject to collect data and avoid the possibility of embarrassment when they were asked the early questions about basic metrics. The interview style moved from closed initial questions that helped define the scope of responsibility of each manager, to open questions where experience-based opinion and preference could be expressed, as the subject became more relaxed. The partially structured approach was also used to pace, sequence and guide the depth of the interview (Hussey and Hussey, 1997; Kvale, 1996).

The interview format enabled issues to be approached in the same sequence for each interviewee. It was considered to be likely that discussion of issues approached from the same direction would help simplify identification of similarities or divergences of fact or opinion. This approach also helped in regulating the time spent on each topic. A further advantage was that interview analysis was simplified reducing the need for extensive scanning of the transcriptions for comparisons and contrasts.

The use of a five-point scale for the interviews was trialed as a means to procure a tangible measure of satisfaction. The values given did not provide for useful discrimination but the invariably verbalised exercise of arriving at the number did provide useful qualitative data. The device of requesting a numerical assessment was therefore incorporated into interviews where inadequate initial responses were proffered.

The experience of Texas Instruments taking 7 years to implement a corporate-wide innovation system reported by Jelinek (1979) suggested difficulties might arise in doing a TIPS trial. Peer comment suggests that system implementation speed has improved during the last 20 years with the advent of information technology but still requires dedicated team effort of about 3 years duration (Menke, 1999). Therefore the initial means adopted to provide feed back on TIPS was to use a

postal survey requiring written responses to two open-ended questions posed to solicit reaction to a general description of TIPS. The questions were selected to help provoke a sincere response from senior managers, evaluate the proposal, refine the proposed system and predispose companies as potential system trialists in further research. In the event, trial implementation was found to be necessary.

Interview analysis method

Interviews were about one hour long and recorded, independently transcribed and checked for typographic accuracy. Key management needs and issues arising from each interview were listed and clustered for comparison.

For the small sample sizes used here and with the use of a partially structured approach, in-depth interview comment frequency is not a reliable measure of significance (Griffin and Hauser, 1993). The strength and impact of comment was therefore also considered for its contribution to the findings. These characteristics were not overtly measured but rather reflected in summaries and conclusions assembled after the series of interviews were finished. A summary of responses to questions and themes of consequent discussions was reviewed for anomalies, contrasts and reinforcement within organisations and across industry types, size and turnover.

The use of software aids for transcription analysis (Hansen, 1998) and thematic analysis procedures were also investigated (Zorn, 1998). In the event neither approach was required since the partially structured interview format provided adequate classification and weight to question responses.

Information sought during interviews included both fact and opinion. Fact was verified, as far as possible, by referring to official documents including Annual Reports. Some financial information could not be verified for commercial reasons or because it was embedded in composite accounts.

Fact and opinion were verified where doubt existed by discussing interim findings with interviewees and integrating responses into the data used for this thesis. An

alternative to this procedure would have been to request personal verification of interview transcriptions. While this would potentially give more accurate raw data it also provided opportunity for inadvertent corruption of the initial data by the interviewee in the light of the situation prevailing at the time of editing. This would inevitably be outside the stable five-month data collection period and may have introduced additional variables and anomalies.

3.3 Selection

3.3.1 R&D organisations

Organisations were selected from 17 significant (mainly government based) R&D purchasers and 19 R&D government (nine) and industry association (ten) based providers (Appendix A).

A sample size of around ten interviews was initially considered appropriate and manageable for adequate representation of the sectors of interest and for the style of research being undertaken. Organisations were selected to provide a range of organisation size and the type of client on whose behalf the R&D purchase or provision was made.

Four pilot interviews were undertaken. It became evident that different aspects of project management were emphasised at different management levels in the provider organisations and therefore specific representation was deemed to be required.

A sample of 12 interviewees was finalised from the 36 listed organisations. Four interviewees represented different R&D project purchasers and 8 representatives from R&D providers. The provider representatives were at three management levels, (upper, middle and lower), in three organisations executing a significant number of R&D projects and programmes for the selected purchasers.

The selection of specific interviewees was done by the Chief Executive Officers of the selected organisations on a basis that met the general requirements of the study

but also best suited their purposes. In the event, it was this process that adjusted the distribution of interviewees across organisation types and management levels. Fortunately this generated a richness of contribution, which it was decided, should be retained.

3.3.2 Companies

Six companies were selected, two in each of the electronics/manufacturing, food-processing and forestry industries. All six companies are or have been listed in the “top 500” (based on dollar turnover) for New Zealand and are generally recognised as being successful and commercially significant (Birchfield, 1995-1999).

Companies were selected for their diversity within the constraints of the small sample. Diversity was found in:

- manufacturing presence (local/multi-national)
- statutory base (private/public/co-operative)
- innovation emphasis (product/process)
- size (between less than 150 employees and greater than 3000 employees)
and
- turnover (NZ\$20 million to NZ\$3000 million).

The selection also considered the proximity of the company base to Hamilton, contacts with the University of Waikato, and the level of interest expressed in the research during initial approaches.

3.4 Primary interviews

3.4.1 R&D organisations

The 12 in-depth interviews with staff associated with projects from research and development organisations were held between 26 May and 1 November 1995.

Interviews were held with five senior managers (U) from four R&D purchasing organisations: (P1, two staff jointly, a and b), (P2), (P3) and (P4). Interviews were also held with eight staff from three R&D organisations: (R1), (R2) and (R3).

Three staff members, one each from upper (U), middle (M) and lower management (L) were interviewed from both R2 and R3. Only two staff members were interviewed from R1, an upper manager and a lower manager. Generally upper managers would be expected to manage project-portfolios, middle managers project programs and lower managers individual projects.

It was originally intended that the interview process be completed within a two-month period to mitigate against differences in responses caused by external influences. However, delays caused by staff unavailability because of restructuring in R2, the workload of one person originally selected in R3 and physical location of P2 extended the process to five months. (In the event there were no changes to external purchaser project accountability requirements or internal implementations of provider systems evident, reported or advised during the five-month interview process.)

An introductory letter and a common list of questions were sent to interviewees a week before the interview (Appendix B). The questions formed the basis and a logical progression for the interview process. Additional questions were introduced as required to clarify or amplify responses and to explore related important and relevant matters.

The interviews took place in essentially the same social and economic environment and are considered valid in the context of this investigation.

3.4.2 Companies

Eleven in-depth interviews were held on the premises of the company with one program (M) and one project (L) managers from each company between 26 June and 14 August 1998. One interview was conducted with both the program and project managers present. As for the R&D organisations an introductory letter and a common set of guideline questions were sent to each manager prior to the interview (Appendix C). The guideline questions were similar to and based on those used for the earlier interviews with R&D purchasers and providers. The

ranges of responsibility for those designated M and L was very wide across the total sample.

The electronics companies were comparable. E1 presented the company engineering manager (E1M) and R&D laboratory manager (E1L) and E2 the operations manager (E2M) and R&D manager (E2L).

Food company F1 managers' jobs related to product and process development projects whereas F2 managers attended to "new-to-company engineering" projects. F1M was the R&D manager for the whole company and F1L was a senior food technologist at one of the company production sites. F2M was a major "site engineering and projects" manager and F2L was an engineering project manager.

Managers from T1 had an R&D emphasis and those from T2 had a general business emphasis. T1M came from science background and was the Manager of Research and Technology. T1L was a technical analyst in a production-site-based operational research team. T2M was the Director of Strategic Development and Planning and T2L one of his business development managers.

Interviews within the same company were normally done the same day. The maximum period between interviews in the same company was three weeks. It is not known if any changes occurred between interviews within the same company which may have affected responses between individuals. The external socio-political and business environment was monitored for influence from news reports during the interview period. It is considered unlikely that matters that affect comparisons between individuals from the same company or between companies were significant even in the context of the dynamic business environment.

3.4.3 Interactions

The New Zealand R&D community is geographically and organisationally widespread. However, the R&D community can be considered close knit through common interests, sources of funds and comprehensive communication networks.

Consideration was given to the possibility of bias being introduced into this study by interaction occurring external and coincident to the interview process.

A brief summary of recent historical relationships of the organisations was prepared to identify likelihood and consequences of communication during the interview period. It was considered most unlikely that bias might occur through interaction between participants. The reasons for this conclusion include the integrity of the interviewees, the confidential nature of the invitation to participate and the unlikely advantage of influencing the course of this research at its data collection stage.

The limited sample available, the close-knit R&D community and the relationships and networks already extent cannot rule out the possibility of interaction although it has not been evident.

3.5 Time-block Innovation Project System (TIPS)

3.5.1 TIPS development

The iterative process used to develop TIPS involved these seven intuitive steps:

1. Identify from the literature and first-hand from these investigations factors that promote efficient and effective technological innovation
2. Understand how key factors interrelate
3. Assess why good or bad interactions occur
4. Look for areas where management commonly agree that improvements are needed and can be made
5. Determine a set of principles acceptable to management that incorporates alignment to an innovation strategy
6. Embody the principles into a system with prescribed methods (TIPS)
7. Consider how TIPS might be implemented.

The core concepts of TIPS arose as a result of noting and resolving the:

- ill-defined and changing specifications, sequence and duration of activities encountered in innovation projects

- reluctance for acknowledging, quantifying and aggregating project risk
- persistent nature of requests for calendar-related as well as project schedule-related reports by senior management and
- reluctance for updating schedules.

The assembly of the TIPS concept started with the decision to use the most popular appropriate software platform, Microsoft *Excel* (as evidenced from the literature review and the in-depth interviews). This was followed by the decision to use the duration probability approach used by MacCleod and Petersen (1996), including the same beta probability distribution curve using two time estimates (optimistic and pessimistic) for completion of nominal blocks of calendar time (Mills *et al.*, 1996). Other attributes and features were added to incorporate the findings of the literature review and in-depth interviews in the manner prescribed above and are more fully detailed in Appendix D.

The TIPS development process peer review at conferences in New Zealand and overseas indicated that individual components of the proposed concept had been used or reported by others (e.g. MacLeod and Petersen's (1996) use of two time estimates for risk assessment). However, the concept of adapting and integrating these components to address the problems faced by technological innovation project managers appeared to be new.

3.5.2 TIPS evaluation

To assess the value of the TIPS concept and identify a process for its implementation a summary description was presented for interviewees to consider.

The description format comprised:

- A one page letter requesting feedback
- A one-page fax reply form
- A three-page written description of the proposed TIPS concept
- A two-page spreadsheet with sample project and portfolio data

- A one-page sheet of figures showing key concepts of innovation project types, time-blocks, probability distributions and comparisons with existing methods.

An overview of TIPS and methods embodied in it was sent in August 1999 to the 25 interviewees from the earlier phases of the research to comment on the approach and barriers they saw to it being implemented in their organisation (Appendix D). Six of the interviewees had moved to other employment unrelated to this research and were not available. In one case, however, a replacement was very familiar with the research and agreed to respond. Therefore a total of 20 overview responses were solicited.

Follow-up to encourage responses was required in all cases. The reasons for slow response included overseas business trips, the need to allocate several hours dedicated time for a properly considered response and the over-riding requirement of priority needing to be given to income generating work. A nil return was declared during October 1999 for those interviewees, who after at least three attempts at follow up by phone, fax, mail or email had failed to produce results.

A total of 16 survey results were supplied from the 20 expected. The responses represented three of the four R&D purchasers (three interviewees solicited); all of the three R&D providers (five interviewees solicited) and all six companies were represented through ten interviewees (12 interviewees solicited). The results were reported for peer review.

3.5.3 TIPS pilot trials

The three research provider organisations and six successful companies from earlier research were invited to consider trying TIPS on a sample of their current projects. Local (Hamilton) firms were particularly encouraged to respond so that direct researcher contact and support could be conveniently provided. After discussions an agricultural research company (R1) and an electronics/manufacturing company (E1) agreed to use TIPS on three projects in each company.

The pilot trial took place between 12 July and 13 October 2000 and had eleven individual participants (Table 3.3).

Table 3.3. Summary Descriptions of TIPS Pilot Trial Participants

Participant #	Company	Designation	Function
1	R1	G	O
2	R1	A	O
3	R1	B	O
4	R1	C	T
5	R1	-	T
6	R1	-	T
7	E1	-	O
8	E1	H	O
9	E1	X	T
10	E1	Y	T
11	E1	Z	T

Note: R1 and E1 are an agricultural research company and an electronics/manufacturing company respectively, O represents business/operations and T represents technician/scientist functions

Formally allocated projects were managed by participants designated A, B, C and X, Y and Z respectively and overseen by one project portfolio manager from each firm (designated G and H respectively). One participant (#6) working for R1 with C contributed to a joint survey response and another (#5) working for R1 in association with B also used TIPS on two informal projects and completed the final survey independently. A third participant (#7) was the engineering manager for E1. The functions of the managers, generically described as business/operations (O) or technical/scientific (T), were also identified. Brief descriptions of the six formal projects are in Table 3.4.

During initial discussions, the following three inter-related aspects of the trial emerged as being of particular significance for introducing TIPS:

- Consolidating the type of information useful for managing innovation projects
- Formatting project information for convenient and practical use and
- Encouraging the flow of project information across functional barriers and managerial levels.

Table 3.4. TIPS Pilot Trial Formal Project Descriptions

Project manager	Project description
A	Development, approval and launch of a new model of an existing animal remedy.
B	Development and launch of an existing production management software product for a different animal species.
C	Research, development and commercialisation of a novel animal based drug production process.
X	Development and production of a new network security system.
Y	Fixing six specific faults in a recently launched new product and consequential upgrade of production line.
Z	Production and packaging for a new hardware/software security product for export.

Action research, which involves direct researcher involvement and intervention to encourage the introduction of new systems and requisite behavioural and attitudinal changes, was evolved for the pilot trial. This approach has been used successfully in both education research (Cohen and Manion, 1994) and when introducing new management systems (Koch *et al.*, 1995). Griffin and Hauser (1993) suggests 75% of needs can be identified in one-hour face-to-face interviews with 11 customers. Repeat customer interviewing occurs naturally in action research and so significantly improves identification percentage.

Regular interaction between participants and the researcher developed in two ways - by visits and by weekly email updates. Each Friday during the three-month trial the project manager was visited at a convenient time (A, B and C in the morning and X, Y and Z in the afternoon), usually in the same sequence. The visit was used to assist project managers update the TIPS project spreadsheet and discussing implementation problems and alternative solutions. Each Thursday email updates were sent to suggest solutions to common problems, to provide revised TIPS software, to motivate all participants and to remind project managers of the Friday visit. Interaction with G and H was not structured and occurred informally. G and H nominated company-specific project information fields to the researcher.

Research data was collected informally through notes made during the weekly visits and on reflection, and formally by a survey at the end of the trial (Appendix E). The survey was sent individually to the 11 participant managers, distributed and collected through email using a protected Microsoft Excel spreadsheet.

Definitive statistical analysis, by numerical rating alone was impractical and unreliable because of the small number of trial respondents (nine). All answers requiring numerical rating were therefore supplemented with a request to write down the “Reason for the Rating”. This approach allowed aggregate rating values to be verified and enhanced.

Survey formats and rating scales were based on examples provided by Bruner and Hensel (1994) and Aiken (1996) and standardised to 5-point scales for consistency and convenience. Survey topics covered three aspects of project management; information content (27 measures), formatting (15 measures), and flow (seven measures). There was also a concluding section on organisation-wide implementation requirements and prospects (eight measures).

The TIPS format used at the end of the pilot trials is presented in Appendix F.

Chapter Four presents the findings of this research.

CHAPTER 4 – FINDINGS

The finer the net is woven, the more numerous are the holes - Hans Kung.

4.1 Organisations' Financial Relationships

Four organisations (P1, P2, P3 and P4) purchased 39% of the reported gross expenditure on R&D in New Zealand (Strategic Consultative Group on Research, 1994). Three of these organisations supplied 80% of the R&D income for R1, R2 and R3 respectively (Table 4.1). The providers supplied 34%, 90%, 4% and 100% of the R&D purchased by P1, P2, P3 and P4 respectively. Two or more providers working together supplied some projects. P4 is owned by R1.

Companies did not purchase significant amounts of R&D from providers on an on-going basis.

Table 4.1 Cash-flows (\$m) Between R&D Organisations in 1994/1995

Providers	Purchasers					Totals
	P1	P2	P3	P4	Others	
R1	57	2	0.05	1	10	70
R2	29	1	0	0	8	38
R3	2	3.9	0.07	0	1.2	7.2
Others	171	0.7	2.4	0		
Totals	259	7.6	2.5	1		

Source: Individual Annual Reports and interviews.

4.2 R&D Purchasers

4.2.1 P1

Profile

P1 purchases public good science outputs (R&D) on behalf of the people of New Zealand (Ministerial Science Task Group, 1991) that are:

likely to increase knowledge or understanding of the physical, biological or social environment

likely to develop, maintain or increase skills or specific expertise that are or is of particular importance to New Zealand and

may be of benefit to New Zealand, are unlikely to be funded, or adequately funded, from non-government sources.

Policy and priorities for “public good” science were set by the Ministry of Science, Research and Technology using “programmes” of work, each with up to 10 “objectives” (innovation projects). Project outputs were not intended or expected to be directly appropriable by specific individuals or companies.

Although P1 used a “hands-off” style of project management (P1Ua) it ensured that research was purchased within nominated areas by credible, adequately supported researchers. The type, quantity and quality of the outputs were formally agreed and the researchers were required to report significant variations. The initiative to identify and pursue appropriate alternative research paths rested with providers pending confirmation from P1 to formally advise the acceptability of deviation.

A system of annual review reports formally recorded the research actually done and provided feedback for selecting the next round of project purchases. “Light touch” (P1Ub) monitoring of a stratified sample of 10% of projects during the year was done by informal discussion with researchers. Intensive peer reviews were increasingly being used for provider selection rather than for monitoring purposes.

P1 vested ownership of intellectual property rights with providers on the presumption that they would most appreciate the value of the discovery and should be in the best position to bring it to the marketplace. P1Ua colourfully justified P1’s philosophy:

Columbus set off to discover India and discovered America instead. Our philosophy is to consider objectives (projects) as compass bearings, not maps. We are happy to let people pick up the nuggets of gold on the way.

The smallest unit of management used by P1 was “the objective (project)”. In 1994/95, 588 contracts, typically with three objectives (totalling 1500 to 2000 projects) were signed. Although the average contract or programme annual cost was \$440,000, values ranged between \$50,000 and \$2 million, and most

programmes were multiple-year funded with a trend toward minimum two-year programmes. A typical full-time equivalent (FTE) researcher might cost around \$150,000 per annum, and would be leading one or two objective investigations and contributing to several others.

Accountability

P1 was accountable to the public of New Zealand through its shareholding government ministers. “Adequate and reasonable” procedures needed to be established for managing and reporting scientific research and for its financial management. P1 needed to satisfy themselves with the conduct or quality of the programme and that the contractors had used their best endeavours. Reports were required in prescribed standard formats. P1 acknowledged that the results of research may be uncertain and preliminary results may require revised methods and changed lines of inquiry. Nonetheless, the objectives could not be altered unless agreed by the parties. However, each year the contract was in force, the contractor needed to supply a revised set of objectives.

P1 expected economic, environmental and social outcomes from its investment in R&D. “In multitudinous ways it [R&D] feeds through to benefiting New Zealand” (P1Ua). P1Ua explained:

The overarching drive is the quality of life of “Kiwis” ... including everything from animal ethics right through to safeguarding our history and culture... So almost all human activity of any meaning can be underpinned by public good science research.

My expectation has been that we produce scientific outputs in terms of models that people draw on for all kinds of reasons...

Tangible things [benefits], which are easy to measure, are for example a new plant variety suitable for commercialised forestry or perhaps someone will find a way to kill opossums. Intangible benefits are more difficult to measure such as social science, [for example] creating knowledge about our history, which changes our views on the Treaty of Waitangi.

P1 described the benefits from R&D in terms of generating new knowledge and human capital, both of which were acknowledged to provide potential returns in both the immediate and distant future. Measuring these returns was accomplished by a systematic evaluation system. Additional reviews were done targeting the 10%

of programmes where ‘biggest problems’ were perceived. The review committee, which included people from overseas, “looked at the portfolio of programmes and the [researchers]”. “You might look at the quality of research and output deliverables but you don’t look at whether “the system” has picked it up” (P1Ua).

P1 was developing an economic evaluation capability that would look at “spin-off” or latent innovations from the original activity (P1Ua):

Unlike traditional economic analysis of benefits that looks at return to projects in isolation, this evaluation looks at human capital and antecedent research, including underpinning basic science.

We [P1] are looking at how research that doesn’t appear to have gone anywhere creates a technical platform for downstream research... or you find that an innovation in fact came from a totally unexpected quarter and you can’t attribute all the benefits and costs to that research programme... you have got to look at interrelationships.

We are going to endeavour to measure the kinds of non-economic things, like human capital... and create some kind of economic acknowledgement that in funding research you have... to measure a scientist contribution looking at their whole career including what they have done outside of the public good framework. We are also acknowledging a key point from the new growth area... which is that technical change is irreversible... and therefore creates cumulative wealth.

P1 required that organisations funded to do research had to provide a structure to enable the research to be managed, monitored and evaluated. P1 did not itself engage in “hands-on” management but rather “creates the framework through which management can be successful”. The structure needed to provide accountability for meeting any legal obligations such as ethics approval or consultation with Maori, and exploit intellectual property. This last provision was particularly important because the case for providers retaining ownership of intellectual property had been hard fought against contrary views from MoRST.

P1Ua asserts:

Purchasers can’t be too hands-on and prescriptive. You have got to give a lot of flexibility because any centralised allocatory bodies have only got 20% of what they need to know [to make decisions] in a hands-on way. So we accept our ignorance in major chunks of the business.

This hands-off approach was reflected in P1's organisational structure. The Chief Executive had a staff of eight programme managers supported by three evaluation and review staff and three policy staff together with a team of 13 for secretarial and office support (at June 1995).

The mandatory 3000 word annual "achievement report" described the main results and achievements. Alternative achievements and/or explanations on why a particular output, or set of outputs or intended results were not achieved were fully acceptable. This was a common situation... "scientific research being what it is" (P1Ub).

Report assessment used two main criteria; the quality/clarity of reporting and the level of achievement compared with the level stated in the original objectives. Additional information was requested for unacceptable reports and the report reassessed. Control action rested with the Advisory Committees who had selected projects for funding. The expectation was that any further funding sought by researchers who filed unacceptable reports would be considered in the light of previous performance.

P1 considered that the processes for collecting and using information on projects was robust and appropriate but that the percentage of projects covered was inadequate for maximum returns. "I can't see any obvious way of improving the framework, processes and procedures" (P1Ub). P1 also considered its reporting procedures to be satisfactory. Reporting was universally applied but "Of course we take [the reports] at face value...we have no way of verifying that anything that is said in the report is accurate" (P1Ub). The fact that auditing was an on-going and increasing activity suggests that P1 had, in fact, some concern with accountability satisfaction.

4.2.2 P2

Profile

P2 bought R&D on behalf of a New Zealand primary producer board for generic industry benefit. Funds came from a farmer export product levy that also supported product promotion, production and market access.

The producing farmer was perceived to benefit largely by having reduced production and processing costs and as well by making New Zealand products attractive to customers. Delphi analysis of experts was used to select R&D topics that were then ranked in discussions with primary producers. Quality Function Deployment (Hauser and Clausing, 1988) had been proposed to improve the match between research project objectives and producers' needs.

In stark contrast to P1, P2 had a "hands-on", "interactive" and "outcome focused" style of project management. It used a database software system with financial information and milestones to prompt reports (P2U). Specifically excluded was "performance information" ("because of the Privacy Act").

Project funding was allocated annually. Continuity of quarterly paid project funding depended on satisfactorily meeting milestone targets (typically three or four per year). This assessment period was considered to be the most frequent practical monitoring and control period, given the available tools and the costs of operation and compliance. Funding for projects extending beyond the financial year depends upon their "merit" compared with other R&D opportunities for that year. In practice, 81% of projects ran for two to five years (P2U), indicating that there was continuity across financial years.

The onus of reporting deviations from expected deliverables rested with the researcher. In contrast to P1, work outside the contracted scope was not supported unless there was a prior formal agreement from P2U. P2 owns the intellectual property rights arising from the R&D it funds, emphasising the expectation that intellectual property would most likely be sold back to the

originating R&D organisation for exploitation. P2 took active responsibility for implementing new knowledge. The justification of P2's philosophy was that projects it managed represented the best opportunity for enhancing returns to the industry through the focused introduction of new knowledge and technology.

P2 funded 166 project contracts in 1994/1995. A typical unit of managed research, might be about \$50,000. Although large machinery developments requiring up to \$550,000 per year for three years were done in the early 1990s, current individual project expenditure rarely exceeded \$200,000 annually.

Accountability

P2 was formally accountable to New Zealand producers through its primary producer board and required work to be done to the scientific standard appropriate to the field of research. If a project was likely to be overspent the contracting parties had to consult. P2 also had to be consulted if the provider thought that the success project's success was improbable or progress might be significantly retarded.

The returns P2 expected were described by quoting an example of tangible success (P2U):

“A 400% increase in productivity on some farms within three to four years... increase in [production] percentages by up to 30%... savings of \$5000 a farm by drenching on the basis of faecal egg count rather than by a rote 21 or 28 day rotation”. Now if you transferred that onto 100 other farms in New Zealand it would pay for virtually the total programme.

P2 measured R&D benefits by assessing the responses to open-ended questionnaires sent to researchers and users of research information. Researchers were asked what they believe they have really achieved. P2U was “very happy” to use these subjective measures of success asserting:

Just because you don't get a result it doesn't mean you are not worth funding. I think we still get this attitude of confusion between reaching milestones, which is an activity, and something you put on the table, which is a result. You meet the milestones - you perform for us there, if you get a result that's excellent, if you don't, providing you have followed the process you have said you are going to follow, we are still quite happy not to downgrade you as a

research provider. Users are regarded as a captive and interested audience who can be questioned on a regular basis. The response to questionnaires sent in by farmers regarding the [] project is taken as “the farming community” response. These farmers “have seen the benefits... and said... it is the best investment the producer board has ever made”.

P2 had a Chief Executive and three staff (two project managers and a secretary). Project managers had to “keep negotiating and re-negotiating milestones and performance” (P2U). Milestone reports (typically one- to four-monthly intervals) were compared with original intentions and for testing termination criteria. A project plan calling for, a one-month feasibility and a three-month concept development was used as an example. If the feasibility showed that continuing was unattractive, the project would be dropped, no matter what expectation may have originally been held for a successful outcome. This was in stark contrast to P1 where funding for R&D in the general area is committed for a year. The P2 overseeing council made decisions affecting project support every quarter, which ensured that representatives of producers, processors, science and academic endeavour influenced project termination.

P2 did not doubt that the project management system could be improved. However, the increased effort that might occur needed to be assessed against the perceived benefits (P2U):

We have read d*** near every book about project management... the system we are going through now is called quality function deployment (QFD)... so we are using the matrix to drive our next round of projects.

P2 did not require greater accountability but would like to be able to assess whether it had got “value for money” from a provider. Issues of “level of overhead recovery” and “costs of operation” made this assessment difficult. There was no “standard formula or format, every [provider] organisation is different and it does cause us [P2] a lot of concern” (P2U):

There has got to be some realism in setting overheads... in relation to the facilities used to get the job done... we can get the job done far more cheaply at universities but their accounting is not realistic on the other hand.

P2 was concerned with accountability measurement for “quality of output”. P2 described quality level as being met if “we get what we paid for on time and within budget” (P2U). However, a product was considered of better quality if the outputs of research “can be easily adopted by the end user”. The problem P2 faced was to find a measure to determine the level of this perceived improved quality.

4.2.3 P3

Profile

P3 was a trust settled by the Crown in 1987 to promote and encourage “the agricultural, pastoral and horticultural industries in New Zealand” (Annual Report, 1995). Funds from interest on capital that became available to the New Zealand government when phosphate fertiliser mining activities ceased were intended to support, supplement and hasten solutions in areas the trustees perceived to be of strategic importance. Areas of topical interest were selected and advertised by the Trustees each year to give direction to interested parties about new funding priorities. The four government-appointed members of the Trust Board, in conjunction with a scientific advisor, approved grants for research, development and marketing.

P3U described the style of project management adopted by P3 as “low key” and assessed the ability of each bidder to deliver a successful conclusion to the type of work proposed. P3 used milestones for tracking and in 1995 moved from quarterly to annual reporting (similar to P1). Milestones and progress reports were requested for interest and information about progress rather than for pro-active direction or management, except in the case of “obvious problems”.

P3 funded 109 projects in 1994/95, which indicated that a typical project would cost \$25,000 annually. This typical cost was, however, misleading because they included “fixed sum fellowship grants” and “one-off payments” for study tours. Many projects are multiple-year funded.

Accountability

P3 was accountable to the public of New Zealand. P3’s contracts require that progress payments required confirmation that “expenditure to date” was according

to the approved budget and that the project was proceeding as indicated in the original application. Reporting scientific outcomes and outputs was required annually.

The researchers retained the benefits of R&D funded by P3. This reflects P3's "hands-off" approach. In contrast to P2, P3U advised that P3:

probably doesn't receive any tangible benefit, as such, because it is a charitable Trust; we don't make profits out of people. The intangible benefits would be that the trustees have the satisfaction of knowing that they are fulfilling the objectives of the Trust.

P3 measured results by comparison with the target set and achieved for milestones. However, three problems occur. Firstly, each project was quite different; secondly, milestones were stated differently; and thirdly, because of the "nature of research, often things don't go according to plan. But in general people are pretty good in trying to provide the necessary details" (P3U). A further success measure was the subjective assessment done by the scientific adviser. P3 acknowledge that there was always room for improvement but was "pretty satisfied" with the assessment procedures used.

P3 only had one full time employee, a Secretary/Manager who administered the grants and did all the accounting work (P3U). A scholarship programmes' manager and a scientific advisor work part-time and support the four trustees who met monthly. Some control was possible by withholding quarterly payment "until the trustees are satisfied they [the researchers] are doing their job properly" (P3U).

Providers normally published project management information in various types by progress and achievement reports. However, since 1994, P3 have been establishing a publication series, with assistance from a consultant, to help promote technology transfer.

P3 was satisfied with accountability. Their system of reporting required confirmation by the contracted researcher or certification by the provider (usually senior management) that the project was on track. The quality and extent of

reports to P3 were, however, not prescribed. The scientific advisor who assessed the reports sometimes requested additional information if deemed necessary.

4.2.4 P4

Profile

P4 was a manufacturing company owned by R1, which purchased selected R&D projects with the specific view of transforming new knowledge and technology into saleable product. P4 reflected the R1 strategy of considering itself in the technology transfer business.

Informal discussions on a regular basis were used to prospect for potential R&D projects, which were then selected using financial benefit assessment methods. These could develop into formal contracts, which were formally managed. Time schedules and financial breakdowns were used but no quality measurement was undertaken (this was ultimately derived from sales income).

P4U described the project management style as “interpersonal”. The physical size of the operation, the co-location with R&D personnel from R1, the narrow product line and the co-operative personalities involved, allowed this approach. P4 was funding only one project and screening three others at the time of the interview.

Accountability

P4 was accountable to R1 for translating R&D results into financial gain by selling innovative products. Intangible benefit to P4 had been, for example, establishing a distribution channel between themselves as a provider of products and farmers or veterinary surgeons and farmers. The channel not only routed product to the marketplace but brought back information to “tell us how our products are performing” (P4U). The distribution channel also provided convenient access to the market for testing new products. P4 also identified itself as a conduit to transfer R1’s new ideas to the community, for generic national/taxpayer benefit.

P4 assessed the financial returns through a “bundle of financial measures including Net Present Value (NPV) and Internal Rate of Return (IRR)”. “I’m not particularly interested in payback, I think it is a very bad measure” (P4U). In addition,

“monetary benefits”, which may accrue to R1 but which were difficult “to put an NPV on”, were considered (like the distribution channel example). “That relationship may be of considerable interest [value] to us” (P4U). P4U went on to say:

I am satisfied that in the monetary sense they [the measures] are the ones we should be using. We may well have used the right measures but if we then back a project, which turns out to be a dismal loss-maker, then something is wrong and we would then question if we are using the appropriate measures. Is there something about funding original research and development [that] would require us to use measures [that] aren't usually used in conventional financial analysis? I don't know the answer. I have certainly asked the question of people that are in the funding game. Nobody has got a better answer to what we are doing but there might be one somewhere.

The Chief Executive (P4U) selected and managed projects. This enabled the personal approach and maximum flexibility reliant on a high degree of trust. Schedules and budgets were easy to monitor (P4U) but not the research quality. The quality of research could affect the options for the form of the final commercial product. A thorough understanding of the elements of the new product would enable greater flexibility in production or presentation to the consumer. Good quality was important, however, P4 did not know how it could be measured, monitored or controlled but was realistic enough to expect schedule slippage. P4U reflected:

... having got some information, how one measures the worth of that information as against the original targets is very difficult for the monetary provider. One ultimately has the recourse back to the research people and you will say “You told me these 5 things, [but] how important are they in terms of the overall objective we are heading for? Do you mean we are now 10% of the way?”

Researchers also had to realise that they did not have to go to any particular purchaser to support a given project if they thought they could get a better deal elsewhere (paraphrased from P4U). A continual evolution of learning and performance was sought (P4U). P4 used past project management information for the improved management of future projects. The information collected needed to indicate areas where past mistakes were made:

Now the essence of project management as I see it is to track through not only while your doing the project but afterwards in reviewing what happened to find out how you could have done better.

Accountability was considered a mutual obligation between provider and a purchaser. P4 was reasonably satisfied with its ability to report how well their R&D investment had translated to income. However, P4U acknowledged that accountability was “difficult [for providers]... because they are dealing in the unknown”. Like venture capitalists, P4 “backs people, and what is thought their ability to deliver, as much as the quality of the science”. Like P2, P4 was dissatisfied to the extent that it was “not sure how we define and quantify the quality that we are looking for”.

4.3 R&D Providers

4.3.1 R1

Profile

R1 was a Crown Research Institute (CRI) with 1040 staff developing, accessing and managing intellectual property and undertaking technology development and transfer activities in the food, fibre, biotechnology and other industries based on pastoral agriculture (R1 Annual Report, 1994).

Strategic management tools such as “key results areas” were used alongside milestones, job costing and “project management”. R1U used payback as well as NPV (in contrast to P4U in the same organisation) for project selection.

R1 described its structure as a “Divisionally aligned around industry sectors and outputs” (R1U). Within the structures were Joint Research Centres for science collaboration with universities and Technology Development Units (TDUs) for exploiting technology arising from science. Research programmes for P1 appeared to be the practical unit of operation with programme leaders taking on the responsibility, more or less successfully, of resource allocation between objectives. The style of project management was “insular” and “individualistic”.

The prevailing impression gained during interviews was that corporate organisation and management appeared remote from operational R&D project management, apart from necessary financial linkages.

Accountability

R1 was accountable to the public of New Zealand through shareholding government ministers for delivering R&D. R1 sought a profit of between 4% and 10% return on assets (ROA). The management systems to achieve this were still being developed but were “basically done through job costing and project management” (R1U).

Lower management considered tangible benefit from R&D as the achievement of a saleable product. However, scientists also regarded publications as a tangible end-point. R1L commented:

Now that’s very well but it can be destructive in some ways...they publish things, which are intellectually useful. By disclosing it you have lost your novelty and you can’t gain intellectual profit in that area. So there is a fine line between the two. I perceive that what should come out is research which comes up with an idea which can go on either to be an P1 funded [research] project or a TBG funded project that result in a saleable product.

The key intangible benefit was “linkage” (R1U):

We want a link with global players...we are in a global market...R1 wants to build a strong branded entity and position in the market as a key player in the biotechnology revolution.

Another significant intangible benefit according to lower management, was the sense of scientist motivation. R1L advised:

...it’s what drives them, not so much necessarily the product, they are after the success of the science and that is where the project manager comes in... to couple that drive to complete the science to the focused goal of the product.

R1 was not satisfied with the current accountability measures. At the lower management level, measures such as whether or not the project “stayed within budget”, were considered crucial. Other important measures were “whether the

objectives was achieved and whether the project meets its ultimate objective by [generating] a product, a patent or piece of intellectual property” (R1L).

P1 programmes at R1 were monitored and controlled using the reporting system that P1 had set up. A separate internal R1 management system was used to prepare bids for P1. R1U explained (paraphrased):

We are writing business plans around major investments. The board has to determine if investment in intellectual property is going to be made when they review business plans. Those business plans do have project management components in them including milestones, which are monitored on a regular basis.

Project accountability was shaped more by individual managers’ response to contractual obligations than directed by corporate intent. For example, unlike many of his colleagues, R1L used resource allocation and scheduling on a regular basis alongside milestones and objective setting although only “sometimes” used critical path analysis. Project review meetings allowed everyone to contribute to project decisions.

Job costing, project management and science investment were intended to be linked and transparent at R1. Scientists and science managers monitored project progress through a corporate “reporting mechanism” to the General Manager through TDUs. However, project management did not have any particular format. Reporting was monthly and quarterly with finances and intellectual property investment progress being tracked separately. (The system had been installed for only four months at the time of the interview).

Lower management in R1 monitor by “setting objectives, milestones with time schedules and having regular meetings whereby people report on their progress with respect to those documents” (R1L). He advised:

I also use a critical path analysis sometimes for a project. Or, I might add, a rather watered down critical path... it doesn’t necessarily have lag times and things like that. It is enough to see the relationship between various milestones...But on [an organisational] level I don’t think that’s done anywhere near enough. I am doing some work with a P1 bid at [], we’ve gone

through the bid, objective by objective and put in place milestones, key tasks and a number of people down there say “this is good”. When they all sit down with the other guys who are working on milestones in their objective... they realise how they could help one another... they didn’t know until they sat down to discuss it. So I think communication is really the only essential thing. You get people saying... not another meeting!... well that’s because they always have pretty useless meetings.

“Consultation with the people involved” (R1L) was the chosen control technique:

Most people are sharp enough to see the consequences of a continued line of action and appreciate being asked how they would find a way around a problem. Causes of problems come out quite quickly in an open forum... so I use a sort of group therapy to come to a conclusion. If that fails and I can see what is happening I will use my position of power to direct people what to do.

A failing perceived by R1L was if a scientist saw something of interest and diverted “60% of their effort away from the objective”. In this situation, the new work was kept “on hold” and perhaps developed as another project. R1L explained:

The idea of research [is] that you complete one set of objectives and on the way hopefully you have made a couple of other breakthroughs that if they are important enough may actually supersede the work you are already on. Unless you change the resource level they can’t run [extra objectives] in parallel... all you end up with are a plethora of unfinished projects of varying degrees of importance. Every one [objective] is important to the person working on it but probably not particularly important to the organisation.

And further, in another vivid description:

I think probably the problem with R1 is that they don’t even know when there is something wrong until it’s too late and then all hell breaks loose and everyone sticks their finger in the pie, everybody has their six pennies worth and there is a mad flap! Things are either smoothed over by constructive reporting or people are just given a ticking off. All that does is to get their back up and are even more “anti” next time they are on a project. So it’s a fairly destructive cycle (R1L).

R1 upper management saw project management as a strategic tool to help manage key result areas. Investment strategies were formulated by identifying key result areas. For properly management each result area needed to collect and analyse information on particular topics. Examples of important topics given by R1U were financial information, client information, intellectual property status and the status

of the underpinning science and technology development. R1U considered projects should be tracked using job-costing systems within the business financial system.

Lower management at R1 used project status information provided by or extracted from key project personnel to compare progress with baseline or proposal data. To promote communication, the status report was circulated to those involved in the project. Lower management at R1 used project management information for project reviews at completion. The potential for helping identify reasons for success or failure was, however, recognised.

R1L thought that project management techniques could provide a direct positive benefit if they brought in projects on schedule. Appropriate monitoring and control provided for early warning so that corrective action could be taken where projects were not going to plan. Advising a client about problems or delays at the due date did not give good returns.

Project management information also identified successful achievement of milestones so it could be celebrated to motivate staff. "People enjoy working in a project team that is successful or even in a team that is a good one, even if it doesn't always succeed" (R1L).

R1 was not satisfied with the accountability it provided to purchasers except to P1 (R1U). Even with P1 projects R1 "thinks that it could do much better" (R1L), specifically in improved communications by running effective meetings. R1 wanted greater accountability from its project teams (R1U). Project teams needed to have a "better understanding of the market and [give] more attention to managing clients effectively".

4.3.2 R2

Profile

R2 was a CRI employing 416 staff, 30% with PhDs, working in major laboratories at Wellington, Auckland and Christchurch. In mid-1995 R2 restructured to create four divisions (Manufacturing, Energy, Natural Products Processing and Pioneer) (R2 Annual Report, 1995).

Institutional unity was conveyed through the statement of corporate intent. Key performance indicators covered science, technology transfer, human resources and financial information. Corporate systems existed for project financial dealings and R2M at least aims to “maximise project NPV”. Internal resource management systems are in place. Quality was being addressed for general process procedures (although not for “quality of research”) through ongoing ISO 9000 accreditation.

A new corporate project management system, which focused on establishing good communications and confirming initial project specifications with the client, was being tried for general introduction in April 1996. The organisation project management style was “progressive” and “corporately acknowledged”.

Accountability

R2, like R1, was accountable to the public of New Zealand through shareholding government ministers. R2 upper management did not consider that they invested in R&D. Rather, “somebody else does; we are just carrying it out” (R2U). R2 considered that the organisation needed to provide a financial return to their shareholders and a social return to the government by:

providing a means by which certain capabilities, seen as important to the country, are maintained and that technological opportunities are created for New Zealand industry. There is a staff benefit in the sense that we provide a means by which individuals can develop their careers in an area where career opportunities are relatively limited.

Middle management identified “purely financial criteria...increased NPV” (R2M) as the tangible benefit of investment in R&D. However, middle managers thought that lower managers may not agree with this philosophy. “Many would still question the appropriateness of making a profit on P1 work (projects)” (R2M). R2 accrues incidental intangible benefit from “contributing to New Zealand industry” and “gaining a profile”. Lower management in R2 clearly identified new products as the most obvious tangible benefits. R2L explained:

the stuff that I’m doing in the main programme is far more academic, publishable conference presentations, which will contribute to world science and may contribute indirectly back into this more applied work...but the benefits are a lot less visible.

R2 sets itself corporate targets for the various benefits it thinks it will provide. These performance indicators were negotiated each year with the shareholders, and sometimes Treasury, and were published in the annual report. Performance measurement included:

- for science targets: “Complete 90% of contract research investigations on time”
- for technology transfer targets: “have at least five TBG contracts with New Zealand companies accepted in a given year”
- for human resources targets: “the dollar amount per full time equivalent spent on professional development and training” and
- for financial performance and position indicators: “net profit and current ratio”.

R2U was concerned about these targets and notes:

there is some debate at present about what are adequate (appropriate) non-financial performance indicators. The measures need to reflect the way we contribute to NZ Inc. and to social and environmental issues that are important to the country as a whole. They are very difficult to deal with but one of those things that you have to do in today's environment.

R2U thought that measures R2 used were:

really written for the benefit of reporting to shareholders and the country as a whole. We would actually like to refine some of them... to become drivers to move the organisation to the type of company we need to be in the future, to be strong and making a difference.

R2 was satisfied with present systems but recognised the need for improvement.

Middle management at R2 recognise the theoretical need to use project plans to track and monitor progress, which allowed “re-examination, reorientation or abandonment of projects” (R2M). The work ethic and business orientation “varies greatly from team to team... and between sites”. R2M advised that while teams or business areas were run “fairly professionally” they are “a little short of knowledge

and tools... some are doing a good job intuitively, others are really just lucky or unlucky”.

Lower management at R2 aim to achieve personal satisfaction levels while meeting formal expectations. R2L liked to aim for a high quality journal for publication even though only the fact of publication was counted. A useful assessment of quality was “how much closer this [product] is to getting on the market as a result of this year’s effort” (R2L). The measures used often rely on subjective judgement.

R2 formally structured its organisation through project (objective) team managers to programme managers who reported to divisional managers. “Our management systems largely concentrate on financial management systems” (R2U). Quality management systems were expected to become as pervasive as financial systems.

The development of strategic plans was difficult for some divisions. There were no problems for disciplines related to strong industries like telecommunications and transport but most, like the “cutting” division, were diverse, making project and programme portfolio management in a business context difficult. It was difficult to “know” the market and “know” the existing and internationally developing technologies. On project management R2M stated:

I am getting more and more insistent on project plans and reporting mechanisms. Most of the data available goes into our financial accounting system. We need something to come out of that or be siphoned off on the way through. We need a simple project planning system and for people to change their culture so that they don’t behave in a complex or a non-project-oriented manner. We are not trying to get a complex system with software to compensate for behaviour.

Different types of software were used for planning big projects at R2. The project manager planned smaller projects. R2 did not have formal project monitoring. Monitoring and control was done to the requirements of the most demanding customer. Quarterly reports to the general manager were essential to satisfy P1 and for long term projects. R2U reflected:

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One of the areas of improvement that we think that we as an organisation can make, in fact, is to have better project management. It's an aspect that is actually missing from our quality management procedures at present.

R2U advised that some clients wanted a higher quality of plan presentation incorporating "milestones, level of effort and expected overall outcomes". R2L used Microsoft Project for projects over about \$50,000 but "quite often" he used hand-drawn Gantt charts.

A new project management system, to provide a minimum standard, was expected to be in place in April 1996. It is "very simple" and most of it "is related to in fact the quality of communication that you have up-front with the client in setting or understanding their expectations". R2U explained:

We will have happier customers and will be able to manage our resources better and so do more work and be more productive. If the people are like me they like working in a slightly structured environment so all of that helps as well. We don't have a lot of projects that require sophisticated project management procedures and so the intent is not to have or to use high power project management software unless the area of activity actually warrants it.

And most importantly the systems will interface with our financial information system so that information is available to job managers at the lowest level, all the time, whenever. The financial packages that CRIs generally bought into did not deal with project management issues particularly well at all. I think we have probably got ours [financial system] working best...it is important that the jobs drive the systems rather than the systems drive the jobs.

Project control was done at various levels in the organisation. At the senior level, programme managers were required to supply progress or monitoring reports. The information was used to re-set priorities, re-agree budgets and re-look at resource availability. Because responsibility was highly devolved, progressing and financial control was "pushed right down as far as we can in the organisation" (R2U).

R2 middle management considered that monitoring technical progress varied considerably within R2 and that this could "only ever be by discussion or reporting on the verification of work [through peer review]" (R2M). Reporting variation against project plan was desired and expected but clearly not yet achieved. R2M believed a one-year project would ideally have 15 to 25 tasks with one or two

tasks achievable each month. R2M said it was very difficult for business area or project managers to communicate what they were doing and where they are going “which is kind of interesting”.

Project managers provided control at middle management in R2 by reporting on the situation and recommending options for any necessary corrective actions. After a written briefing a “round the table/whiteboard” interactive session was held. This created a problem of lack of communication if a project was in control and no variation report was raised. R2 considered it was important that researchers remained in control of their projects. Discovery was an important part of the research process but budgets were not unlimited and the risks are not zero. R2M concluded:

To handle a portfolio of projects successfully you need to be in a position to make a rational decision to terminate something or change its direction. However, I would expect people to indulge (spend some time) in doing “black projects”. I mean... not particularly hidden from me but just things that aren't formally recognised on the budget. In other words, to be involved in some creativity to get things to a point where we can propose them for NSOF [Non-specified output funding from P1].

From the lower management perspective in R2 the project or programme manager set project plans as objectively as possible each year. These people then had the responsibility of monitoring progress against those plans. Since “things don't always work out the way you want them to” the project manager had to ensure that deadlines were not getting too unattainable. If they were, extra resource had to be brought in. If over-expenditure was likely to occur “you have to stand the loss”. R2L reflected that:

Since people are paid a salary...here in this firm I don't think anyone is averse to working long hours if we are working to a deadline...basically it is charity...you win some and you lose some.

The innovation project process was considered by R2L as:

the best you can get for the sort of work done... because it is just so unpredictable. Things that you assume are trivial are usually the ones that give you the most problems... you say it will only take a week to write that bit of software... six weeks later... whereas something that you have been really

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stressing about just falls into place. Last year we were running about eight projects... on balance they evened out.

Project managers had monthly team meetings to allocate more resources to meet hard deadlines. R2L advised:

I can't honestly think of a better way of controlling the situation in a small team where we have to look out for each other. In bigger teams it is probably different. In the new structure we can swing people in from other parts of the company to get specific expertise to get you out of a real problem.

Upper management at R2 "really only use project management information to look at staff productivity and sector profitability" (R2U). The information obtained provided a snapshot for R2U but:

it would be nicer to have a more dynamic picture of what's going on so that differences, variances, problems areas can be seen not just quickly but also their magnitude or impact assessed.

Information from completed projects, even "one-off jobs", was useful for senior managers although more useful "further down the organisation" (R2U). There was scope to learn how to improve planning and pricing work.

There are areas that tend to underestimate the amount of time... that's a natural tendency people have because they don't want to frighten the client off.

Project management information could be used to generate better client relations by having customers who were more satisfied, or less unhappy, because of increased information flow through situation updates. Customers won't have to "face dilemmas that they are not prepared for" (R2U).

R2 also saw a specific benefit of project management techniques because "we don't have good systems for the utilisation of capital resources" (R2U). Middle management at R2 was also sensitive to the need to have project management information and was in the process of getting "finance and admin people... to get some new project reports established" (R2M). The review of projects was "something I've always felt as very important" (R2M). Staff at R2 could use past

experience to understand and improve how they could manage risk and deal with uncertainty. R2M lamented:

Some practising researchers have a poor feel about what they can achieve in a year... some researchers forget what targets they set themselves by the time they get to the end of the year. They [researchers] are optimists but also kind of flexible in their thinking about the future, including the future they predicted a year away 12 months ago! [paraphrased]. This makes some things extremely difficult. We promise more than we can deliver. We inevitably put a lot of pressure on profitability.

Improved project management was expected to provide better control over “the losers”, overruns and generate a more business-like culture. R2M considered:

people [researchers] will also find it easier to fulfil their obligations to a variety of projects (when they are listed as a resource on a number of different projects), which should result in greater work satisfaction as well. And perhaps they will gain the ability to cope with a slightly greater degree of variety than at present.

R2 lower management noted that project information in the newly implemented quality system procedures was actually scheduled for review each year:

We can expect to learn about fundamental mistakes like when we are bidding for P1 funding we always tend to underestimate, at least by half, the time that it is actually going to take.

Lower management thought that project management could best be used to increase returns to the organisation by optimising human resources allocated to projects.

R2 were prepared to offer clients whatever accountability they wanted (R2U):

The fact of the matter is that many of our customers do not require particularly sophisticated monitoring and reporting, which of course, is not a good thing either from their point of view or ours.

R2 upper management was satisfied that the internal level of accountability automatically provided is higher than that required by clients. However, reciprocal accountability of management and support services back to teams was also considered essential. Smaller jobs were substantially dealt with at the project

manager level only. Larger projects demanded greater attention from upper management and therefore needed effective systems to generate information for accountability upwards in the organisation. In contrast to their senior managers, R2 middle management (R2M) were not very satisfied with the accountability provided to clients:

The whole spectrum [of accountability] is there, but the lower 10% need dragging up a long way. R2 needs more accountability from its project teams for revenue, expenditure and technical progress...not so much for allocation of human resources...we've got to expect a bit more flexibility [there].

Lower management (R2L) was satisfied:

I'm prepared for an audit at any time. This is a personal thing. If I say I am going to do something I tend to do it.

The perception was that R2 was satisfied that project accountability was adequate.

However, R2L thought its satisfaction may have been mistaken:

If the dollars and hours add up for the [our] outfit they are happy. If the dollars and hours don't add up then they are not happy. I don't think they are actually accountable...I said I would publish two papers, as to the quality of those two papers? As long as I do it within the dollars that were stated in the bid. I mean it might sound...I might be completely wrong but it is just what it seems like from the bottom of the organisation.

4.3.3 R3

Profile

R3 was an incorporated society under the Incorporated Societies Act with no formal financial obligations to members. Board members were drawn from representatives of producers, processors, research and business communities for a primary product. R3 had 120 staff and effectively acted as a research association (RA) for the industry. It has maintained a relatively stable relationship with its clients since being established some 40 years ago.

Government contestable R&D funding in 1990 saw R3 introduce comprehensive financial systems directly relating to specific jobs or projects. The techniques used for managing projects, however, have been left entirely to project managers on the basis that they are the people in the best position to assess requirements to meet the needs of both R3 and the client. Regular informal discussion of projects

focussing on the financial data was used to assess progress and forecast deviation from agreed milestones. The project management style here was “minimalist” and “delegated to individual research groups”.

R3U used benefit/cost analysis to promote projects to potential purchasers. Project tracking was done on a financial and percentage completion basis as estimated by a business manager. R3U regarded the process as working well. R3M, however, challenged the ability of business managers to assess percentage completion on the more innovative projects with hidden snags or unexpected breakthroughs. He gave an example where an estimate of “20% [progress] may mean that you’re really only 5% through the job or it may mean you’re actually within 5% of completing the job”. Successfully achieving individual milestones was also recorded and used as a measure of overall project success.

R3L used Microsoft Project to plan milestone achievement for each significant project but never had the time to update the plan. Rather he used face to face discussion to collect updates and used spreadsheets “a lot” to do business analysis.

Accountability

R3 was in practice accountable to its voting members, its primary producer board and its industry association (processors) and 2 individuals appointed by the Royal Society of New Zealand. R3 believed the returns to its industry from its investment in R&D was substantial. R3U’s conservative estimate was that a ten-fold gain has been made from the investment in technological R&D at R3 during the 40 years of its existence.

An intangible benefit was the reputation built up through doing good science and being internationally recognised for it. The flow-on effect was the perception that “if they’ve got good science in New Zealand they must be producing good product” (R3U).

A middle manager viewpoint (R3M) was that a benefit expected from doing good R&D was seen as:

[a positive] response from people...either the purchaser will give you more contracts or those who are targeted (e.g. specific companies in the industry) may request you to assist them in their operation.

Intangible benefits come from:

the boost to staff of successfully completing a project and especially if it [the result] provides an unexpected benefit. The boost to staff can be pretty dramatic...they are more committed, they are more innovative and staff thought patterns more expansive.

Lower management in R3 identified the ability to offer jobs as a benefit, staff also got a great deal of satisfaction from delivering R&D. R3L acknowledged:

We are...a bit purist in that we can say we work on behalf of the [] industry, in spite of the buffetings of the various funders. The satisfaction comes from the actual processors themselves and the reputation and track record that we are growing as individuals and as an organisation. We do feel some appreciation...It feels good to be working on behalf of the industry.

R3 measured tangible benefits on a financial basis both in the sense of immediate return to R3 on doing the project for a purchaser, and in the measurement of longer term benefits for the industry. The former could be done readily through the financial information processed during the course of the R&D and the latter was done in an *ad hoc* fashion as the results of R&D projects diffused into the industry over a number of years. There were no specific measures used for this latter assessment or systems designed to specifically collect appropriate data. The purpose of R3 generating quantitative information about benefits to the industry was to gain recognition for their work, justify their existence to producer board members who apportioned funds for R&D in competition with promotion and in general marketing of products and services. R3 were reasonably satisfied with the methods employed.

The measurement of intangible benefits “makes life hard sometimes...it’s really hard to judge and say that any one project was really worth the investment” (R3M).

Lower management were not happy with the financial measures of benefit at a project level by R3 because they were too “loose” (R3L). R3L explained:

They [projects] are so subject to things like exchange rates when you do an overseas job, they are subject to how honest you have been with filling in your time sheet and the charge out rates you use... you can actually fiddle the system and make it look pretty good.

Each of the disciplines at R3 was effectively a research business with its own manager. Business managers reported to the general manager of either science or engineering, the latter also being the CEO for R3. R3U explained:

The accounting system is fixed and monthly business managers meetings are held...but there is really nothing else... The business manager has control over financial, people and other resources...and so is fairly autonomous.

The project managers, responsible to a business manager, usually had a free hand and control when, for example, negotiating a crisis. The business manager tended to oversee the people resource and the project managers focused on the technical aspects of projects.

Lower management at R3 would have preferred that more senior staff took a technical interest in projects rather than merely a business overview. An R&D co-ordinator would have been helpful to provide better service to clients and at a technical level too. The P2 milestone reporting structure, which required three or four reports per year on each project, had a dominating influence. The Australian equivalent organisation was requiring two reports a year and P1 required annual reporting. The reporting format was not unduly onerous but only applied readily to projects where continuous reportable progress occurs, rather than those that “stutter”.

Because R3’s monitoring system met the expectation of its customers it was satisfied with existing arrangements. It was wary of implementing “fairly significant monitoring systems that only add an accountability tick to the person doing the job” (R3U). Project control was exercised to a certain extent through monitoring finances. If the project had spent 75% of funds and was only half-finished, the project, business and general managers tried to resolve the situation. R3U queried:

I don’t know how one would control an evolutionary or developmental process because the end-point is the end-point. It’s going to take you more or

less time than you expected. I don't know how you can control it to get...on budget, all of the time (at the project level)...you can't completely control it.

Middle management in R3 suggested the way to monitor by:

having a fair idea of where you want to get to and where you are now...and a gut feel for how long it takes for the various stages of work (required). You can use a linear method to assess (actual against expected) progress...but you might suddenly make a breakthrough. It really comes down to how realistic they are in their thinking, how logically they think and the type of people in the workforce.

Control needs an understanding, 'a handle', on where the problem is and then get to the bottom of it. You get handles by talking to the project manager's team...asking them where the problem is and what changes are needed.

Lower management at R3 compared actual and planned progress on milestone achievement and kept all projects rolling in parallel to avoid "rushes", as key milestones became imminent. Talking to project leaders on a monthly or "as needed" basis provided the control feedback loop. If the quality of the output was not quite what was expected, a sense of disappointed was conveyed, but that was the practical extent of control. A group member from outside the project team appointed as an advisor or consultant was a ploy sometimes used to get some fresh ideas. Discussing every project in depth at monthly meetings was not time effective. R3L concluded:

By better monitoring I could have better controls. In this kind of business the manager interfering on a day to day, or week to week, basis would stifle innovation and make the researchers frustrated.

The ability to interface financial and project management information through software was considered desirable and had the potential to give more power to monitor and control projects. The "pay-backs" were envisaged to be "quite significant" and relieve pressure and stress. The practical problem was seen to be the risk of upsetting existing financial software and the cost of implementation. R3L concluded, "I'm not happy with the way we've been monitoring progress".

R3 upper management was concerned with generic issues such as determining project status at the end of a financial year. The assessment and interpretation of percentage completion of individual projects at "year end" became vitally

important since it affects reported financial balance (R3U). The sooner the status could be predicted the greater the ability to control expenditure in a corporate sense. The investment, or otherwise, in capital equipment or in acquiring new technology or human resource could be decided in a timely fashion if “year end” status was reliably predictable. The value of project management information was in providing “weather forecasts” to improve investment decision making. Early and reliable prediction of project performance gave management time to explore future opportunities to exploit the new status of knowledge or technology.

R3 middle managers used project management information for feedback across organisational levels and to customers. A systematic approach “makes sure it happens” (R3M). Better usage could be made of project management techniques at R3 if it were able to optimise the contribution or utilisation of resources and help smooth workload.

Managers tended to spend their time doing what they most enjoy, what they had an interest in, so there was inconsistency in the contribution individual managers make to specific projects. A system to ensure a consistent oversight involvement “would have a lot of benefits” (R3L). R3L concluded:

But I think there would have to be a lot of changes in management structure to allow that to happen. It would need an acceptance of a different way to balance the overheads and improved administrative support.

R3 believed it gave purchasers of research very good feedback on “what exactly is happening in the project” (R3U). The system “actually works pretty well for us at the moment” (R3L). R3 were therefore satisfied that they adequately met the basic requirements for money and time expenditure accounting for internal requirements from which input costs could be reported to meet the specific requirements of individual customers. The level of reporting and the time and effort expended for a customer was “certainly” related to the amount charged. In terms of quality, “I guess all we can promise is to provide to the best of our ability” (R3M). The overall result was that R3 satisfaction with accountability was “quite variable” (R3M), dependent upon client expectation and the level of service bought.

Accountability for the “intellectual side” was recognised as subjective and rested with the business manager (R3U). Upper management believed it appropriate to put their “trust” in business managers (middle and lower management) to provide adequate accountability. A system to measure or quantify the level of intellectual completion of a project was unknown and had not been investigated. It was stated that the overall level of accountability demanded of the business managers looking after a program of projects made them “over accountable”. R3 would like to give managers a “corridor” in which to progress work, rather than have them continually operate in a “straight jacket” (R3U).

4.4 Companies

4.4.1 General

People designated M and L across the company sample had a very wide scope and range of responsibility. The electronics companies’ manager levels and responsibilities toward innovation projects were comparable. For food companies F1 management was related to product and process development projects whereas F2 focused more on engineering installation. There was an R&D emphasis for T1 and a general business emphasis for T2.

Both electronics manufacturing companies were small private companies with high export sales. Both used a deliberate if not formal innovation or new product development process for managing projects. No formal portfolio system was evident.

The two food companies were large and strongly driven by the needs of overseas customers (one through their parent company). One was a co-operative and heavily involved with joint industry funded R&D that had generated revolutionary product and process innovation. The other company imported and acquired new technology and emphasised financial benefits for selecting and controlling projects.

Each of the forestry companies was large and exported low value added (bulk) product to their major clients. Their innovation emphasis was currently on efficient

primary production and processing. The forestry companies also tended to look overseas because many of the problems in the comparatively immature New Zealand industry had already been investigated. These investigations lead to capital works projects to import “new to country” innovation.

The companies investigated tended to spend a consistent amount on R&D. Electronics companies spend a relatively high percentage of their sales income (4-6%) compared to food and forestry companies (1-3%). This could increase when specific projects were undertaken as a result of opportunities or parent company requests; decreases occurred when profitability had been adversely affected.

Both forestry companies had a weaker industry inter-relationship than F1. Like F2, they drew on extensive international R&D expertise through contracts and business connections. T1 and T2 had more external contributions to technological innovation than E1 and E2 but not as much as F1 and F2.

Initiation of significant technological innovation was through the R&D function, accountable via the CEO to the board for all companies. Minor production improvements and implementing larger innovations were said to occur through operational functions. Quality maintenance throughout this process was done through the direct accountability of people in the smaller companies (E1 and E2) and through systems or specialist functions for the larger food companies (F1 and F2). T1 and T2 were in an industry where quality issues themselves are still the focus of innovation projects and there were no clear patterns for innovation quality accountability.

Companies used financial measures (primarily NPV) to compare project benefit. However, the reasons for doing innovation projects were not solely for direct and immediate financial gain. Market leadership and positioning were also strong drivers. Financial measures dominated the selection methods (NPV – 4; ROI – 2; and VA – 2). Methods used to adjust resource allocation, or to hold or kill projects were not specified. However, stage-gate based methods were used by one company in each industry (E2, F1 and T2). All firms used formal project reporting and reviewing procedures.

Monitoring innovation projects against parameters fixed at the start of the project was used but was not considered to be particularly useful. All providers and companies used Microsoft Project software but almost exclusively for overall planning in the R&D department or for detailed planning and provisional scheduling on small evolutionary projects. In practice project control was done by personal communication according to the style of the project manager. Project information was mainly used to prompt project managers to identify sub-optimal performance and bring about re-alignment.

All companies accepted the costs associated with project selection, planning and scheduling where there was an impact on cash flow or resource allocation. Costs associated with monitoring and control were minimised either by relying on individual accountability or by creating systems with routine progress reviews. Post-project reviews were considered potentially useful but generally wasteful of resources. These were not done in four companies and not done willingly in the other two.

The electronic companies had little time for formal resource accountability systems. Resource allocation problems were solved on the job or at project meetings. Accountability for delivering projects to the organisation rests with lower and middle managers but delivering benefits from innovation projects to the company formally rests with senior managers and executives, who acted through review meetings. Lower level managers considered they were “well in touch with the market” and therefore contributed significantly to making products acceptable to the market.

The food companies have large operation systems. One system was highly sophisticated and integrated into industry R&D effort but suffers from poor quality information input. Both food companies are organisationally remote from their large overseas customers and rely on marketing information from other parts of the organisation. The systems appeared to be adequate for short term developments but do not adequately address strategic requirements in a transparent way. Lower

level managers wanted to be accountable and were expected to be accountable by their seniors but could only contribute to project success in a tactical sense.

Forestry companies have less mature management and innovation support systems. They were more interested in “doing the right things rather than doing things right”. T2 and T1 sensed the need to be effective rather than to be efficient.

Innovation projects were selected when there was a strong market pull (especially by a known existing client), when market leadership was important and when there was good prospect for early profitability. Project teams were selected on technical expertise but involvement from the marketing was variable especially once the project had been initially defined and until there was something tangible for the sales force to see. Too many projects were attempted for the resources available so staff were over-committed and delivery was often late. Smaller companies were particularly reluctant to rely on external R&D providers to supplement their own efforts unless they could be supplied with a packaged and reliable solution. Larger companies, however, were prepared to go off-shore to known experts.

All companies appointed managers for innovation projects. The structures and systems used to support the manager depended upon needs and desires of project sponsors. Project size, complexity, pace, uncertainty, risk, geographical distribution and affiliation of contributors, location of key expertise, laboratories and production facilities, and finally the flexibility and nature of the scope also influenced management structures.

The formality of contractual arrangements appeared to depend on project monetary size and the importance of the intellectual property likely to accrue. Projects with high levels of uncertainty and risk tend to be managed on behalf of companies by industry associations, whom seek to maintain neutrality by using industry research associations. These projects, and those with less risk, could alternatively be undertaken within the company to more closely direct the research and allow staff to gain knowledge by personal involvement.

All companies desired “more appropriate” rather than “more” accountability. The smaller electronics companies wanted to find simple useful measures for each project that maintain the empowerment of lower level managers but allow senior managers to make informed decisions. Food companies had to effectively operate portfolios of projects across the traditional dimensions of technologies, products and markets as well as the industry or parent company (in the wider context) and the local production site. Forestry companies had less developed innovation routes and a diversity of projects and contributors. This complexity created difficulty when trying to optimise innovation opportunities.

4.4.2 E1

Profile

E1 made electric fences and security systems and had strong but indirect relationships with agricultural research and university R&D centres. The company was a pioneer in electric fencing and has in the past also made mechanical farm equipment. The company retains strong family leadership and had an extensive overseas dealership network.

E1 had 18 FTE R&D staff working on two or three major projects (typically 12 to 18 months long) and an unspecified number of three- to four-month projects. Of the \$2 million innovation project budget, 80% was spent on new products and 20% on “maintenance” [product upgrades].

E1 used EVA and ROI as important financial measures to select and monitor projects. Microsoft Project was used for planning and preliminary scheduling but not for allocating resources or financial tracking. Of the companies interviewed E1 were the most flexible in their expectations of project outcomes and handled expectation change within its formal processes.

Although it maintained a watching brief on CRI and university research activity and occasionally employed students E1 did not have ongoing formal contractual relationships. The small R&D contracts it let to other R&D providers were usually well defined with low risk.

E1M explained the company R&D philosophy as, “everything is driven by the dollar” although it could be either “economically justified or strategically justified”. “Meeting the requirements for market leadership in innovation” and having “the most powerful [products] on the market” are valid justifications for doing projects.

E1L explained:

They [senior management] have a sort of road map... a rough strategic plan. I wouldn't say it's a really good one but it is there. What we plan now, a month down the track... will probably change.

E1L defined ROI as the key tangible benefit. As an R&D laboratory manager he also saw retaining good staff an important intangible benefit. Good staff stayed only if they have a creative challenge (problems arise if they “get assigned to product upgrade projects too much”).

One department did all technological innovation. A project plan (which was “a script, budget, schedule and resources [requirement] list”) was prepared for each project (E1M). They had a project leader for day to day co-ordination and have “buckets to collect all the costs in” (E1M). E1L confides:

You guess how long things [will] take at the beginning. I mean, it's pretty difficult to actually stick to those... and things tend to take longer for whatever reason... The worst thing I find, a lot of people I see using [Microsoft Project] go into too much detail up front and you've got to be updating all the time... it's the same mistake everyone falls into.

Accountability

Each project reported monthly and checked “in terms of performance to schedule and to budget. If it's on time you know it will be roughly on budget” (E1L). Any new market or technology was reported to the department head immediately it was discovered. E1L grouped project staff of different disciplines. “It creates a bit of chaos... but its about [improving] communications”.

E1M was convinced that “over-control” stifled creativity and innovation. He said if speed was important “you can't put too many controls on”, which slows the organisation. E1M considered it most important to preserve the schedule and was

happy to ask his staff, “Should we modify our specifications to enable us to keep to our schedule?” E1L thought that real control resided with the project team. They had been empowered by management to get the job done and no project had “got the chop” after a complete script had been approved. E1L thought thorough groundwork was important:

I think we are a little bit lean and we are in danger of missing important bits of product development and of course if you don't do them they come back and bite you.

E1M was concerned when projects were too long:

My attitude is that if a project takes longer than 12 months it's too big... The projects that have been dogs round here are ones that have been two, three or four years duration. If it takes longer than 12 months you can't see the end of it when you start.

E1M used project management information to look for the “out of the ordinary” (for monitoring and control) then filed it. During the interview he considered the use of project information for learning from post-mortem reviews (for “those things that go wrong”) but he was not enthusiastic to implement such a scheme. He recalled a previous employer (merchant bankers) who did not care what their engineers learnt “as long as we made a return on investment in the short term”. E1 was prepared to get return in the short to medium term. Overall project management should provide “faster ways of doing things”. Technology (for project management) should be packaged so E1 could pick it up and use it rather than invest in further development. “We don't need to design it, we just need to know how to use it”.

E1L confirmed that this company had no formal system that used information for other than immediate action. He chronicled key events on one successful project over about 18 months. The most important reason for success was attributed to adhering to a “zero defect” design philosophy rather than following any particular project management methodology. E1L thought that the best way to learn to improve future products was to analyse product failures rather than analyse process (project management) failures. However, a comprehensive innovation

process could ensure failure was reduced. “The project team get 99.9% of it right and it’s that 0.1% which is overlooked, missed or not seen that causes problems”. E1 now used in-process peer review, which was “probably quite hard for engineers”.

E1L recounted his sadness at the losing an innovative engineer, who had just moved on:

[He was] pushing the limits... to put a product together very quickly... he was really not satisfied with what we were doing... he’s got ideas at the next level beyond... which we have now unfortunately lost. He has a passion for what he does... doing things that the tool designers said would never work. You have to think about the process as much as the product itself.

E1M reflected:

In terms of tracking [projects]... [our system] would probably fall apart to some degree. If you’re making money and are successful you put less controls on simply because you say, “we must be doing something right so lets get on with life”. You just go for it and sell as many as you can. I would say these measures are adequate... but there’s always room for improvement. We really very seldom have arguments about dollars... the arguments and concerns are always to do with “have you done it on time?”

E1L confirmed:

Ultimately the product manager is sort of accountable... because we’re having weekly meetings our time frames do change. Things are changing all the time and specifications of the product changes... The project team tends to run the whole thing... once it’s started it (the project) won’t stop. I think it’s a reasonably good system. It’s really empowered the project team to make it happen.

However, some projects have been done where, “really the volumes that were sold were nothing like what was quoted at the beginning.” E1L reflected that E1 did not “really do a great deal” in accounting for risk. There was presently no formal method of “calculating or communicating the level of confidence in the project plan”. The method currently used by E1 established reasonable expectations for duration then made updates and communicated progress through regular (normally weekly) meetings. E1L thought the company did want more accountability,

particularly in scheduling; meeting deadlines was very important for the company's calendar of distributor conferences.

4.4.3 E2

Profile

E2 was a family firm that grew from the successful development and export of novel measuring equipment for the agricultural sector. E2 was located in a large industrial centre and had core skills in electronics manufacturing and in batch assembly of instruments incorporating metal and plastic components.

E2 spent about 4% of sales revenue on “four or five “R&D” projects” and 2% on “product support” projects (about \$1 million total). E2 had about 10 FTE staff doing R&D. The company used NPAT to select and financially monitor projects and the stage-gate approach to monitor overall project progress. E2 drew innovation contribution from a small number of CRIs and universities using *ad hoc* contracts.

E2M measured tangible benefit directly in terms of return on shareholders funds and related intangible benefit directly to “the drive for market leadership”, which was stressed in the strategic plan. The aim was therefore to “strike an even balance between those [products] that give a return and those that make a statement”. However, E2M said, “We do not believe in individual project life” and advocated the importance of the overall return on the entire R&D portfolio. E2M acknowledged that the company's current financial controller did not share that view, however, as the cost of detailed individual project accountability was prohibitive. “It's questionable what the extra information and detail would really add in terms of the decision making process” (E2M).

Accountability

E2 advised it had three parts to an overall product innovation group; an R&D team, a product development team and a project management team (with a lot of overlap between personnel). “Every idea in my view comes from a different starting point and you can't actually write down exactly how things start” (E2M).

The product development plan had to be signed-off by the Managing Director before a “project” was created at E2 and :

sometimes we do things because the managing director says we we’re going to do them... we have that freedom... we have to have that flexibility.

E2M did not consider project review valuable:

We have a final project review and it’s often left and left and then you think “Oh help, we’d better do it”. You potentially end up trying to identify responsibility and apportion blame.

E2M also monitored monthly expenditure in terms of percentage of R&D spent on each project, filed it and did not use the information for project control. “It’s not a valuable thing to be spending time on”. Review was, however, done to identify strengths and weaknesses of individuals in a confidential way. Individuals were also responsible directly for quality management (E2L).

Project meetings were held weekly and reporting and reviewing done monthly. The monthly review could change the “whole project’s thrust” (E2M). Issues that required changes “within the plan” are done by talking directly with those affected rather than by calling a meeting:

[Our] product development plan isn’t what you think it is. It only really states what the goal is, what the target completion date is and who is involved and what their responsibility is.

E2M considered the company would do better “if we got a little bit more formal in our processes right at the front end. [We] just don’t spend the effort in the feasibility planning”. E2M was seen as a gatekeeper who had to be satisfied that “things stack up” before signing-off the expenditure. “Everyone’s got to buy in to the thing and that can be difficult depending on where the push is coming from.” E2L agreed and said E2 had considered a formally established executive review team of three or four people but there were two major disadvantages. Firstly projects evolved in unpredictable ways (sequences) making routine decision-making processes difficult to accommodate and secondly the managing director might decide to handle a situation in a particular way without reference to some

team members. “We are scared of setting up a group which is not really appropriate”. E2 also did not want to create a generic product development manager since, like the quality function, they believed the responsibility should rest across all staff involved.

E2 tried not to “embed things too much in formalised techniques or structures”, but had a “market requirements spreadsheet”, a “product requirements specification” and a project schedule that the project leader updated between weekly and monthly (depending on the stage of the project). “We don’t have a formal expenditure tracking system” (E2M). E2 recorded “product failure rate” when innovation outcome was a product and “judgement” to assess R&D project performance. E2 would like to find and use some kind of tracking tool.

Accountability measures were not formalised, “Personal accountability is a very strong part of the culture here” (E2L) and “there is constant pressure for productivity...[meeting] deadlines...[but willingness] to negotiate changes”.

4.4.4 F1

Profile

F1 is a co-operative owned by producers of the raw in-feed material. It has the dual role of satisfying a requirement to process all raw product made available and meet needs of the end users (as relayed by the industry marketing-arm). Further complications are the seasonal availability of the non-durable raw product and the weather-related fluctuation in volume. Since the marketing function is centralised and geographically remote from the bulk of suppliers, there is a tendency for producer influence to be strong. Therefore, the strategic components of project portfolios are strongly influenced by the need to satisfy owners.

F1 is the most significant company in a national primary production industry and exports almost all of its production. Product development is mainly to suit specific needs of overseas customers and both novel processing and large-scale production technologies have contributed to strong growth. F1 spends about \$5 million on its own account and contributes \$25 million to its industry research association. A

total of 127 projects were underway at the time of the interview. By this means F1 shared R&D risk with other companies and leverage funds from government. The staff actually involved in innovation was too difficult to estimate for both F1 and F2.

F1 had a formal stage-gate based product and process development system integrated with its quality system, partially linked to the company's financial system and with tenuous links to an industry-wide project system. Estimating NVA, NPV and probability of success aid project selection.

F1 is therefore accountable for its contribution to the industry's production-based innovation and the central marketing function consequently information flow is sensitive and complex. Company related initiatives have to be secure but co-operative owned contributions must be made available to competitor companies to maximise industry returns.

F1 used local R&D providers frequently and often has just a simple project brief and an intellectual property agreement.

F1 had taken advantage of standardising some project management information with their co-operative and marketing-arm colleagues. However, commonality was limited. Two separate development project systems existed within the company because a smaller company with a strong R&D culture had recently been acquired and the two systems had not yet been merged.

F1M considered short-term NPV gain as the company's main driver for innovation projects. Improving "plant throughput, yield, and quality (more acceptability to our customers)" all added to the "security of our business". "I think the company is in a bit of a dilemma at the moment... The capacity of staff to handle innovation projects is "higher than the company's desire for it" (F1M). F1L was more accommodating, "we stand on the shoulders of our R&D to solve day to day technical problems".

Accountability

F1 was organised into “about half a dozen development centres along product and factory lines” (F1M) each run by R&D people whom “own their stage-gate based development process”. Staff are also involved in the industry projects, which are overseen nationally but essentially dealt with by development centres at production sites.

F1L considered that the quality system was the common thread running through projects and across organisational boundaries. “Quality systems have to be consistent or the whole industry can lose its integrity” (F1L). However, despite common systems, R&D was perceived to operate “total differently” at each site.

F1 might not agree with some development work done at production sites on behalf of the industry or have direct control. The R&D purchaser (F1 or the industry) used meetings as a focus for monitoring and control.

F1L used two-monthly reports based around schedule updates and supplemented it with regular phone contact with the project team members located off-site. Face-to-face meetings were also held every two months. F1L explained, “I have a timeline in my head” and regarded himself “close to the customer” so sensed rather than formally identified potential problems. But F1L confided:

I know that just about everyone is frustrated by how I am managing the project... I can only control by cajoling, which isn't controlling. It's just asking... I am able to impart a sense of urgency.

According to F1L, control was not a group exercise but should be handled one-on-one:

It's all very straightforward. It's voice contact. They adjust their actions if they haven't thought about it enough. I just sort it out.

F1M thought:

The biggest problem is actually raising the little ideas and opportunities that people see up to the level of corporate interest and support. Where they sit (site staff) away in the corner, well you're really wasting your time.

F1L received lots of project information but only used it “in the sense of knowing where everyone’s at rather than taking urgent decisive action”. “I’ve never struck... a major blunder yet so I don’t quite know how I would handle that” (F1L). (Using project management information to review a project was a new concept to F1L but he thought it a good idea).

F1M considered that the quality and volume of project information indicated activity. He investigated when levels were low. Post-project reviews were not routinely done on completion (“Projects [that die] never really have a clean end”), but some projects have been overviewed at a senior level. Normally “there are more important things to be done”.

F1L pointed out that if analysis and decision making relied only on calculated numerical information he would want to be very sure that the information and calculations were sound (“high quality”). On the other hand, driving projects by “sentiment” was also bad, so F1L favoured analysis:

It’s very easy to have a complicated large spreadsheet, which is your analysis tool and find there is a bug in it and you’re actually driving your decision making as badly as if you were driving it on sentiment.

F1L also considered that people close to the market did not assess sentiment better than those more distant. He put great faith in experienced technologists saying, “smart minds can drive a heap of costs out of the final product” (F1L). “You have to roll out products which on analysis look like breakeven rather than look like winners”. However, to temper the above argument F1L said, “You may have to do a project that is “not a great winner” just to satisfy an important customer, but if the [subsequent] analysis says it’s a dog, you must have the capacity to kill it” (paraphrased).

According to F1M, accountability should rest with the person who had “promised to make a buck out the project”. It may be someone from “the technical side or the market side”. It was “business accountability” that was required. When an R&D person was responsible “it doesn’t really work”. F1M’s position meant he should

have ultimate control but he acknowledged, “it is not until you try to kill or try to inject more into something that you find out how difficult it is”. He was not satisfied with the quality of information put into the current project management system. The system accounted for time and expenditure on projects but project leaders were really still too far from the market to be accountable for the final outcome. However, F1L was satisfied with the level of resource accountability in the present system.

4.4.5 F2

Profile

F2 was part of a large international food company. It was located in a major fruit and vegetable growing area and provided processed foods for local and international markets. F2 relied on an established know-how and the capital equipment base originally developed by its original well-respected pioneer family owners. Its innovation was mostly “new to the country” where the large size of the venture and the company’s international connections enabled overseas ideas to be readily imported. F2 had also developed internationally recognised activity-based accounting systems. New developments focused on providing product for specific overseas markets as directed by strategy developed by the US-based parent company.

F2 spent about \$10 million on R&D, which varied between \$5 million and \$30 million depending on the global requirements of the parent company. F2 were running about 40 projects including two that were very large.

F2 used a form of net value assessment for project selection and specifically identified timelines, Gantt charts and Microsoft Project for planning and scheduling. Independent spreadsheets were used to manually interact with the company financial system. F2 had relationships with established local contractors for well-defined process installations using industry standard contracts (for mechanical and civil engineering). F2M advised:

We only invest in technological innovation, or anything for that matter, if it will produce our product better or more economically than our competition.

It's got to improve profit and make the production of that food safer and have some tangible benefit in the production process. [As for] intangible [benefit]... complexity is a real issue and reduced complexity is a plus.

F2L saw process cost reduction a major justification for innovation projects. Reducing labour was also seen as an intangible benefit "Pure labour is a boring sort of a job" (F2L).

Accountability

F2M described his project department as having "a very loose structure":

We don't have roles for people. What we do have is a checklist, or it's really a contract that we all signed... its about ten steps. We've agreed to perform each of these steps on each project... having advanced checklists of everything that has to happen in every project... didn't really work. We've come back to being flexible but having a very fixed framework.

F2L advised that project teams often have a sponsor from product marketing, someone from factory production and other people with a particular involvement like packaging and maintenance. The engineer would usually run the project. "We are assessed on our ability to bring the project in on budget... [at] the promised time".

F2 had weekly project meetings:

No detail discussion... Here is the schedule... This is where we are up to. What's coming up next week... then budget and burning issues.

The meeting minutes form the basis for reports to the project manager and sponsor. Actions were numbered as they come up, recorded and tracked:

The schedule is important at the beginning then once it is under control there is more attention to achievement and budget. We identify high-risk areas first, "we scour the world" for options, then if required, start a development project and flag the high risk to our sponsor... So it's talking about risk as [needing more] time... if we were trying to quantify it.

F2M was happy with the system they use for projects up to about five million dollars and thought the secret was to "monitor regularly and put pressure on areas

that are not keeping pace”. The schedule was very important and kept updated.

F2L described his process:

I use a tracking system, which says it's [say] 50% or 75% complete. I can change those to suit what I think... I'm accountable... they are always looking to me for assurance that things are on track.

F2M deliberately tried to “thin down to the bare essence” the project information he received and considered it was only required to enable progress toward achievement. He minuted meetings as “required actions” rather than cataloguing matters of fact.

F2L said the company was always trying to improve its project management systems but he would like more information process automation to deliver routine financials for project tracking. He wanted to spend less time on assembling the “metrics” which help him assess project welfare. F2M was satisfied with the simple checklist style system they had developed.

Project accountability occurred at project meetings. “There will be an individual who's responsible for that area and they'll be held accountable pretty much as peer pressure”. F2M thought the company was satisfied with accountability. F2 had gone through “a couple of [review] cycles recently... we've got clear signals to get on with it”. F2L was positive about the fact that there was a system, it does get used and it does produce results. As with E1, F2 emphasised the importance of the sense of purpose and control perceived by the project team. However, F2L thought the company did desire more accountability from staff working on innovation projects. He thought this was revealed in the type of annual review questions all staff were asked.

4.4.6 T1

Profile

T1 was part of a company with a long association with the New Zealand forestry sector and now part of a US-based conglomerate also involved in downstream products including paper. Innovation had focused on genetics and tissue culture

but attention was now being given to measurement and management of primary resources.

T1 did not want to disclose the size of their R&D investment but said it had 30 on-going projects. T1 used only periodic reporting and reviewing arrangements for R&D projects and specifically mentioned NPV, ROI, and EBIT as finance-based selection tools. T1M believed that benefit should be assessed on a project-by-project/tangible-and-intangible basis. ROI and NPV are both used as tangible measures of benefit and view intangible parameters; risk mitigation, strategic fit, regulation compliance and knowledge transfer. “We haven’t been able to work out a system for valuing those intangibles for everything. It’s not easy” (T1M).

T1 used exchanges of letters for small contracts and formal arrangements used for larger contracts. Some contracts were said to be effectively “annual but renewable” (T1L).

Accountability

The R&D done in each division was overseen by a highly qualified scientific coordinator also responsible for creating awareness throughout the organisation. General managers also asked T1M for help. T1M admitted that “The links with marketing aren’t as strong as I would like them to be”. R&D project ideas were currently bereft of marketing input. “[Marketing] don’t have enough resources at the moment”. T1M was trying to put together a system to review projects. “Trying to find a company system that everyone is happy with is a nightmare. Everyone has his or her own system in place...”

T1L confirmed:

We have our own way of managing our own projects... We try to stick to basically a 3-month time horizon... we assign leadership to an individual who will lead and manage the team for those 100 days.

T1M operated on project reports with annual discussions for project continuance and funding on an annual basis:

our whole strategy is revised each year... sometimes the paperwork is not always ideal but the process is working. We have proper work plans for operational trials. The key thing is to have the right people in the rest of the organisation who are prepared to take up the research... the movers and the shakers I call them.

T1L acknowledged:

there are no rigid procedures that dictate how we report research results. I guess it comes down to a good benchmarking system to see how we are progressing. We're very much in the process of change... I'm not satisfied with what we've got... we can't measure it at all.

We as a geographically spread team try to... get together once a week by conference calling... to report progress and reallocate resources [if necessary]. If it's felt that the milestones are not achievable, we would have to review the project... if people find that they are not getting enough time to do projects, probably reprioritisation is the way to go... probably we should be less broadly focused and concentrate on fewer projects and get them finished.

T1M wanted her "customers" (like general managers) involved at an early stage:

It's an ownership thing. They can get you on the right track and tell you when you're on the wrong track. Everyone is losing out by the "hands off" approach adopted by having people at that level not understanding how innovation can help their business... unless you've got the support at this level... [it] won't actually translate into something that happens.

T1L thought that project management systems should be used to "prioritise and evaluate value, assess the required resources and get a good plan in place". This final and most important step was neglected when "you have a research or a technology focus" and you get "too busy churning out results and reports and not seeing it implemented". He concluded with the reflection that "all research and project oriented people have a role to facilitate change... otherwise it is a waste of time".

T1L envisaged the prospect of using project management information to learn from how projects have been managed in the past positively. T1M recognised that:

there is always room for improvement [in accountability]. If anything, the end of the project is where everybody needs to do a bit more work. Proper evaluation of whether a project achieved something... we don't discuss the end of the project enough probably... and the least with marketing.

While T1L concluded:

It's probably fair to say we don't have any rigid procedures... It's a flexible type of system I guess... the measure of our success is not in how we report results, its how we actually implement that result... It's fair to say I'm not happy with what we've got.

4.4.7 T2

Profile

T2 was part of a large group of primary/industrial processing companies producing solid wood (with relatively little value added) mainly for export. It had an emphasis on optimising capital investments and was active in seeking opportunities by scanning R&D and new industrial processes globally.

T2 had 10 large, 12 medium and many small projects at the time of interview. The projects included technological, market-related, acquisitions (two) and strategic business unit projects. The company used a stage-gate process borrowed from a US telecommunications company for general project monitoring and Microsoft Project for detailed planning. However, T2L confessed:

People use all sorts of different things [to manage projects]... Our company has gone through [a lot] of change so a lot of the disciplines you would expect to see bedded into a successful company simply aren't here.

T2 had a wide variety of contractual arrangements and not every small contract was formal. The company was “not strong” (T2L) on intellectual property even though they have an “in-house army of lawyers”. Financial tools used by for project selection included NPV and Monte Carlo modelling.

T2M was clear that tangible benefit means “direct impact on the bottom line in cash”. T2L measured tangible benefit by predicted NPV and “created value”. T2L said EBIT was used as a tangible measure of success.

T2M considered that intangible benefits came from knowledge capital, “so that you build the capability... to reinvent the business you are in”, and was mostly held informally by staff, although some large projects had retained databases. “Better

environmental practices, health and safety” are the two main intangibles for T2L as well as “long-term sustainability of our plantations”

T2 had a strategy council that met quarterly with senior management representatives to set high level direction. Big projects had steering committees and below this general managers as overseers. T2L acknowledged:

we've had systems in the past and then they've fallen over. I would not put it as one of our core capabilities, but it has to be.

Accountability

Brief project meetings were held to review the monthly project reports. Quarterly review meetings were used to decide any major changes in the shape of the project. The stage-gate process generated additional information for high level review by the strategy council.

T2L stated:

Most people here do weekly reports. Everybody does a monthly report. But there is no formal framework in terms of what you report and how you report it. Costs are all tracked monthly. We all get “downloads” on project expenditure. We all know what our budgets are... There is no automatic link between project software and financial information. I think we're pretty weak frankly.

We are working on [the quarterly reviews] but [the directors] don't have a framework for actually working through how they might evaluate projects at their different stages... What we often find is that they revert back to the last decision...

T2L described his projects as “a series of brown boxes jammed full of emails”. He advocated the Internet for communications and reckoned that forums and chat-rooms would be a really powerful tool for sharing knowledge but “a lot of people don't see anything in it for themselves so they don't bother.”

T2M firmly believed that project management information was used for monitoring and control and, at a higher level, for balancing the portfolio of projects, and to help explore, “Have we got the right focus and are the right things happening in the

critical areas?” He perceived the need for a process to compare the relative importance of projects because it forced senior management to address the problems of issue resolution and resources at a high level not dealt with by giving a project the label “high priority”.

T2M thought it important to have a common project management language across an organisation. “Project management is common sense... but if everybody takes different project management courses they all talk different languages”. T2M was also concerned about innovation capacity in his workforce:

We’ve got far too many accountants... and foresters... where do you get people who are actually trained to think and problem solve and who will work through the processes we have discussed?

T2L turned most of the high volumes of project information into direct action and had a philosophy that concluded “there are only three reasons why anybody does anything: to improve economics, to make life easier and to have fun”. He saw the way ahead as:

embedding a system that senior players will buy into that will take something right from idea to launch... to look back to [check] has it delivered on the promise, who’s accountable, what have we learnt? Then we have got something that’s good and useful.

T2M had been implementing the stage-gate framework and rated his progress at 5 on an ascending scale of 1 to 10:

The whole project is trying to give more accountability than we used to have. If you had asked me the same question 12 months ago in the different organisation structure we had, I would have put it [the implementation ranking] a lot lower. I absolutely desire more accountability.

T2L said he provided senior managers with the accountability required on a case by case basis. Some wanted updates every fortnight others “are happy to wing it... they like to play loose and fast”. He confirmed the company’s desire for more accountability in exactly the same terms as his boss, “absolutely”.

4.5 TIPS Survey Response

4.5.1 R&D purchasers

P1U did not think he could comment on the TIPS proposal because TIPS did not address strategic policy, his area of expertise. He thought TIPS would not help R&D purchasers, providers and companies to select the contents and size of strategic buckets because current involvement, performance and opportunities was independent of strategic policy formulation. However, he did consider TIPS would be useful to companies involved in implementing strategy.

P3U considered that “providing funding” and “managing projects” were not related, which reflects P3’s “hands-off” approach. Therefore TIPS was not relevant to her. In contrast, P4U thought TIPS provided “a simpler platform (a Microsoft Excel spreadsheet) that allowed innovation project management to be available to all personnel involved”. P4 would require to “view or sample TIPS to further consider implementation”.

4.5.2 R&D providers

R1L regarded TIPS as being “a useful extension” to a system R1 tried last year. “It looks as if it will deal better with unpredictability... which has been an issue for us”. R1L pointed out that “NPV given success” still needed to be supplied. (R1 presently use @RISK software for this purpose.) R1 would like to know more about the model and see TIPS demonstrated.

R2U agreed that R2 required a “structured approach like TIPS”. Its staff was computer literate and would find TIPS “easy to pick up” and use on its Intranet. R2U confirmed that project managers presently handled resource management but thought this might need to migrate to a higher level for optimisation. R2 was emphasising project management systems and training. R2U was concerned that its intellectual property was handled in an *ad hoc* fashion and research results were not disseminated in a managed way. TIPS could mitigate this problem by extending the scope of management beyond “delivering results”.

R3L envisaged the advantages of TIPS as:

In a number of R&D projects, the target outcomes or solutions are unknown or ill-defined at start-up. While the desired output is some form of technological outcome/system/ability/product/capability. TIPS appears to allow these types of projects to “morph” as they progress in order to best achieve a successful outcome without being constrained to original “guesstimates” as to cost, value etc

However, R3L added:

a large part of our innovation and project management revolves around multiple projects, with the associated problems of dynamic resource allocation and tracking. Therefore, even if TIPS does not handle these issues, there needs to be a relatively easy way of integrating it with packages or tools that do.

R3L expressed a need to organise, schedule and monitor resource allocation rather than allow the human resource to self-optimize:

I am also unsure how TIPS manages research projects that may result in the development of knowledge or capability that, while not directly contributing to income, does provide the foundation to generate further income through increased capability, technology, etc.

R3L wanted to avoid providing an estimated benefit or value of the project. This was a useful insight since it forced into debate the motivation for funding innovation and the assessment of “difficult to quantify” benefits.

4.5.3 Companies

E1

E1M envisaged TIPS would summarise a project for portfolio management and for assigning priority in a scarce resource environment. However, he thought TIPS provided nothing new or better for planning, tracking or controlling projects at an activity level. Time-blocks were viewed as an aid “for project reporting rather than a planning and control method”.

E1M considered the main issue in project management was:

keeping staff wound up and pointed in the right direction, accurately reporting progress, correctly identifying and resolving big issue early, and accurately predicting the time/cost to completion.

E1L thought TIPS interesting and favoured “trying this approach on a real project to see what results are possible”. TIPS provided project staff flexibility, especially to exercise leadership as a block manager when the project phase was predominantly in the area of their expertise. The “stretch” across the limited range of disciplines typical in E1 projects could be considered as “on the job training” or extending skills and helping provide the motivation and challenge good staff desired.

E1L considered the TIPS summary sheet with listed priority rankings useful. E1 currently had, “several projects all listed a No.1 priority”. E1L commented that the company tried to avoid multiple-tasking:

the best way to ensure project completion is to allow the design team to focus on one project and leave them to it.

Consequently, caution would be required using TIPS to radically or frequently change project priorities or expect many staff to float across high priority projects. Defining the date that project income commenced may create difficulties for E1 because the distribution chain is long and products tended to have a seasonal sales pattern.

E2

E2M and E2L sent in a combined survey response. E2 suggested appointing an NPD or innovation manager with development and maintenance responsibilities for TIPS. TIPS would be used to assess and compare “new technology/blue sky” projects, which currently do not have any formal method for evaluation. (This response is in contrast to E2’s earlier stated position where specialist managers were not normally appointed.) Short-term projects [evolutionary innovation] was:

committed to on the basis of manufactured and development costs versus estimated sales at an assumed selling price. Once commitment is made then time and cost estimates prior to and following income commencement can be maintained using [existing] project management tools.

This suggested that E2 found traditional systems adequate for well-defined, short-term projects where it is considered unlikely that support will be withdrawn or that

technical and market changes are unlikely. Unlike E1, E2 tends to retain the same project leader throughout and therefore has to contend with lack of knowledge and expertise during some project phases.

E2 considered “breaking down a critical path into time units of nominally equal length” a difficult concept and thought that a full project description in terms of a Gantt chart was needed to assess critical path activities, which would be the focus of the “time-blocks”. “The smaller the anticipated duration of the project [i.e. the smaller the time-block size], the more difficult it is to see how [nominally] identical time-blocks can be established for critical path activities.” An extra problem perceived by E2 was that if activities ran parallel with the critical path then “how do they get costed?” “If all necessary activity blocks are included then TIPS seems to imply sequential rather than parallel [significant] activity blocks”. As this was not the case, the model needed further clarification.

E2’s response was useful because it characterises the engineering approach, where TIPS initial planning would be done in the same way as assembling a Gantt chart: activities (or milestones) expected need to be listed, the duration for completion assessed and then a sequence for execution proposed. Resource issues are normally dealt with in a second iteration and the sequence then optimised. Activities on the critical path can be identified and bottlenecks eliminated (Goldratt, 1997). At this point, in engineering terms, a time-block template would be overlaid on the initial Gantt chart to identify activities that could be expected to occur within each time-block. Some of these activities would be on the traditional critical path and some parallel. All activities within a time-block must be allocated a cost. Therefore, time-blocks may be more adequately described as a sequential, singular series and contain all activities done in a nominated period, which include those on the critical path.

Each respondent from the electronics companies was from an engineering background where detailed planning is common and processes likely to be used are well known. Therefore, TIPS was seen as having most value in activities at higher levels in the organisation where current processes are not always defined or

communicated. Processes describing time-blocks in marketing and sales domains might be assembled, characterised or assessed by marketers in other ways.

F1

F1M thought that TIPS could improve management efficiency by aligning existing time-based requirements for each project (specifically citing “accounting and reporting processes”) and strategically aligning the project portfolio. He noted two problems evident in some of F1’s divisions: the need to determine NPV and the tendency for F1 project managers to gravitate toward a “short-term” focus.

Difficulty with TIPS may occur when review functions were out of phase with actual performance of the activities.

Finally, F1M considered scheduling personnel on a daily basis as impractical since multiple-tasking on various projects was common. This important observation highlights the conflict between traditional prescriptive top-down management and management where the worker is empowered to select the highest priority work consistent with overall most efficient practice (c.f. R2L’s desire to manage staff in detail).

F1L commented only that he was comfortable with the TIPS approach, especially since it demanded significant contribution and involvement from marketers who were perceived as particularly remote from production site staff.

F2

F2M concluded that TIPS combined several well-proven methodologies and should therefore be robust. He described it as “simple enough”, an aspect he considered important since “many systems lose the plot as they become too complex (academic)”. F2M suggested that meaningful feedback could only be achieved by trying the system and was looking for an opportunity to do so.

F2L considered using TIPS for F2 to formalise the innovation process. “At the moment there is no set path or method to follow through this type of project other than PERT/Gantt”. F2’s innovation projects are likely to take place over several

sites, so good communication could be difficult. However, as a specific director is assigned to innovation, email [the Internet] could be used.

F2L considered that TIPS had the advantage of “ranking innovation projects which helped project staff to work out [their] priorities”. He also confirmed that F2 would only proceed with a project if there were strong projected sales returns. F2L implied that “marketing” was significantly involved in selecting and monitoring projects. F2 had a fundamental requirement for functions and disciplines to cooperate and would find a non-engineering (neutral) innovation project management system desirable.

T1

T1L found it difficult to understand the TIPS process without seeing an example. “It looks like it frees up more time [to work on] the project compared to managing the [project] process”. He reflected that:

businesses are probably more interested in return on shareholder funds (ROI) these days than change in value (NPV). It might be useful to incorporate IRR into TIPS.

(Using ROI on an individual innovation project basis is a problem, but it is a valid concept for portfolio optimisation. Using IRR is inherent in calculating NPV, but IRR is a misleading concept because its mathematical derivation is quadratic, which means that a solution may have a negative value. Therefore it is best to avoid IRR.)

T2

T2L thought TIPS would best contribute to innovation at T2 by dynamically quantifying the probability of project completion alongside the net present cost (NPC) for completion. This feature may provide a basis for deciding to abandon some projects currently lingering at T2. T2L reiterated that a number of specialist software packages were in current use. “Having TIPS in Excel makes it available for use to a far wider audience”. T2L concluded that TIPS “conceptually looks fine” but wanted to know “how simple is it to learn and use and how much will it cost?”

4.5.4 TIPS survey response summary

TIPS was perceived as having the potential to provide a sound and robust method to plan and manage innovation projects individually and together in portfolios. TIPS did not provide a way to directly or solely develop innovation strategy policy or to select “strategic buckets” to define portfolios. It did, however, help rank projects within portfolios. TIPS did not directly allocate regular resources but, by ranking projects, it would inform empowered staff about high priority projects and provide them and their managers with a basis to promote effective and efficient resource use.

All survey respondents for whom innovation project management was directly relevant (14/15) considered TIPS had various advantages over current systems. The remaining survey respondent did not feel qualified to comment because her organisation had a “hands-off” approach to funding. The most frequently voiced advantages of TIPS can be distilled as “providing a tangible, simple, consistent and transparent means to regularly compare innovation projects for compliance with organisational strategy and permit inter-project ranking”. The widespread familiarity of managers with Microsoft Excel spreadsheets (the proposed platform for TIPS) readily avails project information to different functions and sites for action.

Two respondents needed specific additional guidance to clarify their understanding. Six out of the 15 respondents specifically would require TIPS to be demonstrated on a “real” project before considering TIPS for their organisation. TIPS represented a new amalgamation and integration of project management methods. In addition to survey responses the TIPS concepts were presented for peer review at national and international conferences (Mills *et al.*, 1996; Mills *et al.*, 1999; Mills *et al.*, 2000). Project management professionals did not raise any fundamental objections or find fatal flaws.

4.6 TIPS Pilot Trials

4.6.1 Usefulness of the action research approach

During the first week of the trial, participants were given a protected copy of the Microsoft Excel spreadsheet template and the TIPS philosophy was introduced at a one-hour seminar at company premises. Project managers A and C used monthly time-blocks (project duration six months to two years) and B, X, Y and Z used weekly time-blocks for their shorter projects as suggested. The Friday visits to project managers were particularly useful in encouraging regular project reviews. A copy of each project's updated TIPS file was made and retained by project managers at the end of each week, primarily for trial record and review.

Work commitments and illness disrupted visits. The actual number of meetings with project managers A, B, C, X, Y and Z was 6, 9, 12, 10, 6 and 8 (out of 13 scheduled) respectively. Meetings lasted from 10 minutes to 90 minutes but were typically 30 minutes. The time project managers spent on TIPS each week outside the meetings was irregular and highly variable (zero to four hours per project).

Regular interaction with project managers using TIPS during project reviews was valuable because they presented problems, conflicts, frustrations and insights first hand. The immediacy of the interaction also helped motivate four software upgrades during the trial (8 August, 7 September, 20 September and 29 September). General issues identified at visits were able to be aired at subsequent visits and with other project managers and were often discussed or resolved through the email updates. The action research approach therefore stimulated both progressive learning and TIPS system development.

4.6.2 TIPS implementation during the pilot trial

While all project managers were well-intentioned, the rate the TIPS project sheet was initially completed was strongly influenced by external commitments, work priorities, project complexity, the developmental status of TIPS and the ready availability of data. For example, at the first weekly meeting project manager Y was able to enter all data into all fields of the ten-week upgrade project within one hour. The two participants on project C (a two-year "blue-skies" research project)

took the longest and did not complete data entry until the last week of the trial when the data fields and TIPS software functionality had been developed to accommodate their reasonable requirements. They were further delayed by the time taken to extricate two auxiliary projects, initially co-scheduled to enable work continuity for the research group staff.

Technical/scientific project managers had difficulty acquiring future income information from business staff whilst business/operational project managers had difficulty in acquiring good cost and schedule estimates from R&D staff. These issues were generally because the associated people were not involved in the TIPS pilot project. For example, future income estimates for C had to come from a commercial partner and for X and Z from marketers who had already unconditionally approved the projects for commercialisation under the normal regime. In all cases there was no apparent justification to request information that was considered either confidential or unnecessary for project continuance. R&D cost and schedule estimate information was difficult to access because overhead factors used to cover risk and for maintaining support staff were not openly shared across functions.

The original intention was to send TIPS project and portfolio files to project portfolio managers G and H at the end of each time-block for progress reporting and to assign the updated project priority rank. However, the practice for most projects was that submission did not begin until the end of the trial period. Therefore, TIPS interaction between these management levels was not adequately tested.

4.6.3 TIPS information development

The final format for the pilot trial TIPS project worksheet (weekly time-blocks) is shown in Figure 4.1. During the pilot trial the number of TIPS project sheet data fields was increased from 24 to 27. Four fields (Target Market, End User, Customer/Voice of Customer and Date Output Required) and two fields (Probability that Block Goal is Achievable and Calculated Probability that the Project is Achievable) were added to satisfy marketers and scientists requirements

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respectively. Four fields were deleted to simplify and tidy the worksheet (Time-block size, Unique Resource, Probability of Success After One Extra Time-block and User's 2). The "User's 1" field was customised to provide all unique data required by each company (R1 identified six items and E1 seven). Editorial changes were done to describe many of the fields more accurately. For example, "Block Name or Milestone" became "Block Goal".

TIPS Week-block Project Sheet, Bob Mills, University of Waikato, 29 Sept 2000
(Enter your data inside the double lined boxes)

SUMMARY		COMPANY SPECIFIED DATA					
	Company's Priority Rank Number for this project Company's Strategic Category for this project Target Market Customer/Voice of Customer End User Project Output Project Name Project Sponsor Project Manager Interest Rate for using money (%) Date Output is required						
Apr-01 1.00 Check Data 0 0	Calculated Date First Sales Income receipt expected Calculated Probability that project is achievable Calculated Probability that project is achievable on time Calculated Project Costs before sales income, NPC (\$'000) Calculated Sales Income given project is achieved on time, NPV (\$'000)						
<i>(Transfer Summary and Company Specified Data to Portfolio sheet automatically by pressing *Ctrl-</i>							
BEFORE FIRST INCOME							Probability of finishing within 7 days
Block End Date	Block Manager	Block Goal <small>(The final block goal is "First Income")</small>	Probability Goal Achievable	Elapsed Time (Days) Optimistic<=7 Pessimistic<=>7		Net PV Cost \$ ('000)	
29-Sep-00			1.00				
6-Oct-00			1.00				
13-Oct-00			1.00				
20-Oct-00			1.00				
27-Oct-00			1.00				
3-Nov-00			1.00				
10-Nov-00			1.00				
17-Nov-00			1.00				
24-Nov-00			1.00				
1-Dec-00			1.00				
8-Dec-00			1.00				
15-Dec-00			1.00				
22-Dec-00			1.00				
29-Dec-00			1.00				
5-Jan-01			1.00				
12-Jan-01			1.00				
19-Jan-01			1.00				
26-Jan-01			1.00				
2-Feb-01			1.00				
9-Feb-01			1.00				
16-Feb-01			1.00				
23-Feb-01			1.00				
2-Mar-01			1.00				
9-Mar-01			1.00				
16-Mar-01			1.00				
23-Mar-01			1.00				
30-Mar-01			1.00				
6-Apr-01			1.00				
13-Apr-01		First Income	1.00				
<i>(Update one time-block automatically by pressing *Ctrl-</i>							
AFTER FIRST INCOME							
Net Sales NPV (\$'000) Calculation							
Year (from now)	Net Income						
0							
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							

Figure 4.1. The TIPS Project Sheet for Weekly Time-blocks

After discussions early in the pilot trial, two pragmatic simplifications were made. Firstly, the end of the project was defined as being at the “Date of First Income Receipt”. Secondly, the sensitivity analysis offered by calculating the probability of completion after one extra time-block was considered too subtle for practical use. The changes reduce control and analysis functionality but could easily be reintroduced.

Calculating and expressing project risk was clarified by defining three types of probability:

- The probability of ever achieving a block goal
- The probability of achieving a block goal on time (using optimistic and pessimistic elapsed time estimates for each block goal and the Beta distribution approach after MacLeod and Petersen, 1996) and
- The probability of commercial success (incorporated into the dollar value of project “Net Income”).

The probability that the project is achievable is calculated as the product of all probabilities of ever achieving individual block goals. The probability of achieving a block goal on time multiplies the achievability probability by the normal distribution aggregation of the probabilities of achieving each block goal (i.e. the normal PERT approach).

The ratings for overall “usefulness” of the project management information fields were considered and counts at values equal to or less than 2.0 (“not very useful” and worse) and equal to or above 4.0 (“very useful”) and better were set (Table 4.2).

Overall, TIPS data fields were rated at an average of 3.4 or slightly more than merely “useful”. Company R1, which had a less structured existing innovation project management process, found more fields more useful than E1 (9 c.f. 1 of the 27 fields rating 4 or higher). Portfolio managers and business managers rated information fields as most useful (21 and 13 fields respectively rating 4 or higher).

Table 4.2. Usefulness of 27 Fields of TIPS Project Information

Group	n	Number of	Number of	Mean rating
		fields rating ≤ 2.0	fields rating ≥ 4.0	
All	9	0	4	3.4
Company R1	5	0	9	3.7
Company E1	4	2	1	3.1
Portfolio Managers (G/H)	2	0	21	4.1
Project Managers (A/B/C/X/Y/Z)	6	2	2	3.2
Business Operations Managers (O)	4	0	13	3.9
Technical Managers (T)	5	4	2	2.9

Where n is the number of survey respondents in the group and rating values range from 1=not at all useful to 5=extremely useful.

Technical managers were least impressed, rating four of the fields (Priority Rank, Strategic Category, Project Income, and Company Specified data) at 2 or less. Both company E1 and the project manager groups rated the Priority Rank and Strategic Category fields poorly. Technical managers thought that the field, Project Income data, was not useful nor were Company Specified data fields, (incorporated at the request of portfolio managers).

In a fully operational TIPS environment, priority ranking will help empower staff to self-select day-to-day work and will strongly influence project funding and resource levels. The fields currently ranked poorly by the technical managers will consequently attract increasing attention.

4.6.4 TIPS software format

During the pilot trial the TIPS project worksheet was reformatted from three to four groups of data. Originally data was bundled into Summary, Technical Estimates and Commercial Estimates boxes. Summary information is copied, transposed and pasted into the portfolio worksheet to provide a one-line project status. The titles of the latter two groups were perceived as discouraging marketing staff from being involved in events prior to First Income.

The final layout grouped generic Summary data and Company Specified data separately (copied and pasted by a single keystroke macro to the portfolio sheet). The other information was still grouped the same way but renamed, Before First Income and After First Income. The overall rating of 3.3 for the TIPS format indicates that it is useful (Table 4.3). Company R1 (mean 3.8) and the project managers (mean 3.4) were the most positive. Company R1 and the technical managers group considered that familiarity with Microsoft Excel across functions and levels was particularly useful (rating 4.0 and 3.6). Six of the nine respondents verified that Microsoft Excel was useful as the platform for TIPS whereas the other three had reservations especially about tidiness, flexibility and robustness at the user interface.

Table 4.3. Usefulness of 15 Aspects of the TIPS Format

Group	n	Number of	Number of	Mean rating
		fields rating ≤2.0	fields rating ≥4.0	
All	9	0	0	3.3
Company R1	5	0	5	3.8
Company E1	4	2	0	2.5
Portfolio Managers (G/H)	2	2	0	2.6
Project Managers (A/B/C/X/Y/Z)	6	0	2	3.4
Business Operations Managers (O)	4	0	0	3.1
Technical Managers (T)	5	1	1	3.3

Where n is the number of survey respondents in the group and rating values range from 1=not at all useful to 5=extremely useful.

Specifying *achievements* instead of *activities* and tying these into the calendar on weekly, monthly and quarterly basis was rated positively (3.4 and 3.2 respectively), with little variation across groups (range: 2.5-3.6). However, Block Goals were thought to have been allotted inadequate physical cell space, even though the Microsoft Excel cell “Comments” feature was found to be a useful (if cumbersome) option for expanding descriptions, listing tasks and allocating jobs.

Company R1 considered the Probability of Block Goal Achievement and the consistent approach to estimating schedule achievement as very useful. This contrasted sharply to the views of E1, who rated both these features very poorly.

Similarly, the presentation and transfer of project information and the convenience of updating TIPS was rated at 4.2 to 4.8 for R1 compared with only between 2.5 and 3 by E1. This may reflect the multiple site operation for R1 compared to the close-knit single site operation of E1 or that R1 did not already have a coherent innovation project system.

4.6.5 TIPS project information flow

Useful project management information must be identified and then acted upon to effect good monitoring and control. Overall, respondents slightly agreed that TIPS could be expected to increase useful project management information compared to existing arrangements (3.4 cf. 2.6, where 1 represented strong disagreement and 5 strong agreement). TIPS identified project information more effectively and earlier than did existing arrangements in both companies (3.8 mean). R1 thought that existing information exchange between R&D and marketing functions was unsatisfactory (1.8 mean) where it was acknowledged no formal arrangements were in place. However, E1 managers agreed they had satisfactory arrangements (4.0 mean). Similarly, project information exchange across management levels rated at poorly in R1 at 1.8 and neutrally in E1 at 3.0.

R1 considered that TIPS would increase the amount of useful project information exchanged (3.5) but E1 disagreed (2.8). However, when asked if TIPS was expected to improve useful communications between R&D and marketing, R1 expected no change while E1 expected a slight improvement (3.3). R1 thought communication across management levels would slightly improve (3.4) when using TIPS but E1 expected deterioration (2.7).

Some managers wanted TIPS to give a summary project history. Y assembled a history for his project during the trial by adding summary data to a project-specific portfolio sheet at the end of each time-block.

4.6.6 TIPS implementation

A better user interface, perhaps using icons, was urged by three of the nine respondents, suggesting also that TIPS should be linked to a company database. Other suggestions included changes to accommodate schedule probability

calculations using a five-day working week (rather than a seven-day calendar week), changing company time sheets to show *achievements* rather than *activities* and automating management report form generation.

Respondents suggested that staff education was needed to obtain upper management “buy-in” of TIPS. An organisational culture change was also needed to accommodate the philosophical differences with existing arrangements so, for example, *achievement* rather than *activity* is celebrated and to accept that *past expenditure* is an investment in *new knowledge*. Awareness of the TIPS approach would be required for all staff, with project manager and higher levels needing specific training, in both project management principles and TIPS software use.

The estimate for the time to establish an operational TIPS system ranged from “As long as it takes for you to write a specific programme” to five years. The broad median consensus was 12 months, which is considerably shorter than the three to seven years expected from companies reported in the literature.

4.6.7 The rated value of implementing TIPS

Company R1, project managers and technical managers rated the value of implementing TIPS, or a similar approach, for monitoring technological innovation projects, as high (4.0) (Table 4.4). The mean rating of all respondents was moderate to high (3.6). Only one respondent gave a value of less than moderate (3.0) and indicated that dedicated software would increase the rating from 1 to 5.

The mean for the probability of implementing TIPS was moderate, reflecting the developmental nature of the pilot trial and the lack of information about its performance elsewhere. R1 perceived the most value (4.0) from implementing TIPS, having no consistent innovation project approach and projects operating from dispersed sites. Project managers placed the same high value on TIPS, which was encouraging, because they had had the greatest interaction during the pilot trial and were potentially most affected. Likewise, technical managers rated TIPS highly, the survey data indicating positively their expectations of improved communication of project information, particularly to higher levels of management.

Table 4.4. The Rated Value of Implementing TIPS (in your Organisation)

Group	n	Value of implementing TIPS	Probability that TIPS (or equal) will be implemented within 2 years
All	9	3.6	2.7-3.1*
Company R1	5	4.0	3.0
Company E1	4	3.0	2.3-3.3*
Portfolio Managers (G/H)	2	2.0	2.5-4.5*
Project Managers (A/B/C/X/Y/Z)	6	4.0	2.5
Business Operations Managers (O)	4	3.0	2.8-3.8*
Technical Managers (T)	5	4.0	2.6

Where 1 is nil and 5 extremely high. * the higher value is true if dedicated software is used.

4.7 Summary of Findings

P1, P2, P3 and P4 represented a wide spectrum of types and sizes (including the largest) of New Zealand R&D purchasers. Projects ranged from \$10,000 (with completion in less than a year) to \$1 million (for a three-year contract). This might represent from perhaps 10% of an individual's time to the major work for a team of, say three researchers and their support staff over several years. R&D provider project sizes related directly to those of R&D purchasers. Some consultancy contracts were considered by one respondent as innovation projects ranging down to about \$1000 expenditure.

Each company interviewed had a similar size range of innovation projects. Larger projects cost more than \$1 million and the smallest ones about \$10,000 with an average cost of about \$250,000. The two electronics firms allocated about \$100,000 per researcher which is similar to the project-specific charge-out allocation in R&D companies but is less than the \$150,000 rate expected by R&D purchasers. The higher level could be expected to cover general overhead costs such as library and information access and the high cost of specialised equipment required for fundamental research. The companies surveyed allocated overheads differently and did less fundamental research than research organisations.

An R&D project in New Zealand might have 200 to 20,000 person-hours compared with US military standards, which specifies 1 million person-hours as being a “project” (Frame, 1987, p 198). Thus R&D projects in New Zealand are “work packages” or “sub-tasks” in US military terminology (Raz and Globerson, 1998).

All R&D purchasers require accountability from their providers on at least an annual basis and sometimes quarterly. The accountability requested and provided for the more fundamental or public good nature project is more detailed but less frequent than for specific and applied research. R&D purchasers make it difficult for R&D providers to be efficient because each purchaser has different accountability requirements. All R&D purchasers’ require interactive involvement and have developed automated systems to handle reporting. However, automated reporting isolates rather than integrates the efforts of project teams to satisfy purchasers.

R&D providers rely on a few key purchasers for a substantial part of their income so project management arrangements are dominated by the needs of dominant purchasers. Providers found the varying accountability requirements of purchasers were frustrating and caused inefficiencies. Most R&D providers use project management software but principally for initial planning and commonly use milestone, quarterly and monthly reports or reviews. Evolutionary innovation projects are more common in companies than in R&D organisations and often use weekly reviews.

Accountability in companies focuses on satisfying internal rather than external sponsors and ultimately the end user. The output of the innovation process in companies is vulnerable to change, particularly in fickle markets. Existing ways to progress innovation through traditional project management methods or through stage-gate processes do not appear to satisfy the company managers interviewed.

The information gained from interviewing innovation project managers was used to design a novel technological innovation project system (TIPS) to better meet their

needs. The design featured *achievements* within series time-blocks of constant length (week, month or quarter) rather than *activities* of variable length and inter-relationships used traditionally. TIPS was implemented in Microsoft Excel spreadsheet format and sent to interviewees. A request to interviewees to respond to a survey considering the prospect of implementing TIPS in their organisation generated an 80% response rate. Fourteen of the 16 respondents identified potential advantages of using TIPS compared with existing arrangements.

A three-month action research pilot trial was done to implement and refine TIPS on three projects each in R1 and E1 and to determine its potential usefulness and value. At the end of the trial data from participant managers indicated that project management information collected by TIPS was adequately comprehensive and very useful. Participants agreed that TIPS was better than existing arrangements at indicating the need for corrective action.

TIPS methodology was rated very highly by one of the companies, six project managers and five technical managers. The second company rated the value of implementing TIPS as moderate. Respondents considered TIPS could be implemented in their companies within 12 months. One third of the participants thought TIPS might be better implemented in dedicated software.

Chapter 5 discusses the findings presented in this chapter in the light of the literature and current needs.

CHAPTER 5 - DISCUSSION

Team Leaders use sophisticated project management software to keep track of who's doing what. The software collects the lies and guesses of the project team and organises them into instantly out-dated charts that are too boring to look at closely. This is called "planning". – Scott Adams.

5.1 Introduction

The nature of business is to profitably meet the needs of customers and thereby produce an acceptable return to shareholders. Customers select the product (or service) that they perceive will secure the scope and level of benefit they desire for a price they are prepared to pay. Companies strive to satisfy customers by increasing product benefit and/or reducing its price. Improving and changing functionality, style, durability, connectivity and convenience are ways to increase customer benefit and are technological by nature. Improving and changing product and process technologies themselves can also reduce price. This improvement and change process can be appropriately described as technological innovation. It must be cost effective in the long term when aggregated across all the company products and services if the company is to prosper.

Economists have explained the essential need for innovation but people from all levels of management in industry and from academia consider management of the innovation process is unsatisfactory. The findings of this research verifies this dissatisfaction and identifies some prospects for improvement.

The disintegration of technological innovation into discrete and poorly connected segments within and across organisations appears to cause dissatisfaction, inefficiency and ineffectiveness. Innovation management is substantially isolated from mainstream operations in traditional organisational strategies, structures, processes, systems and methods.

Further disintegration is apparent in New Zealand by the influential government R&D purchasing policy (undertaken by P1), which extends support for innovation routes only as far as the "public good". R&D providers are expected to exploit

research findings by working with companies to create and improve products, processes, systems and services. However, companies interviewed had no significant ongoing relationships with institutional providers. The R&D purchasing agencies interviewed (apart from P4) also tended not to ensure the integrity of the innovation process, they simply purchased R&D.

P2 was more proactive than P1 in promoting continuity of the innovation process for industry benefit. However, it did not recognise risk as a valid consideration in delivery performance. P3 focused on ensuring sector R&D support rather than on ensuring direct benefit to the sector and P4 appeared constrained to seek solutions only from its parent company.

Promoting the understanding of the innovation process within an organisation (Barczak and Wilemon, 1999; Menke, 1999; Englund and Graham, 1999) can mitigate dysfunctional innovation when it co-ordinates strategies, structures, processes, systems and methods. Dysfunctional innovation, however, is an enduring national problem for New Zealand (Darroch and Engelbrecht, 1998) and therefore comprehensive reform and integration is required.

5.2 Technological Innovation in Organisations

5.2.1 Organisational fabric

Widespread dissatisfaction caused by project managers' attending to compliance rather than to the customer (Frame, 1994) was evident. This is not surprising since it is widely perceived that marketers deal with customers although this was clearly not the case. Further, marketers usually play a significant role in defining solutions that are expected to meet customer needs. Innovation project scope (PMBOK, 1996) is usually described in terms of a defined solution (often a product) rather than more dynamically in terms relating directly to a potential contribution to a defined strategic objective.

In companies, essentially prescribed solutions were handed to the R&D department or the engineering and production departments to make happen. Specialised

project management tools developed and used by technocrats exacerbate the problems of marketing/ R&D/ engineering communications. Marketers in large organisations appear to have little time for or no active interest in the project until it nears completion. The fundamental structure (hierarchy) of organisations therefore has a negative influence on innovation project management processes and methods.

If customer requirements change or if new technical solutions might increase customer benefit or value, a change in scope needs to be recognised then communicated before it can be implemented. These changes should trigger a project management tool requirement for re-planning, re-scheduling, re-costing and re-resourcing. When changes to scope are not translated into the project system, a mismatch between planned and actual expenditure, delivery schedule and output occurs. Data obtained in this study showed little formal project updating actually occurred in practice. The reason for this seemed to be that once a project was approved and resources committed, it was considered more cost effective to have project staff work on the project itself rather than work on the overhead activity of upgrading project management information. Innovation projects in New Zealand organisations are small, so few supported dedicated project or programme managers.

Project managers currently do not adequately attend to customers directly and don't frequently use project management tools to maximise customer benefit. Project overruns are indeed common yet do not appear to be the direct fault of project management tools (Shenhav, 1999). Archer and Ghasemzadeh (1996a; 1996b) and Archer *pers. comm.*) argued that overrun was caused by either lack of project manager training or discipline, rather than non-availability of tools. Ultimately, however, overrun can only be caused by either unplanned events and delays or customer needs and expectations not being met within the context of the originally defined project scope (leading to scope creep). Extra cost or effort is then required for redress. Existing tools to accommodate change are unpopular, appear too hard to use, are perceived as taking up too much time and money, or simply do not deliver useful outcomes.

Developing better tools to handle complex problems is desired by some of the interviewees (for example in R2, R3, E1 and T1) and Thamhain (1999). However, developing simpler and more widely understood tools, to align technological innovation with strategies, which satisfy customers, is more fundamentally important.

5.2.2 Strategies

One organisation encountered during this research was so jealous of its strategic plan that only the chief executive knew what it was! Most organisations openly declared some form of vision statement and loose objectives or indicators but were more circumspect about the strategies they wished to follow for realisation. The strategies espoused usually related to the way they planned to reward their owners, serve their customers and treat their staff. Processes to arrive at the position (goals) organisations wanted to achieve in various markets, with various product lines by various dates were not evident.

Strategies were only overtly linked to projects in the organisations the interviewees represented except for P1 and P2, who were strongly driven by precedent and by perceived public or industry good through a comprehensive policy setting process. In contrast, the three research providers grouped projects in the context of their business divisions around core competencies. The three companies who had recently introduced stage-gate processes did not appear to have developed a recognisable link between project portfolio management and strategic planning or strategic implementation, although this was a declared intent.

The concept of allocating innovation resources into “strategic buckets” designated by senior management appears to be the most simple to understand and quantify from those listed by Cooper *et al.* (1998; 1999). This concept related well to current practice or desires of both R&D purchasers and companies. R&D providers had immature practices and were more vulnerable to income variations and the variable demands of their clients. However, there was no evident reason why R&D providers could not adapt to a portfolio approach for linking strategy and projects. Cooper *et al.* (1999) argued that there is a wide divergence in

organisations about the best way to categorise portfolios. If implementation was seen as being difficult, however, it may be prudent to recommend at least initial descriptions and proportions of generic categories.

Policies or directives governed R&D purchasers' portfolio categories so these organisations short-sightedly did not want additional strategic guidance from direct feedback from existing projects. The five innovation categories used by Wheelwright and Clark (1992) for companies and the nine portfolio categories suggested by Cooper *et al.* (1998, p 188) appear to be generally useful and applicable as is the allocation of funds advocated by Bright (1964) and Karger and Murdick (1972). A prudent proportional allocation as the starting point in a generic "strategic bucket" system for R&D providers and companies might therefore be:

- derivative (customised) products 70% evolutionary innovation
- new product platforms 20% revolutionary innovation
- breakthrough products 5% revolutionary innovation
- company R&D 3% R&D
- industry partnership R&D 2% R&D

5.2.3 Structures

Marketing and R&D

The role and power of project contributors is the key structural issue for managing technological innovation projects in organisations. As Mintzberg (1979; 1989) points out, the marketing function dominates the company-centred view of the world. Marketing still sits at the crossroads between production and the customer and between the forces of standardisation (systems) to effect efficiency on one hand and the forces of disruption/innovation (R&D) on the other hand to create or secure new opportunities. Marketing was also seen as (or is actually part of) executive management. The multiple-dimensional aspect of the marketing function, however, causes an information bottleneck. Marketing, especially in large

companies, still view project management as a convenient way to prescribe and parcel work (for R&D and engineering) and monitor its performance.

A more comprehensive view of innovation is required. Structures must avoid using systems that create delays and cause disconnection to the dynamic business environment. Interviewees in this research were acutely aware of information flow problems on innovation projects. The widely adopted solution was to forge direct links between the customer and the innovation team. This effectively bypassed the marketing function in the operational sense and required marketing to contribute to through the innovation project management process. However, direct involvement with projects created difficulty for marketers. Unlike project technical staff (for whom project information was the lifeblood of their existence) marketers need to give high priority to serving current customers. How therefore, can marketers be motivated to remain involved throughout innovation projects? One solution from the findings is to arrange projects to be dealt with on a business calendar basis rather than on a project event driven basis. Another initiative is to arrange for innovation projects to extend beyond the production process hand-over date into the commercialisation period. This is where project activity is centred on sales and marketing and R&D are often reluctant to provide support if interesting new work awaits.

Informal communication is essential and consequently structures that encourage equity and open access between all those involved in innovation projects should be considered. The practice of physical co-location of different functions is successful at F&P and PEC in New Zealand (Poulin *et al.*, 1998a) and at Intel in the US (Colwell, 1999) but not to any significant extent in all but one of the organisations interviewed. In this study direct interaction between technologists and customers and shared information with marketing necessarily occurs in the context of innovation. This concept is clearly not a problem in organisations that adopt Mintzberg's (1989) organic approach and who trust and respect contributors to do what is right (Packard, 1996). However, this approach might be conceived by militarists as complicating the chain of command, which is important in crises, by creating duplicity. The logical consequence is that R&D purchasers, providers and

companies should be geographically clustered for effective and efficient innovation. An alternative means to join R&D and marketing within a structure is to retain multiple-disciplined staff. Customer contact and information processes could be simplified. However, managers tend to migrate to their area of true interest, so structural failure may occur.

There are further problems associated with attempting to adjust the structural location of functions to enhance the innovation process. Why should production, engineering or administration functions be less favoured to co-exist with marketing than R&D? How would organisations, which are content with existing structures be persuaded to change?

Structures in researched organisations

The structures in R&D purchasing organisations P1, P2 and P3 were primarily arranged to ensure compliance with policy and regulations ensuring equitable access to results by all contributors rather than to encourage lines of R&D that might directly contribute to the capture of tangible benefit by individual organisations. P4 was only interested to capture specific benefit.

R&D providers structured themselves into industry sectors or specific technologies to relate more holistically to clients. Clients had the advantage that specific R&D could be done without the need to carry the overhead of their own R&D organisation but had the potential disadvantage that a knowledge diffusion route was created.

Product innovation in the small electronics companies was done in dedicated tight-knit groups. The larger food companies centred their developments round R&D groups and development centres where pilot scale equipment was available.

Forestry companies appeared to be less organised and relied on centrally based co-ordinators to tie various efforts together. These structures appeared to relate mainly to the number of company sites and the maturity of the industry. The single site organisations did not need systems to co-ordinate effort but still required processes to orchestrate innovation. The less mature forestry industry appears to

create processes and systems on an *ad hoc* basis but linkage with financial systems always appeared important.

The discipline needed for innovation success appeared to lie with adhering to good processes rather than complying with the dictates of good organisational structures.

5.2.4 Processes

The wider context

Processes aim to improve efficiency by standardising ways of doing work. The specific process of systematic entrepreneurship (innovation) also uses projects to ensure that organisations are effective in planning for the future (Drucker, 1985; Quinell, 1998). Technological innovation project management was considered as an integrating process for delivering an organisation's future rather than merely a method or a tool to manage risk or isolate non-operational activity by E1 and E2, partially so by F1 and F2 and occasionally by T1 and T2. Rather than R&D being seen as a parallel and non-operational activity (Mintzberg, 1979), it might better be represented as an early phase of operations delivering future product choice to the organisation. Institutionalising polychronicity (Thoms and Pinto, 1999) into operational culture creates distinct advantage for functional relationships. As an operational process, innovation commands commitment and contributions from R&D and marketing departments as well as engineering and production.

Interviewees were concerned about the effect that changing project priority had on maintaining project momentum. Research providers coped by concentrating on milestone achievement as an end in itself. In doing so, they ran the risk of losing sight of end goals. Upper management in all organisations was inclined to deal with downward priority change by reducing support rather than by killing projects. This, however, under-resourced projects and diluted overall effort, which lead to staff de-motivation and a sense of loss of process control. At the other extreme, middle and lower managers considered some projects were wasteful, but still supported by upper management in spite of poor prospects.

Quantification and transparency

The innovation process was perceived more satisfactory when quantitative and transparent (particularly in E1, E2, and F2). A sense of control was created by empowering contributors to manage their own detailed time allocation in co-operation with immediate managers (particularly R1, R2, E1, and E2). This empowerment could be improved by allocating overall project priorities, but none of the organisations interviewed did this. Progress on high priority projects depended on the availability of appropriate resources rather than allocation of time to available resources. (Management generally finds procuring resource an easier task than managing time at the individual level, particularly where creative people are involved.)

These observations raised two issues. Firstly the literature and the experience related by the interviewees suggested that some quantitative innovation project information was unreliable. Dollar NPV estimates for project benefits were especially cited. Secondly, in some organisations (especially F1) strategic planning and any information indicating strategic direction was restricted to upper management (especially F1). Widespread dissemination of innovation project priorities was considered a high business security risk to the extent that disaffected key staff could potentially sabotage projects.

Reliability of quantitative information for uncertain estimates, such as sales returns will always be a concern. Estimator bias is a significant factor affecting the validity of this kind of data, particularly when the organisation does not have alternative verification. Two solutions are available: either an alternative and perhaps indirect method may be used to generate comparative data, or the pressures that encourage bias can be neutralised or diluted. Practical ways to verify estimates include multiple estimators, multiple methods and using independent expert panellists. Any process adopted should encourage trust and ethical behaviour. An indirect way to encourage irreproachable behaviour is to keep traceable records and track changes of estimates with time.

The problem of retaining organisation security in an open process relates to organisational culture, size, inter-staff trust and personal ethics. A common solution observed during the interviews was to use acronyms and code names for project titles.

Access

Nelson *et al.* (1997) suggests that openness is a characteristic only of early stage innovation, whereas speed and order prevails as the innovation progresses. However, since openness generally enhances speed and order, then it should be considered as a characteristic of the whole process. Peters (1992) observed how openness was linked to a high level of individual accountability (higher in one company he visited than was usually created by bureaucratic systems). Openness and transparency are, however, evidently counter-cultural in some large and conservative organisations like F1.

The study verified that innovation process data have to be accessible to managers at all levels and frequently across geographically dispersed sites. Evidence from the literature, interviews, surveys and pilot trials confirmed the perception of convenience and widespread use of personal computer-based spreadsheet software (especially Microsoft Excel), which can be linked to an Internet-based system if desired. Specialised project management software was found to be poorly utilised for innovation projects and not common at higher management levels in the organisations interviewed, whereas there is general spreadsheet competency and use at all management levels (see Pollack-Johnson and Liberatore, 1998; Fox, 2000).

Operational linkage

Since upward reporting processes contain information of low durability and decision making at lower organisational levels is encouraged in organisations today, the need for frequent formal reporting was expected to be low. However, this was not the case, especially with T1 and T2. Quantitative information (particularly financial) was handled through computerised information systems in

all organisations. Downward reporting processes were updated on company-wide information systems particularly in the large organisations.

In all cases upper management needed information refreshment suitable for accountability to their owner's (typically annual reports, quarterly financial statements and monthly cash flow) whereas information useful for innovation project priority and pace decision-making was generated at significant events (at the end of activities) and milestones. All provider organisations carried out activity and milestone schedule planning in the traditional manner to suit activity sequence and resource scheduling optimisation requirements. Strategic project management information was, therefore, desynchronised from upper management reporting events. If technological innovation projects are considered to be an extension of routine operations, this mismatch needs to be reduced or eliminated.

A dedicated process?

None of the providers and companies interviewed operated a comprehensive and dedicated innovation process, even though processes operating concurrently at different levels or across different functions in an organisation can be expected to improve innovation efficiency (Kanter, 1983; Murmann, 1994). Stage-gate processes (used by three companies) coupled with project portfolio analysis (not currently used by any companies on a formal basis) for example, provide key elements for an innovation process.

This lack of a cohesive approach to innovation is not surprising since earlier attempts by others defining and operating a process had encountered problems (Jelinek 1979). This probably is now mitigated by modern information and communication systems. The widely held view that no single route exists for realising commercial potential (Bray and Perry, 1994) can also deter advocates of an integrated innovation process.

Existing R&D provider processes rely on a mixture of individual project manager skills and an informally co-ordinated variety of project management tools. Emphasis is more on getting the job done (being effective) rather than on standardisation of processes (being efficient) therefore tools are not well integrated

into organisation systems and processes. Company innovation processes appear to start as informal linkages between tools, managers and reporting systems then grow into more formal systems as geographical dispersion and maturity occurs.

5.2.5 Systems and methods

Communication

Communication, described as the “negotiation of meaning”, is extensively needed for the innovation process (e.g. E2L) although not necessarily in a precise and durable form. F1’s efforts in using detailed checklists to promote project efficiency did not work but a simple fixed framework did. These examples demonstrate some pragmatic solutions and are a compromise between Mintzberg’s (1979) standardisers and creators.

A simple (albeit superficial) information flow was desired for managing innovation projects. Formal communication (downward) appeared to be essential for establishing organisational frameworks (the policies and rules) and for efficient upward feed of information, whereas informal communication was favoured and most effective for feedback (e.g. F2L). Fixed but open frameworks appear to work well for operational management (essentially for horizontal communication). Directives were perceived as unwelcome constraints to responsible staff members, who regarded them as dis-empowering.

Time, cost and resource usage was optimised using existing methods where detailed scheduling was practical. However, where there were many unknown activities, detailed resource allocation was usually impractical and unreliable. Detailed schedule information was, therefore, treated as directives of suspect quality, from project management staff and often disregarded.

In contrast, Internet or Intranet communication was seen as non-threatening because the recipient controlled engagement. As well, messages are convertible between producing and distributing formal and informal information. Therefore, innovation project managers might find flexible, familiar and less intimidating

formats more useful than traditional scheduling methods or representations (like Gantt charts).

Uncertainty and risk

While Shenhar (1999) incorporated uncertainty as a risk factor quantifiable in a general sense (high and low, for example) most authors avoid trying to quantify what by definition is not quantifiable. Risk analysis, however, is common. It is a fundamental attribute of PERT and is quantified by the calculated probability of completing an activity on time. Risk calculation traditionally requires knowing the Critical Path, three estimates of project duration and normal probability distribution curves. MacLeod and Petersen (1996) shows an elegant solution using two duration estimates in conjunction with a Beta distribution curve. Using time as a measure of risk is a convenient and accepted practice for planning and scheduling but those interviewed rarely used it for innovation projects.

The time-box approach, where uncertainty is related to specification creep, used by Mimno (1991), DSDM (1999) and Hung (1999) for developing software, has merit. Rigidly fixed short timeframes and resource allocations enable cost constraint but require functionality to be compromised if unforeseen events occur. This is particularly necessary where new technology platforms are frequent and is useful with a regularised product and captive and tolerant clients, a situation frequently found in software product development. Clients can therefore reasonably expect a minimum acceptable performance level and pay incrementally more for the functionality they can afford. This situation is analogous to some other types of evolutionary innovation, such as product upgrades, but is not often the case for revolutionary innovation. The time-box concept is therefore useful only for handling specific types of innovation projects.

Monte Carlo methods are most useful for assessing critical path robustness, but also requires information on a complete set of project activities and their interrelationships. This makes the method unsatisfactory for innovation projects.

Curiously, companies did not provide voluntary comment on systems and methods used to identify or manage risk or uncertainty. This may be because decisions to undertake a project had already been made and change in risk level did not need to be regularly reviewed. Alternatively, the companies may have thought that unless the project went for longer than the approved time, or budget or external factors over-rode the need for the project, it should automatically proceed. It was not evident that risk and uncertainty was or needed to be routinely considered at the operational level, although changes in risk were required to be reported (E2L). Cooper (1993), Matheson and Matheson (1998) and Menke (1999) all regarded risk assessment important for portfolio analysis (typically quarterly). Therefore, practice in assessing risks in innovation projects in New Zealand did not approach benchmark levels.

Planning and scheduling

Planning for innovation projects was reported in the literature and verified by interviewees in this investigation to be essential but was not necessarily accurate or precise. There is benefit in using small, even-sized, independent work packages as practical units for monitoring and control (Raz and Globerson, 1998; Humphreys and English, 1993; Frame, 1994). Consequently, for study in this research, there is merit in unifying the concepts of a time-box and a work-package into a calendar period (collectively called a time-block) to amalgamate benefits. Further, if these time-blocks could be tailored to suit the overall span of the innovation process and could be reviewed and revised on a regular basis, they could provide the framework for a useful innovation project process.

One company manager (E2M) suggested that review frequency depended on the stage of the project. Review frequency would presumably increase toward the end of the project to monitor the cumulative investment of resources. If this is important then a process that accommodates the change in time-block size from larger to smaller, at a review point, may be useful. Adopting time-blocks could require less detailed prescribed constraint on resources. Alternatively, by only specifically allocating precious or unique resources, their status could be recognised and their use more easily monitored at a higher level.

Empowering human resources so they can themselves determine how best they should spend their time each day is an important motivator especially for creative staff on innovation projects. To enable empowerment, staff must know the overall relative priorities of projects (Cooper *et al.*, 1998). A new control choice then becomes possible for executives. High priority projects are enabled to proceed as fast as approved expenditure rates permit or as fast as possible by not limiting their resources.

Innovation projects “come from anywhere” (E1M) and can be characterised even though “You guess how long things will take...at the beginning” (E2L). All projects were evaluated and approved to start before being formally adopted. Therefore, inadequate information was used to make firm plans, firm schedules or firm commitments to unconditionally support innovation projects. However, since early starts were considered important (as also argued by Twiss, 1992a), it is evidently more practical to first formally start the project and then incrementally improve the quality of project information. An innovation project system should therefore accommodate this prospect. The problem of deciding the point at which, an innovation project had started was a particular problem for internal projects done by research providers and companies. The problem of project approval was related to the poor quality and quantity of information used for evaluation. The very purpose of R&D, however, is to improve this quality and quantity! The “fuzzy front end” of the innovation process therefore, remained fuzzy and a prescribed process was required to deal with it.

The concept one manager in a forestry company (F1L) had of planning only for a 100-day horizon was investigated. The concept had derived from educational influences (a university course taken by his manager) using examples based on the marketing industry. This created the interesting situation where a forestry company with a 25-year product processing cycle needed to deal with strategic requirements that could be outdated in 3 months!

Electronics and food industries used quality systems, stage-gate processes and project management in conjunction with each other without problem. The ability of

forestry companies to maintain systems, however, was doubtful, probably because they lacked staffing capability due to disruptions in the immature industry and the wide geographical contribution to innovation effort.

Budgeting

The amount spent on innovation projects was generally fixed and the ways in which the total amount was allocated by companies (based on percentage of sales) aligned with Goslin's (1967) and Balachandra's (1996) expectations. Special additional provision was sometimes given to large strategic projects. The level of detail, particularly financial, was higher for large projects because large sums of money drew attention from owners and therefore executives. However, managers still needed to include large projects, which demanded organisational resources, in portfolios to balance resources.

While not palatable to some managers, the discipline of a "sunk cost" R&D regime has strong merit (see the F&P case in Poulin *et al.*, 1998a). The only purpose for recording separate expenditure against innovation projects appears to be retrospective assessment of the project's financial performance or that of its managers rather than for day-to-day control. In practice, innovation project financial review was rarely done on a formal basis except on large projects because it is difficult to attribute the exercise high priority and to allocate true cost and income contributions.

Purchasers and providers used project financial information to ensure that outputs were delivered before funding ran out. The quality of outputs, therefore, depended on the accuracy of initial expenditure estimates, the diligence of researchers, the difficulties encountered and the cost of overcoming them. Lower managers in provider organisations perceived contract change negotiation as either failure to plan well or failure to deliver on promises. The prevailing systems delivered ineffective project management and the perception of a high risk of failure. R&D providers needed to collect financial information mainly for accounting to purchasers for expenditure, a function already routinely done by organisation accounting systems! Therefore, there is little point in companies collecting

expenditure information for managing individual project management purposes. The exercise of retrospective financial information collection could be done within the existing company financial systems and did not need to directly relate to the project management. The financial information useful to all organisations (because it can be controlled) was the budgeted future costs and expected return from a project.

Monitoring

The evidence from interviews supported the inference that while methodical and formalised monitoring arrangements were beneficial, it was contrary to the practice and cultural inclination of project managers in New Zealand (Shane, 1994). This may be because of the small size of projects and teams, a high level of trust, and/or propensity for delegating responsibility to lower levels of project management. The level of monitoring and the type and quality of the information collected depended on the level of control required and the level of management that exercised control. The more hierarchical the organisational structure the more extensive the need for monitoring. Where speed of decision making was important, empowerment at lower levels helped (e.g. for E1 and E2). Regular and consistent project information monitoring was thought to be important for comparing alternative on-going projects. This was required normally weekly at the operational level and quarterly at executive level. However, there was no evidence of formal systems providing this desirable comprehensive arrangement in the organisations represented.

A common frequency, timing and type of monitoring information collection was desirable across portfolios, organisations and if more than one organisation were involved would usefully be done in concert.

Finding that progress estimation between milestones (typically about quarterly) by R&D providers (e.g. R2L and R3M) was unreliable and misleading does not bode well for using this method for process control. However, even if reliable means were found to assess progress, assigning additional resources may not be possible in specialist fields. In some cases the line of work originally intended may have

proven to be fruitless altogether. Therefore, attempts to recover the original schedule may not provide benefit. Consequently, more frequent interaction between researchers and management was considered desirable although not usually appreciated by researchers.

Widespread use of Microsoft Project for planning by lower level managers, but lack of updating, suggested that the required effort did not return adequate benefit. This may be because planning was too detailed and required great effort to update (E2L). Alternatively or additionally, informal communication in small teams and small projects and trust that best endeavours were being used, may provide a more acceptable and possibly more efficient and effective solution.

P1's monitoring of R&D purchaser's was characterised by reliance on national and international peer researcher processes for integrity. Therefore, reporting by publication was important for maintaining standards, disseminating knowledge and stimulating interaction with peers. Formal reports were more to account to the public for annual expenditure. P1's review processes appeared to be needed to verify that researcher peer collaboration and overall quality was maintained at a high level. This contrasted with R&D providers who used the monitoring process to help write business plans around major investments. Therefore, the same project was monitored by the purchaser for scientific quality and by the provider for potential business value.

Purchasers desiring greater "hands-on" control required more frequent monitoring. However, R&D providers also needed to update progress on the potential for exploitation. The evidence suggested that monitoring was best done at least quarterly. Direct consultation was sometimes used for high level monitoring but this did not guarantee that organisation executives were made aware of significant problems (R1L and E1L).

A purchaser (P4U) and two providers (R2M and R3M) expressly reported problems in assessing overall project progress. Many causes created difficulties including not knowing beforehand:

- all the steps required to reach a milestone or objective
- if any of the options would provide a satisfactory solution and
- if future steps would yield solutions adequate to maintain progress.

Frequent monitoring in these situations (R2M suggests 15 to 25 times per year) would more readily identify a problem, which could be addressed by allocating more resources or by trying alternatives. If the problem was larger than first thought, progress toward a solution could be justifiably less than previously reported (regression rather than progression). This situation requiring re-scheduling if not re-planning. Therefore, innovation projects needed to deal with changes in the unpredictable rate of problem-solving as well as variable markets, technologies and competition.

Weekly project reports and staff meetings and monthly reporting and review meetings were common for smaller projects in companies. Companies commonly conducted quarterly strategic reviews. Interview analysis verified a generalised pattern of reporting evident across the innovation project spectrum:

- Anytime - unforeseen major impediment to project progress discovered
- Daily - individual work allocation, informal monitoring and control
- Weekly - exception, issue and action list reporting
- Monthly - resource reporting (financial, human and physical)
- Quarterly - general, priority and strategic fit review
- Annually - fit with company vision and purpose.

Control

The literature review highlighted increasing complexity in the innovation project control problem (Rautianen *et al.*, 1999). A fickle market must be targeted using better technology through unpredictable innovation routes (Bright, 1964). Strong links to the business process (Thamhain, 1996) must be provided to accommodate the increased use of informal controls (Bart, 1993).

The purpose of control is to effect change so actual results match desired results. In traditional projects, the output is prescribed and stays relatively constant. In

innovation projects, the final output changes to meet actual need. A good indicator for “expected/desired result” in traditional projects is derived from “actual/scheduled progress”. The Gantt chart is a useful representation of this status. In innovation projects the schedule is unlikely to remain fixed. Therefore, comparison against schedule is not particularly helpful for control. However, information describing projected results and the route to achieve it becomes paramount. Gross control across portfolios means that innovation projects must be represented in the context of alternatives.

Change has a cost and consequence on project delivery and must be controlled (Frame, 1993). However, change control itself, adds cost. P2’s hands-on approach probably generates higher project management costs than, for example, P1 projects. Traditional project management control methods are expensive for innovation projects, especially where detailed effort goes into planning, scheduling and optimising prior to implementation. Reducing detailed planning should reduce change control costs but could also reduce the prospect of optimisation through activity sequencing and resource levelling. However, if speed is important to be effective in the marketplace (for example in evolutionary innovation), then less detailed planning may be desirable.

Project control is often effected by resource levels or scope adjustment. This typically needs to be authorised by senior management, who need justification for the change. Justification normally comes as information, (usually reports), traditionally written by lower level managers. These provide memory aids and a written record to justify recommendations and to provide an account for later actions. There is a conflict between the efficiency and effectiveness of informality and the reasonable requirement for documentation for accountability. Therefore, concise information in a useful form should accompany ideas through the innovation process.

Monitoring and controlling innovation projects was done at various levels in the organisations examined. Devolution “as low as possible” (R2U) had the advantage of moving decision-making closer to those with the highest level of technical information but further from those with strategic responsibilities. Rather than every

decision needing to rise through a hierarchy, the traditional project framework provides a way to ghost future activities with a high level of detail for prior approval. Senior management need only deal with significant changes and exceptions for realignment to strategy and vision. Innovation projects, however, are exposed to frequent pressures to change to remain aligned with customer needs, available technology and the actual progress toward achieving project outputs and outcomes. The number of changes and need for review is more likely to be related to elapsed time rather than accomplishing an activity or milestone.

There is role reversal evident in operational innovation projects when compared with traditional projects. In innovation projects, activity alignment (effectiveness) is more important at the operational level than activity achievement (efficiency). Activity achievement becomes the prime responsibility of strategic managers who need to ensure adequate resources are allocated to the most important projects in their portfolio. To facilitate efficiency, innovation projects would therefore sensibly be ranked and that rank declared to everyone who needs to know.

Companies perceived “getting a project under control” was about first tackling high-risk elements to reduce uncertainty (R&D) then setting and aggressively trying to maintain a schedule. Reducing project scope (and usually expected duration) provided a good control mechanism, ideal for incremental innovation but not helpful for long-term R&D projects. Companies found it difficult to justify doing their own R&D projects but reluctant to buy R&D directly from local providers. Instead they worked together in industry groups or imported proven ideas. There was little company commitment to be involved in fundamental R&D and poor integration of the total innovation effort. Creating a system to accommodate and integrate all phases of the innovation process, not just new product development, may help participants align their efforts and encourage better performance by individual companies and nationally.

Accountability

Kerzner’s (1997) commentary on the trends for project accountability concluded with the present joint responsibility between line and project management. This

reflects the more general view that everyone in the organisation shares ownership of accountability for innovation projects. If this is true then the responsibilities and authorities at each level in the innovation process should be made clear. Peters' (1992) description of accountability shows that individual accountability moved from the line manager in the 1960s, to the project manager, then through the entire organisation, to the customer in the 1990s. If this is to be realised more generally, the innovation process must be made transparent, even to the customer. This trend is evidenced by transparency needed by quality systems in the 1970s and 1980s and is supported by Kerr (1975) in his discussion of reward systems.

Research providers appeared to be the most compromised by accountability requirements. They have to provide formal accountability to their owners but also the variable requirements of their many clients. Standardising to meet the requirements of their most demanding customers is too expensive and inequitable. Tailoring to meet each customer's specific needs on an *ad hoc* basis is too inefficient. Therefore, the argument to standardise using time-blocks is proposed as a project information platform. If a common standard for innovation project information is widely used R&D purchasers can compare alternative providers. An additional advantage is ease of transfer of information between collaborators, partners and purchasers of partially complete innovation. Innovators and the national innovation system also need master only one project management system and a common base for costing.

Monitoring and control functions related to the organisation through recognised accountability paths. Higher level staff may be totally accountable to high level management but many staff also related to functional managers. Weekly reporting on small projects may be made directly to the project manager but an alternative is to appoint a time-block manager (or managers for multiple-site projects), responsible for activities within a nominated period of time (rather than a specified activity) in a specific location. A time-block manager could be selected to have specific expertise related to the phase or location of the activity. This proposal was in response to specific requests from several interviewees to keep control close to the action and to maintain face-to-face monitoring and control.

In summary, accountability arrangements the interviews inferred as desirable include:

- Anytime - individuals to advise urgent impediments to functional and/or time-block manager
- Daily - individual work allocation, monitoring and control (in conjunction with functional manager where appropriate)
- Weekly - exception, issue and action list reporting to time-block manager
- Monthly - resource reporting (financial, human and physical) to project manager
- Quarterly - general, priority and strategic fit review to project sponsor
- Annually - fit with company vision and purpose to governance board

Systems and methods trends

The following three trends were noted in the literature and observed in the interviewed organisations:

- a move to individual empowerment
- increased effort to provide access to innovation sources from both inside and outside the organisation and
- acceptance and need to institutionalise processes that can cope with a dynamically changing environment.

Existing systems and methods can accommodate these trends but traditional project management tends to better suit a stable environment rather than the environment of innovation projects. Individuals would like systems that are more useful than those currently offered to the extent that some had created their own (T2M).

5.3 Technological Innovation Projects

5.3.1 Overview

The categories of technological innovation described in the literature and by organisations provided for a wide variety of scope, size and level of uncertainty. If

the uncertainty level was low and duration short then simple traditional project management approaches could be used but would still not integrate well with business operations or be easily compared to other types of innovation projects. The on-going availability of technology improvement always subjects long projects to increased uncertainty.

Curiosity-driven scientific research is not truly independent of commercial drivers. Investors always expect benefit from investment. However, it can be difficult to determine at an early stage the type and level of benefit that might accrue. While levels of risk and uncertainty are high, the probability of success is never beyond estimation. Therefore, all technological innovation can be cast in terms of an innovation project and are amenable to management.

The isolation of researchers from the business process appears to be due to dislocation and creating barriers across the organisational innovation efforts (Allen, 1988; Gilbertson and Knight, 1992; MoRST, 1996b; Gordon and Bush, 1997). Part of the dislocation may be caused by differences in project timeframe and by the value customers and the organisations perceive that researchers, developers, producers and marketers have contributed. Management perceive operations as real-time short-term activity since they provide today's profits by which they will be judged. However, current product and processes owe their existence to earlier innovative effort sometimes referred to as "historical resource" (Barney, 1997).

If the benefits of innovation were only "knowledge creation" and "human capital creation" (PUa) the project would satisfy only intellectual and social needs. However, a platform is provided for potential future wealth creation. If economic growth comes through the tangible creation of wealth by applying knowledge, then innovation can be described as the sequential transition of knowledge into a tangible benefit. This means there is no need for process continuity or strong linkage between the stages. What is important is the usefulness and accessibility of findings so technologists looking for potential solutions can pick up earlier work efficiently and effectively (P2). Unfortunately, the more conveniently knowledge is

packaged the less likely it is to provide inimitable benefit unless it is secured or kept secret.

The corollary, that the benefit of innovation is only that it provides technologists with the ability to solve problems in new and useful ways, is also inadequate. This emphasises solving the problem rather than creating a benefit, and solutions become the domain of technologists rather than of innovators.

Innovation, then, is primarily about cost-effectively realising the vision of meeting a real need in a new and useful way. The vision may be quantified by dynamic specifications. Achievement of the vision requires solving problems. R&D and marketing both contribute to realising the vision, it is not the sole domain of engineering and production.

R&D providers had to generate benefit to their clients and provide a financial return to their owners. Evidence from interviews indicated the many problems of trying to make each project derive a financial return and the fortunate flexibility of reporting systems, which could be massaged to give the appearance of meeting targets. In an extreme case, R3 took on unavoidable uncertainties (like exchange rate fluctuations) and unknown technical risks, for essentially a fixed price and delivery by a fixed date. Two conclusions can be reached. Firstly, the R&D environment does generate high risk at the individual project level, which is not normally acknowledged by purchasers. Secondly, the individual project appears too small a unit to manage corporate risk and resources.

Companies had a much clearer focus on tangible financial benefit as the motive for innovation. Strategic motives like “market leadership” and intangible benefits like “reducing complexity” for innovation were difficult to quantify consistently but it did appear that project-by-project accountability is desired although not always obtained (E2M).

It is concluded that innovation projects are best managed separately but must acknowledge risk and be carried out in portfolios so that overall risk exposure can be mitigated.

5.3.2 R&D

R&D is said to resolve scientific or technological uncertainty (OECD, 1997). Open publication enables findings to be used and patenting secures the right for inventors to benefit from their efforts in exchange for proclaiming their novel solutions. One end-point of this kind of R&D activity may be obtaining a patent, since it provides the customer (the public) with benefit for which payment can be secured (often by the sale of licences). Unsecured “know-how” may be used in producing tangible products. If R&D reduces the uncertainty of innovation then its value can be assessed. R&D is therefore part of the innovation process rather than separate from it (c.f. OECD, 1997).

Frater *et al.*'s (1995) finding that the least likely source of innovation for new products comes from New Zealand government-owned R&D providers suggests gross dislocation of the national innovation process. It could be argued that Crown research does not produce appropriately targeted R&D results, the results may not be appropriable or the results are not reported in a way to catch the attention of companies. Catching attention is difficult enough to do within a company (T2M). One solution is to second government-based researchers to companies to try and emulate or supplement its own. Another solution could be to provide useful benefit-related measures for Crown projects.

Casler (1997) presented an example of milestone/corporate objectives reviews and Iyigun (1999) quarterly-based rolling reviews tied to a comprehensive researcher-generated project management information system, with some features common to the Texas Instruments OST process (Jelinek, 1979). Reporting may be tied to either milestones or calendar periods and relate to what has been achieved relative to a plan or to what is required to be done before a benefit can be realised.

Milestone reporting presumes that a milestone can be and has been met but more typically defines a calendar date when progress on a prescribed element of R&D is presented and where successful completion is expected. Failure to successfully meet milestones reflects badly on providers. Therefore, the prudent researcher or manager is tempted to set milestone targets related to process rather than output.

For example “that 12 experiments will be completed to determine the best means to achieve a task” rather than “that 12 experiments will be completed to determine the best means to achieve a specified performance for a task”. The former approach more easily meets milestone requirements but the latter is truly challenging and is typically required for tangible progress (Bishop, 1992). The latter presents considerably more risk of failure. Challenging milestones should therefore be set to suit convenient calendar dates and sensibly be assigned a probability of completion. By this means, regular reporting-periods can be prescribed and future milestones can be updated to suit current plans rather than original schedules (Leermakers, 1959).

Achievement was perceived as an indicator of past performance (if not progress) and how well the R&D effort has gone (P1). However, investors are more interested in the level of effort still required and the likelihood of appropriable success. The likelihood of future commercial return may relate to past research performance on the project but any such relationship is at best tenuous. Achievement reporting is mainly of value to the R&D community and records sunk effort rather than being useful to the economy or to guide future effort.

The annual 10% R&D budget change limit reported by Howard (1955) for a large US company is the same constraint used by FRST in New Zealand. However, there is a marked contrast between Howard’s requirement to report only on those efforts that took greater than 20% of a researchers time each quarter or Kerzner’s (1992) acknowledgement of “bootleg” work compared with the desire of R&D providers to schedule researchers at a detailed level. This suggests that these managers consider they know better than researchers themselves how to effectively use and therefore direct the use of researchers’ time. This contrasts to researcher views reported by Burgelman and Sayles (1986). Managers needed “to control” because they perceived themselves as being accountable for allocating resources rather than being responsible for providing an environment in which resources could achieve progress toward generating benefit (see Wren, 1979 to compare the strong similarities with Gantt’s ideals).

5.3.3 Revolutionary innovation

Hoban (1998) measured new product “success” by consumer criteria 39 weeks after its introduction to the market, which is more useful than measuring “success” by comparing actual with predicted values of project duration, cost and specification. These latter criteria only usefully monitor pace in complex well-defined situations. In any case, project benefit is more useful in determining success.

The definition of the point in time of when “introduction to the market” occurs is a problem for some companies interviewed in this research, especially for export-oriented organisations, and particularly when there are seasonal and distribution delays (E1). Financially related measurement points, such as “date of first sale receipt”, may be more useful.

Defining the start of the innovation process is also difficult especially if resource commitment and acceptance of responsibility does not occur until a project is formalised. Inevitably time is needed to collect information to evaluate a project. Evaluation must also be done at all levels and by all functions, particularly when looking for fatal flaws. Resource allocation for this effort appeared to come from an overhead so that it did not compete with operational project priorities. It was a “cost of being in business” (Karger and Murdick, 1972).

Kerzner’s (1997) example of risk management and discipline by using stage-gates and project management software in NPD, may be compared with the other extreme demonstrated by Baxter *et al.*’s (1997) findings where uninhibited human resource freedom created delays because of poor communication in highly-resourced complex software projects. Innovation projects may therefore be prone to poorly disciplined resources as well as management systems failure. Discipline is a fundamental attribute of technological innovators but so too is the inclination to test the *status quo* and ask the question “Why do we do this?” Non-compliance can be expected if there is no perceived value in compliance. Diligent staff are also expected to seek better (more effective) or alternative uses of effort if poor

(inefficient) use of their time is detected. Therefore locally overseen innovation process contributors may be expected to work more efficiently and effectively within broad guidelines rather than in compliance with detailed but anachronistic plans.

Traditional best practice to track progress and sustain urgency uses measurement against a prescribed or updated plan (Tabrizi and Walleigh, 1997). These measurements are comparative and internal to the project. However, the same effect could be produced by tracking the remaining effort required for alternative uses of funding (typically other innovation projects within the same “strategic bucket”) with respect to expected benefits. A sense of urgency is derived internally from the prospect that a worthier competing project could take priority, and externally from customer pull.

New Zealand puts less effort into NPD processes than does the US (Souder *et al.*, 1995) yet more reliance is placed export markets. However, the US has harsher product failure penalties, which may generate more diligent effort. It appears that more incentive than currently exists is required to persuade New Zealand companies to adopt systematic innovation approaches.

5.3.4 Evolutionary innovation

Evolutionary innovation builds on an existing base of product, process, technology or market often to extend product life and reap the benefit of invested effort. All companies interviewed had a major commitment to this form of innovation. The literature argues that increased speed increases cost but can improve market share and profit (House and Price, 1991; Smith and Reinertsen, 1994; Janszen, 1997) although Levene and Goffin (1997) is not convinced that there is always a benefit in speed. Speed was particularly important to the electronics companies but was not strongly evidenced in other companies. The practices in E1 and E2 bear out Smith and Reinertsen’s (1994) argument that well-trained people can out-pace most systems in this environment and that an early start is most important. Once recognised, an opportunity was assessed and addressed without delay. Waiting for a quarterly portfolio review meeting to grant resources, for example, may severely

jeopardise the chances of maximising benefit especially of short duration projects. Potential new projects, therefore, either needed dedicated rapid initial evaluation and review or use interim resource from overhead allocation. Review frequency for start-up projects, where project mortality could be high, would therefore sensibly be for example, weekly.

Project resource requirement normally builds up over time and information quality at the early stage is often unreliable. Early formal comparison with other projects is thought to be unwise (Cooper *et al.*, 1998). To tame the tyranny of the urgent it is wise to operate initial investigations with some discipline (Covey *et al.*, 1994). Therefore, competent people might best transform an idea into a formative project by appropriate, regular “non-project allocated overhead” activity within a simple calendar-based innovation process. Colwell (1999) would argue that this process is a valid and necessary use of the 50% of human resource time not allocated to project work.

5.3.5 Project Management

Purpose

The increasing interest in project management (in the context of organisation) is the inevitable legacy of technological specialisation and increasing size (Galbraith, 1968). While some revolutionary innovation follows this trend, evolutionary efforts usually build on existing specialisation and are small. Central to the theme of project management literature is the need to create and impose structural order and efficiency by standardising internal processes, particularly planning, execution and control (PMI Today, 1998). While not rejecting scope change, traditional project management is primarily designed as a sterile straight-jacket to avoid contaminating organisations from novelty and chance (Barkley and Saylor, 1994). Barnes (1990) recognised the benefit of always looking to the end goal. While acknowledging that only the future can be managed he presumes that only the resources originally approved are available to do the rest of the work.

Innovation project purpose is to maximise benefit. Therefore, managing the process should relate to effectively achieving this end-point by the most efficient means. In an uncertain environment it is easier to meet customer acceptability in the short-term by compromising functionality (not basic specification) rather than compromising delivery date or price, which is the argument for “time-boxes” (DSDM, 1999). While this may be true for customised software, especially for essentially captured clients, it may not be true for all market segments especially for discerning customers or where the prospects of follow-on products can be enhanced by investing time or money on a platform development (Howarth *et al.*, 1995). A generalised innovation project management solution must accommodate flexibility to change duration (and therefore delivery date), change cost (and possibly price) and change specification (and possibly functionality) right through to market launch.

Project management tools are required for even small projects (down to 3 months) where they may be less sophisticated but nevertheless comprehensive (Gilbreath, 1986; Fuezery, 1998). Gilbreath also considered the extent of planning detail required, suggesting that only imminent activity needed detailing (supporting Badenoch, 1964). However, EIM considered that the frequency of planning and review also depended on the stage of the project. While project stage, pace, duration and complexity may all be useful criteria to consider in determining the level of planning review frequency, overall duration predominates in innovation projects.

Organisations tend to deal with a range of innovation projects, which need to be compared regularly, so there is a temptation to use the highest frequency as a common denominator. Greater frequency provides more accuracy but only when activities are certain. Otherwise, planning effort, especially for the distant future, could be wasted. It is more useful to consider synchronising common considerations for projects and then select the level of planning to suit individual projects. Therefore, considering the literature and discussion already presented, quarterly strategic reviews, monthly resource allocation reviews and weekly issue and action reviews for all projects provide a useful framework. R&D projects often span several years and could be initially planned in quarterly time-blocks.

Revolutionary projects often last one or more years and could initially be planned on a monthly basis, whereas weekly time-blocks would suit evolutionary projects.

Risk and uncertainty

The main benefit of PERT is to quantify the risk of delay but it does require a known sequence of Critical Path activities, difficult to supply at a detail level across a whole innovation project. Likewise, the Critical Chain approach is useful but is only an embellishment to reduce bottlenecks in known processes. Time-boxes provide a useful concept but offer only a specialised rather than a generic solution for managing innovation projects. Many existing project management tools are already available but are not useful for innovation. It may be advantageous to have a new tool incorporating a risk management arrangement and time-blocks.

The call for high-level resource allocation capability (Levine, 1999; R2U) appeared to be a call for direct control by strategic planners and reflected a desire for hierarchical control not suited to motivating creative people. However, monitoring key staff is of potential strategic benefit. The performance of the people resource appeared to cause significant variation in effectiveness. If the maximum of only 50% of time is allocated to projects (recommended by Colwell, 1999) it is difficult to imagine sustained periods of combined effort to leverage synergy. However, the advantages of fully dedicated project staff can be countered by the need for staff to maintain external linkages and work on new project preliminaries. The best return on human capital is when a person is allocated to not more than two projects (Stephens, 1996).

The literature provides some useful guidelines for human resource allocation but the direction of day to day effort to maximise progress and motivation is best finalised by individuals in conjunction with their project and functional managers. This can sensibly only be done if the organisation makes staff aware of priorities and the level of resource currently allocated to the project. Thamhain's (1999) observations about the inertia encountered for project restart suggests project

managers be cautious about rapid swings in directing project effort. Project managers also do well to be “slow to chide and swift to bless” (Lyte, 1964).

Project completion

The various efforts of Balachandra (1985; 1989; 1996) to identify influential success and termination factors point to one of particular note. Projects that require frequent revision are said to “cause trouble”. It is not clear if this was because by nature they were difficult to plan (because of uncertainty) or if the traditional project management did not adequately cover this situation. Clearly revision requires extra administrative effort if done in a detailed fashion, increases cost considerably and may cause delay.

Five potentially convenient innovation project end-points might be:

- at hand-over for production
- date of first sale
- date of first sales income
- at break-even cash flow or
- at break-even for total project cost.

Hand-over is a traditional end-point but it is perceived as “R&D throwing a project over the wall to production, then running” (E2M). Follow-up work is always required (E2L) but typically tails off with time. Break-even cash flow is a pragmatic end-point since it does not require historical project financial information. However, hand-over problems may still be occurring. First sales date is difficult to determine where there is a long distribution chain (as for New Zealand exporters). Therefore, the date of first income is a more pragmatic choice since it can be observed rather than needing to be calculated. Finally, project break-even is difficult to establish particularly if a project results from a “spin-off” or is “bought-in” from another business. An end-point to ensure that the benefit stream is operational before declaring project completion is to nominate a financially related end-point, such as date of first sales income, and add a fixed period. This maintains effort and association by developers during the “teething-problem” period and does not presume that the project will be profitable. The fact that

innovation has occurred can be declared once the first customer has paid. Completion of the innovation process can be declared at the end of the fixed period.

In practice, project management information is collected almost exclusively for immediate use. Project related information (prices and performances on common tasks or R&D reports) may be stored for comparison with subsequent work but was not generally considered a good use of effort. A requirement for innovation project completion reviews is sometimes preached but rarely practised (E1M). Perhaps this is because future situations may not be similar enough to make valid comparisons.

A valid use for project information on traditional projects was to determine the reliability of past estimates to establish the level of confidence that should be given to estimates for future work. However, this is only useful for innovation projects if the market or technology remained constant, or if the understanding gained during the past project can be expected for a future project. The evidence indicated that changes made detailed trend prediction difficult and not beneficial. Thus, innovation project management information was useful only for immediate decision-making.

Summary

The purpose of project management was to predict the future state of a project. Traditional project management information compares updated past specifications rather than the potential to satisfy market requirements.

The evidence suggests that management want to allocate resources more efficiently and effectively. This is very difficult to do without intense reporting and information management. At the same time, creative people desire more control and autonomy with time to investigate ideas that could develop into future projects.

The availability of organisational project ranking and knowledge of the funded resource levels should enable most individuals to appropriately allocate their own

time. (In any case assistance and direction to errant resources inevitably falls to functional managers and project managers.)

5.3.6 Project Portfolios

The nature of project portfolios

Optimisation of five portfolio characteristics (innovative, aligned, valuable, balanced and optimal) demand that detailed comparison between projects is done regularly (Menke, 1999). In contrast, the best opportunities at any given time have been supported without resort to intensive portfolio optimisation practices (Poulin *et al.*, 1998a). In either case, comparing project cost, duration, risk and value is a reasonable minimum requirement but must be done on a consistent basis. Menke's argument for intensive "pipeline" (project execution) management, resource allocation and levelling requires a calendar-based process.

This research shows that New Zealand innovation project managers do not perceive benefits from doing anything other than planning and initial scheduling using project management software tools. Project size and complexity usually was not large but the desired pace was fast. Therefore as expected, the people-based methods used were perceived to out-perform the system-based options tried. Initial planning and scheduling provided indications of project cost and time frames. Risk and value were not usually used in the context of project management planning but rather in the context of financial and market analysis.

The warnings from Glasser (1982) and Kanter and Fonviele (1987) to consider factors such as internal support and evidence that the project might work (outside those found in common project metrics) indicates that management judgement factors should also contribute to assessing project relative ranking and project survival. Project metrics analysis cannot be sole portfolio arbitrators so effort in fully automating a ranking process would be wasteful.

Dimensions and risk

The bewildering array of portfolio dimensions and combinations of dimensions used to assist in determining project ranking and in optimising portfolios verifies

that no dominant model is evident, although there are some common features (Cooper *et al.*, 1998). One feature is aggregating risk into two categories, technical and commercial. This categorisation was traced back to Booz-Allen (1968) and appeared to be an anachronism from an age of strict functional responsibilities and linear innovation process models. This categorisation implied no significant interaction between R&D and marketing and did not accommodate an iterative, incremental or a dynamic customer-sensitive innovation process. Modern project management software incorporates activity duration risk analysis, which is only useful if a detailed complete schedule can be assembled. An alternative approach proposed here is to aggregate estimated risk progressively on a time-block basis for the project.

Matheson and Matherson's (1998) recommendation for risk measurement to be done in a consistent and repeatable way called for deeper consideration of the options already presented (Bright, 1964; Grunert *et al.*, 1997; Frame, 1998). The popularity and longevity of PERT, which uses activity duration variation as a measure of risk, provided the greatest appeal and was considered likely to be the most acceptable method to project managers. Duration is an intuitive risk measure and is usually related to the controllable unit of effort. Further, given enough time "things can be made to work," "sales will be achieved", or for accommodating uncertainty, "we can find a way around the problem".

Portfolio optimisation, which uses the ratio of net present value to net present cost ($\$NPV/\NPC) to rank the cost effectiveness of projects, was considered useful once primary sorting, categorisation and selection had been done (Matheson and Matherson, 1998). Using risk-adjusted financial measures appeared to appeal to owners.

Knutson (1999) and Englund and Graham (1999) proposed the use of project prioritisation whereas Cooper *et al.* (1998) regarded absolute ranking as vital for good portfolio management. Designating only priority category status could be said to give choice to lower levels of management whereas ranking gives specific direction. However, if upper management had adequate information for ranking

projects (including the political and “level of internal support” information to which they are expected to be privy) then clarity of intent can best be communicated through unique ranking (Dinsmore, 1998). Lower levels of management still have adequate flexibility at an operational level and have a mandate for action.

Overall, the combination “strategic/financial” models used by benchmark firms (Cooper *et al.*, 1999) were good first-order project portfolio approaches to emulate. Portfolio optimising and balancing are second order efforts that appear to be worth consideration.

The prospect of project portfolios in New Zealand

Automating and visualising portfolios for analysis, investigated by Archer and Ghasemzadeh (1996b) and Ghasemzadeh (1998) in North America, were considered useful for organisations confident of the value and quality of base information. The evidence in this research indicated that New Zealand organisations might not reach an equivalent level of confidence. The organisation must be careful not to rely on generating presentation-quality visual aids to impart undeserved importance to the outcome of a process that uses poor quality data.

Project portfolios were an integral part of policy implementation for R&D purchasers P1, P2 and P3 and is not yet relevant to P4, which had only one project. R&D providers on the other hand had less flexibility because bids needed to match the competencies of available staff and satisfy R&D purchasers. In a limited market like New Zealand, R&D provider portfolios were governed by the frames of interest offered by R&D purchasers (market pull) interpreted through specific bid responses (researcher push). However, changes in strategic direction could be effected by specifically directing NSOF money and retained profit and by extending the range of clients. This is necessarily done in an incremental fashion but can be vigorously pursued as a strategic direction. Therefore, R&D purchasers and providers should be able to actively manage project portfolios, but not with the same freedom to pursue direct benefit, as normal companies.

Companies had the advantage that they owned their portfolios and could uncompromisingly prioritise projects. R&D providers, however, undertook projects by way of contract and were obliged to commit agreed resources independent of the actual benefits evidenced as discovery occurred. The benefit P1 contracts provides was that if extra effort or diversion was deemed worthwhile the R&D provider could invest its own resources safe in the knowledge that it could secure and exploit any intellectual property that might accrue. In contrast, the provider needed to carry the risk of securing benefit from any additional investment of its own unless P2 could be persuaded that it was in the best interests of the industry to provide more investment. In either case, up-to-date project information about the costs, benefits and risk of future investment would be useful to:

- purchasers to inform policy decisions
- providers to inform investment decisions and
- companies to channel effort for maximal returns.

5.4 The Proposed TIPS Solution

5.4.1 Introduction

TIPS was developed to manage innovation projects acknowledging that only future endeavour can be influenced. The future envisaged at an early stage is liable to change, so plans need to be easy to update. Staff motivation needs to be high so self-directed effort and informed contributions demands systems that are open and transparent. A Microsoft Excel spreadsheet was selected as a repository for project information and review. Appendix D summarises distinctive features of TIPS presented to interviewees for comment. Discussion is presented here in the context of each group of features.

5.4.2 TIPS key features

Each project has a specified outcome, strategic category, net present cost and net present value, interest rate, date to income commencement, sponsor, manager and unique resource

An outcome and strategic category enables portfolio sub-division alternatives to aid quarterly portfolio review analysis. The term “outcome” was used initially (instead of the current “output”) to give the option of describing the aim in terms of, for example, “maximising the benefit” from exploiting an idea, patent or opportunity or to produce a tangible product or process.

The “strategic-buckets” method allows innovation project funds to be allocated. Comparing projects’ potential cost or potential value can make additional categories. Projects of equal time-block size can be grouped, however the selection of time-block size as a discriminator may be unhelpful. For example, short fast projects and long complex projects may both use weekly time-blocks. This can be avoided by selecting time-blocks according to project duration.

Present value was the method for benefit description most widely adopted by interviewees and strongly supported in the literature. The interest rate used for TIPS reflects the actual cost of money to the organisation for innovation projects rather than adjusted for specific project risk. The probability of completing each time-block was intended to incorporate all project risk, period by period. This means the value of overall risk for every project should be directly comparable.

The date income commenced is a definitive pre-cursor to project completion and is further discussed below.

The key people involved throughout the project are considered likely to be the sponsor, who represented the project to the executive and the project manager, who makes the project happen. The call for high-level resource management has been met by using individual empowerment through publishing project ranking and through resource allocation. Executive’s desire to allocate prime unique resources

was originally accommodated by including a unique resource field. This could be allocated to a champion or someone with a specific technical or motivational skill. Alternatively, this field could be a strategic facility.

Each project is reported or reviewed, daily, weekly, monthly, quarterly and annually at specified levels for specified reasons

Some organisations used fortnight (ten working days) or two-monthly report periods. However, there is potential confusion from using alternate regular periods and the overwhelming evidence for consistent regularity in the literature helped fix the periods adopted. The effect of nominating weekly or monthly time-blocks allows for frequent re-scheduling of projects to accommodate the consequences of fast pace or discovery.

A question arises of whether a mandate is retained for priority or resource allocation if re-scheduling is done between quarterly reviews. A project mandate retained between quarterly reviews provides stability but projects could be deliberately re-shaped just after review approval without re-course. Sponsor approval is consequently verified at each time-block.

Deciding action upon significant discovery (affecting project viability) is also important. A pragmatic rule is to immediately advise the sponsor or purchaser. Because there is a cost in stopping projects (Thamhain, 1999) it seems prudent for projects to continue until quarterly review unless the sponsor or purchaser calls a halt.

A fundamental problem evidenced by the research was the motivation for managers to undertake any re-planning or re-scheduling. Small changes to plans were perceived as not likely to significantly change already hazy futures or alternatively not be very helpful to progressing already well understood remaining activities. A common motivation was the value of a simple plan to demonstrate the consequences of delay to reluctant resource suppliers. A further motivation was withholding funds for subsequent work until plans were updated (or a milestone was reported). A pragmatic view is to insist on quarterly updates for all projects

and expect weekly or monthly time-blocked projects to be additionally updated at the end of each block to secure management support and thereby secure progress.

Project duration is from now (the current date) to a fixed date after net positive cash flow (or income commencement or sponsor approval of a tangible business plan for an R&D project)

Zero-based scheduling and costing is used to define the start of the project (i.e. the start is always at the start of the current time-block). Historical information worth keeping would be stored in other systems (e.g. financial accounts, purchase invoices and experimental records). Defining the end of the project was more difficult!

The TIPS description for project completion used in the original interviewee survey was later considered ambiguous. Calculating project completion date was originally defined according to the size of the project time-block selected. In each case a fixed period element (six times the time-block period) represents a period during which the income/benefit stream might be expected to have been firmly established. The trigger to start the fixed period was not as easy to specify. It was envisaged that cash flow might result from all weekly or monthly time-blocked projects and that only a tangible business plan resulted from quarterly blocked projects. In the latter case, a fixed period of six further quarters was selected as a nominal time during which the business plan could be implemented and start to provide a benefit. It is expected that most quarterly blocked projects would be wound up when the business plan was completed and a new project started specifically tailored to the plan's recommendations. Using these assumptions made it possible to visualise weekly, monthly and quarterly time-blocked projects to a point of stable income.

Net positive cash flow was initially selected as the project end-point trigger so that projects with a slow start to the income stream or high on-going costs could be considered viable. This also accommodated long distribution chains, which experience delayed income. The disadvantage is that net positive cash flow calculations need information about the way that any capital equipment required to

generate the benefit had been depreciated and the actual cost of borrowings. A calculation is needed to determine the date income and expenditure balance.

The point of income commencement is more readily determined (the day the first sales cheque arrives). Another advantage of using this measure is that all “future” benefits also start on that day, a measure commonly used by marketing. The convenience of defining this specific date is that future project development and commercialisation costs could be said to occur before then (\$NPC, called \$D and \$C in Cooper *et al.*, 1995, p 186) and commercial realisation of net benefits (income less costs of production) assuming project success, afterwards. The useful project portfolio dimension called Expected Commercial Value (\$ECV) must consider both \$NPC and \$NPV (sometimes combined and called the Project Net Present Value) together with the probabilities of achievement (Cooper *et al.*, 1995).

Time-blocks of equal duration (one week, one month or one quarter) are allocated to a project according to its expected duration (respectively, up to six months, six months to two years, more than two years)

Time-block sizes proposed in TIPS are selected by expected project duration to get an adequate yet manageable number of blocks for statistical and updating purposes (Mills *et al.*, 1996). However, while this might suit R&D projects it may not accommodate long, fast-paced projects in industry. An alternative strategy is to change the time-block size to project need (noted from EIM). More time would be required to re-adjust schedules between time-block sizes changes but it may be considered worthwhile or convenient (as in the case of an R&D project moving into commercialisation). However, because of the general reluctance in New Zealand for re-scheduling it seems prudent to use the largest feasible time-block size.

Each time-block is allocated a description (milestone), an optimistic and a pessimistic duration, a nominal cost and a block manager

The activities initially within and just beyond the time-block need to be considered so a challenging and realisable tangible goal that acts as the focus of achievement

for the time-block can be identified. A suitable activity end-point may fortuitously coincide with time-block completion. Alternatively, a low risk activity scheduled for completion beyond the time-block end-date could be compressed. A highly uncertain activity could be extended slightly to match the time-block duration. Optimistic and pessimistic duration estimates for the time-block could be selected to accommodate this adjustment. Activity descriptions in practice are only convenient constructs, and even in current regimes often are ill-defined.

Traditionally PERT requires estimates optimistic, pessimistic and likely duration of an activity to calculate an expected time. Interviewees overwhelmingly used CPM and not PERT, preferring to use single value deterministic rather than probabilistic estimates. TIPS calculations started with a nominal period (the time-block) and used two estimates to describe the probability of completing all the activities expected in that period. However, if there was reluctance to use activity-based PERT, was it any more likely that period-based TIPS would be used? T1L argued it would need to “improve his economics, make life easier or be fun” before he considered it. Alternatively, TIPS could be made a job or company requirement. The following are four significant tangible benefits of using TIPS rather than PERT:

- the number of duration estimates for TIPS are less than for PERT (two per period compared to three per activity),
- all estimates on TIPS directly relate to the probability of completing the whole project on time (since they are all on the critical path)
- the effect of any interactions between activities occurring within the time-block could be incorporated in the probability estimate and
- the level of challenge to achieve the milestone in the allocated time could be considered and incorporated in the probability estimate.

The costs of all activities within each time-block are added together. This rationalises costing by relating it to a period of time rather than a specific activity. Cost allocation and payment for individual contribution would, however, still need

to be done according to whether employment contracts were “to do the hours” or “to achieve a specific task”.

Designating specific time-block managers not only moves monitoring and control management “close to the action” to people dealing with specific phases of the project (e.g. R&D, engineering, marketing, sales) but provide career development opportunities.

A further query raised during general interaction with academics, companies and interviewees was how TIPS might accommodate multiple-site activity. The pragmatic solution is for the block manager to appoint separate site managers. Block costs at each site can be added together and separate optimistic and pessimistic duration estimates also made for each site. The values for the site with the highest optimistic and pessimistic durations are used in the TIPS spreadsheet.

Each project has a unique priority ranking

Internal publication of individual project priority ranking is necessary to fully devolve empowerment to the level of the individual. However, this is a most contentious issue for some as evidenced in the literature (Kerzner, 1992; England and Graham, 1999) and in some companies interviewed (F1). The concerns are, that the priority, if leaked, may declare strategic positioning to competitors, it may de-motivate staff working on low priority projects and it may induce diversionary political energy at the executive level.

Concerns about strategic security were already addressed by widespread use of project codenames. Projects often were only a current and partial manifestation of strategic intent. Clear declaration of project priorities has overall benefit to staff. It provides an unambiguous indication of the value of their efforts to the company and leverage appropriate reward and incentives for those striving for progress in their careers. The prospect of having consistent and regularly updated project metrics means that executives can make a more disciplined and rational approach to the ranking process, providing greater comfort and assurance to governance boards. However, those who may perceive diminishment of executive power

through adopting TIPS or similar systems could be expected to make implementation difficult.

Each project description is formatted on a separate spreadsheet page and a summary of descriptor values for each project is pasted on a common portfolio spreadsheet page

Aligning with the common practice of single-siding information for executive action was behind this requirement. Transferring complete files by email attachment was superseding transfer of hardcopy by fax. However, apart from the few companies reported by Cooper *et al.* (1998) the portability and ease of annotation still makes paper the preferred medium for individuals at meetings.

5.4.3 TIPS proposal feedback

Using duration rather than activity-completion for review is already being used in the software industry (time-boxes). However, TIPS is unique in substituting specific achievements within fixed periods in place of activities as the unit of acknowledging and assessing risk, producing dynamic project plans and integrating the innovation process into the operational fabric of organisations.

Responses to the TIPS survey covered a good cross-section of interviewees (all but one of the original organisations interviewed were represented). The necessarily brief description of an incompletely developed system produced some misunderstanding of detail and intent (e.g. individual empowerment was not emphasised). However, TIPS was generally acknowledged as potentially useful for companies, including research provider companies but was not considered specifically helpful for R&D funders serving public or broad industry good where adhering to policy was more important than maximising direct benefit.

There was a concern about the limited ability to accurately ascribe benefit in dollar terms for R&D projects. However, this problem besets all innovation project management systems and was not peculiar to TIPS. TIPS provides a way to formulate discounted project costs to a point in time where first income is delivered and estimate the probability it would be delivered on time. Marketing

provided discounted projections of benefit (\$NPV), which incorporates all associated risks after the date of first sales receipt. The question arose whether TIPS should incorporate the (\$NPV) calculation. The advantages of doing this are:

- \$NPV disclosure exposed marketing and sales staff to the same rigours of discipline required of R&D, engineering and production functions
- marketing was required to be tangibly involved and committed right through the innovation process and
- high risk areas of the innovation process were exposed and could be made the subject of particular attention at an early stage.

The disadvantages are:

- the speculative nature of marketing and sales predictions would be made highly visible and
- at least two extra columns were required on the spreadsheet potentially reducing readability.

The period for discounting project benefits is normally related to the type of project, typically 5 years for computer/electronics based projects, 10 years for mechanical plant and 25 years for physical structural projects. A standardised project spreadsheet calculating a net benefit flow over 10 years (later increased to 15 years) was consequently provided. The TIPS project spreadsheet page subsequently incorporated development and commercialisation costs, and future benefit income components for the “project net present value” calculation.

Electronics companies saw TIPS as a means of summarising projects for reporting and/or ranking within portfolios more than for providing individual project monitoring and control. This provoked a difference in perspective between traditional project management and innovation project management using TIPS. Traditional project management responds to the questions, “When should this activity be finished and what should be done next?” whereas TIPS answers the question, “What must be done by the end of the period?” Goldratt (1997) argued that traditional project management could be more efficient if it did not allow an early finish to be squandered. However, end-of-time-block milestones may be more

effective since they provide both tangible and natural temporal targets and the opportunity to “get a head-start” for the following period. Another benefit of not starting early is that options may be considered more thoroughly before action takes place. Alternatively, there may be an opportunity to divert spare resource to additionally support projects ranked most beneficial to the organisation.

The preference for teams and individuals to focus on only one project at a time (E2L) rather than flit between projects supported the view held by Goldratt (1997) but not the view held by Stephens (1996) or the compromise used by Colwell (1999). Built-in inertia to maintain R&D stability was promoted by P1 and Howard (1955) but would be difficult to rigorously apply in the context of a dynamic business environment. A rule that limited a change in ranking to say, one place each quarter might severely distort short-term project priorities. There are many factors that need balancing at an executive level during project ranking reviews. Therefore, a set of simple rules to govern the rate of change of portfolio rank for best results would be difficult to compile.

Food companies saw TIPS’ intent, to provide a simple means of alignment and integration with business practices, as new and important. Reducing system complexity had a corollary of increasing the need for complex issues to be dealt with by people, who are arguably better equipped to cope. Consequently to be useful, TIPS should enable aggregation of data and provide simple indicators to prompt and guide the direction of complex decision making processes. It could therefore “make life easier” (satisfying T1L).

Forestry company respondents also identified the benefits of TIPS as being able to indicate high-risk project components more readily, thereby freeing up more time to actually manage the project (deal with the complex issues early and “make it happen”).

5.5 TIPS Pilot Trials

5.5.1 Issues for Further TIPS Development

The TIPS Microsoft Excel spreadsheet proposed to the interviewees and revised to reflect their views formed the basis of the system used for the TIPS pilot trials. The pilot trial demonstrated that TIPS is a useful and potentially valuable approach to managing a wide range of technological innovation projects from “blue skies” research to product upgrades. It is useful in all project phases from the “fuzzy front end” to the “frenzied pace of production”.

Developing and formatting improvements were easy for the researcher during the trials because TIPS uses Microsoft Excel, a common and familiar software package. Familiarity with Microsoft Excel also encouraged participating managers to use TIPS and to explore ways to create and customise the functionality they desired. Block cost calculations, for example, was done variously by importing data from dedicated worksheets, by creating a formula within the field cell, by using a hand held calculator and writing a note on the cell Comments pad, or by directly entering in a value estimated from previous experience.

Three of the nine respondents were keen to see TIPS implemented in dedicated software. This would help improve the user interface but requires specialised software and training. Two of these participants were software specialists and the third had seen company specific competitive advantage created by having better interfaces and increased robustness and security.

5.5.2 Issues for Company R1

Company R1 had a very high need to implement a technological innovation system. The TIPS pilot trial revealed symptoms of inefficient innovation practices and identified where change might be considered. The perceived value of basing any new system on the TIPS approach was also very high.

Participants managing the “blue skies” project lead by C acted as “trustees” rather than “promoters” (Stevenson *et al.*, 2000). They appeared to see a greater need to manage their resources (to retain them) than to maximise project benefit for the organisation. Their project management practices therefore appeared to maximise resource utilisation and they consequently introduced and integrated multiple projects into their planning. This diverted focus away from the welfare of individual projects.

The TIPS pilot trial indicated that the R1 cultural environment may need to accommodate greater flexibility in resource allocation and management to allow managers of wealth creating projects to better attend to their work. Empowering human resources by identifying projects of high priority to the organisation should also help create a more stimulating environment.

5.5.3 Issues for Company E1

TIPS was expected to be of moderate value to E1 although all managers sensed its potential. However, the existing innovation process at E1 is discontinuous and does not appear to lend itself to maximising organisational benefit.

There are two distinct stages in E1’s innovation process. Firstly, feasibility studies carried out by marketing and technical staff who determine whether a product can be made and if it has the potential to be profitable or strategically beneficial. If an executive decision is made to proceed, a project is formally created and effectively unquestionably funded through to production. Technical achievability and financial profitability is therefore only tested at the feasibility stage. If a project is not considered achievable (i.e. it incurs indeterminable risk) it will not be given project status.

This staged process has two disadvantages. Firstly, E1 is in danger of not producing breakthrough products from time to time leaving it strategically vulnerable (Bright, 1964). Secondly, if relevant changes in technology or the marketplace occur during the “project” phase there appears to be no systematic mechanism for plan review or redirection. A TIPS-like process could be used to integrate the feasibility and project stages. Further, acknowledging that a small

percentage of risky projects are acceptable could present opportunities for breakthrough products.

5.6 Subsequent Issues

5.6.1 Are innovation projects special?

If innovation projects are seen as part of early phase operations, the motivational perception of privileged isolation, away from the drudgery of routine, may be lost. The urgency and excitement of Lockheed's "Skunkworks" effect (Meredith and Mantel, 1995) is a valuable asset. However, a more useful viewpoint is that innovation be seen as a main purpose or product for organisations. In this way, the "Skunkworks" effect, rather than being lost is distributed throughout the organisation for its enhancement.

5.6.2 How is resource allocation negotiated?

TIPS provided for resource allocation in terms of dollars but did not specify how the resource level should be negotiated or how work was allocated to individuals. When a project is set up, it is presumed that the pace is initially set by the project manager to maximise project benefit to the company. Projects would therefore be resourced to the level nominated or adjusted through the review process. Individual project members would still be allocated to projects by negotiation between project managers, functional managers and the individuals concerned.

5.6.3 Should there be full-time project staff?

Is there a case to have some staff fully allocated (rather than a maximum of 50% allocated) to one project? This is a decision for management and specific individuals. Sometimes both the project and staff will benefit, particularly if project pace is limited by the capacity of specialist contributors.

5.7 Implementing Change

The TIPS proposal survey feedback and the TIPS pilot trial feedback indicated sufficient interest to consider developing a TIPS-based package for industry trials. In line with feedback comments a software based package would need to be

provided. However, “complete buy-in” from the organisation would also be required to comprehensively test the portfolio management aspects of the system. TIPS cannot be fully tested on one project alone since its strength and purpose is in portfolio management capability. Therefore, all projects require an assigned priority ranking consistent with all other innovation projects in the portfolio.

5.8 Discussion Summary

This chapter has discussed relevant issues found in the literature review, the interviews, responses to a proposed technological innovation project management system (TIPS), and the TIPS pilot trials. The proposed system was found to have widespread intellectual credibility. Some shortcomings were dealt with in the pilot trial refinement process but user interface refinement may now be an issue.

Some misunderstanding of the TIPS proposal by interviewees was evident but overall feedback indicated a general understanding of prime intent. Comprehensive documentation and extensive trials are required before widespread implementation can be expected. The TIPS pilot trial indicated potential improvements to the innovation processes in both R1 and E1.

Chapter 6 draws together the conclusions from this research and proposes a way forward for implementing TIPS and areas considered fruitful for further research.

CHAPTER 6 – CONCLUSIONS

We should make things as simple as possible, but no simpler – Albert Einstein.

6.1 Introduction

Long term survival depends on an organisation's ability to innovate effectively and efficiently. Its innovation process should profitably translate the vision of a specific future into a tangible reality that meets actual needs. The level of uncertainty in achieving this process starts high, and tends to reduce as more becomes known about the technology, the market, the effort, the cost and the competition. The level of risk in achieving a beneficial outcome and the level of benefit that might be returned also becomes less uncertain.

To be effective, changes (especially in technology and markets) that may be unknowable when a project is planned, must be continually considered as part of managing innovation projects. Regular comparison and matching of predictive information about alternative organisational endeavours must also be made and will influence or perhaps halt innovation projects.

Efficient innovation management requires assembling systems to integrate strategy and structures. Methods and tools that optimise returns to the organisation for efforts expended are needed. Systems are most proficient in ordered environments, whereas appropriately skilled and competent people are better where order is still being created. Both these environments are encountered in the innovation process. It is most important to find a way to sustainably harness the creativity of individuals for the benefit of organisations.

This chapter addresses the six objectives formulated at the end of Chapter 2 in the light of new understanding and knowledge generated by this research.

6.2 How Technological Innovation Projects are Currently Managed

Fundamental research and early stage development projects in New Zealand are managed using project-event driven milestones, annual reporting and review processes. Public-good R&D is pre-selected and pre-controlled by adherence to government policy and screening of researcher quality. A “hands-off” management approach is adopted and R&D providers are encouraged to commercialise new knowledge by being gifted the intellectual property they generate. Industry/sector-based company R&D is “generic-customer” driven and is managed by a “hands-on” interest in projects to ensure output relevance. However, little or no regard is given to project uncertainty and an informal portfolio management style is used.

Very large and complex technological innovation projects are managed using traditional project management techniques (well summarised in PMBOK, 1996) sometimes supplemented by the more recent and increasingly popular stage-gate process (developed by Cooper, 1993). The former was originally developed for military, civil and power utility projects where clear necessity and a long-term commitment was evident and the pace of change in both technology and customer specification was slow. Sophisticated techniques commonly practised overseas, include, earned-value, resource optimisation, and risk simulation. There are few very large innovation projects in New Zealand and little use made of existing techniques.

Stage-gate processes are used for new product development especially within large overseas companies and by three out of six companies in the very small sample of companies interviewed in this research. These environments have a strong internal competition for resources and need to regularly review the potential benefits across a portfolio of projects. However, management within each stage is done using traditional project management tools. Average sized innovation projects in New Zealand (typically \$200,000, 12-months duration) are often formally planned and scheduled but not monitored or controlled by formal project management techniques. Managers use historical project financial information as a measure of tangible project financial performance by comparing current with earlier or (more

usually) original estimates. Personal communication between project managers and staff is used for motivation and to stimulate effort toward event, milestone or phase achievement.

Evolutionary projects in companies are short and more certain by nature than revolutionary projects. They are characterised by pace, to “catch the market” and “get return on investment”. Investment in these projects often includes production-related capital plant directly related to the project. Individual evolutionary projects are therefore adequately served by traditional project planning and scheduling tools although only complex projects appear to justify re-scheduling at a detailed level. Monitoring and control is done by informal interpersonal communication. The executive confers approval typically at quarterly meetings. Once approved, these projects are rarely stopped until “finished”. Therefore, although innovation is an essential and common goal in organisations, the projects, used as vehicles to make specific endeavours happen, are managed in various ways.

Traditional project management methods are used to plan, establish and gain support for an idealised process and to track progress. Projects are managed in relation to a “self-contained” template prescribed at an early stage when information and understanding is poor. Innovation project templates are not often formally revised in detail unless projects are very large. Typical innovation projects are not formally managed to track changing output requirements or to maximise benefits. Fortunately, regular but informal interaction of project-linked individuals occurs to progress projects to conclusion in spite of system inadequacies. Consequently, traditional project management methods and some practises reported in this investigation can hinder rather than promote effective and efficient technological innovation.

Stage-gate processes (including portfolio management) do promise help to integrate individual projects into organisational and strategic processes but do not mitigate the introspective shortfalls of the traditional project management approach and have not been successfully implemented into the New Zealand organisations interviewed.

6.3 Accountability

Innovation projects are ultimately judged by the net benefit they accrue rather than compliance with a plan. Greater benefit may be accrued if projects are carried out efficiently. However, first they must be effective. It may be true that benefit is maximised by prompt delivery of a specified output within budget. This presumes the accuracy of original plans, or alternatively regular adjustment of specifications and project investment to reflect improving quality of technology and market predictions.

For small organisations and small projects without dedicated project managers the advantages in formally updating project information are outweighed by the need for those who are accountable, to directly contribute to progressing the project itself. Informal updating is, therefore, almost invariably practised. This arrangement is usually locally effective and efficient but denies an organisation the capacity to fully integrate the innovation process into its fabric.

Accountability for innovation project performance is rightfully due to customers or purchasers and to the host organisation. The way these accountabilities are exercised appears to have changed significantly over the past four decades.

Accountability has been expressed to the organisation executive through the internal project hierarchy, the functional hierarchy or both, and thereby on to the customer. However, this research indicates that while delegating accountability downward through the organisation individual as well as collective accountability occurs in practice and may be the dominant contributor to customer satisfaction.

To efficiently facilitate individual accountability, relevant and regularly updated innovation project information should be made available to all those who need to know in a form they can understand and with which they can interact. Where the focus of activity or where project ownership involves multiple interested parties this information, and the way it is communicated, would sensibly be standardised.

In the context of a New Zealand national innovation system, a common information format that describes the status of innovation project prospects may be more useful than information that describes interim progress. A common format may also help develop useful interaction between R&D organisations and the associated industries and companies equipped to secure commercial rewards.

A standardised innovation project management format within organisations would help select, prioritise and rank projects in the context of sharpening corporate vision and implementing a strategy for growth through pursuit of innovation.

This research has also revealed a role reversal that occurs in innovation projects when compared with traditional projects. In innovation projects activity achievement performance (efficiency) becomes the prime responsibility of executive managers who need to ensure adequate resources are allocated to the most important projects in their portfolio. On the other hand, immediate managers and individuals should sensibly be directly accountable for the best use of their time to achieve good activity alignment performance (effectiveness). Put another way, human resource optimisation is not the prerogative of senior management for innovation projects. However, this new arrangement can only be practised if relevant innovation project information is current, transparent, and reflects the true priorities of the organisation.

6.4 Shortfalls in Current Innovation Project Management Practice

Innovation projects are traditionally treated as endeavours isolated from current income-generating operations. While some projects are inter-related in the context of programmes, they are formulated to finish at various stages toward returning realisable benefit. Project progress is traditionally measured relative to project-specific reference frameworks of dubious relevance to the organisation. Assessing achievement progress within these frameworks is subject to both genuine judgement and political convenience, since true values are unknowable. The only certainties during these projects are the money spent and the time and effort taken from project initiation, neither of which is helpful for future investment decisions.

Innovation project managers also find they need to provide both project-related reports and routine business-related reports, often with similar information to satisfy the same people but feeding different organisational systems or processes. This is inefficient and was confirmed in this research as likely to be ineffective as well as consuming extra cost and effort. The situation is exacerbated by additional customer imposed requirements, especially taxing on R&D providers.

Companies fund innovation project portfolios from a generally fixed base, usually as a proportion of sales income. Other organisations fund projects by legislation or by successful bidding. Funding on a portfolio basis acknowledges the uncertainty of gaining returns from individual projects and spreads investment risk. In addition, large projects may be separately funded. Although a greater level of specific project management effort may be expended on these projects it does not make them immune from competition for resources, change of fortune, uncertainty or risk. Although small evolutionary projects may be expected to garner more precise definition, they too should be included in the portfolio and also ranked relative to other innovation effort.

It has been found useful and beneficial to create “strategic buckets” within a technological innovation portfolio in which to allocate financial resources relative to corporate strategic intent. These “strategic buckets” can be defined in many ways depending usually on the type and size of the organisation. Portfolio analysis may also require comparing individual projects across a spectrum of categories. Therefore, each innovation project should be accorded a unique rank made known to all those accountable to the organisation for the investment of their time and effort.

Organisations should deal with risk and uncertainty not by isolating innovation projects from mainstream operations and using traditional methods but by integrating them and managing them in the context of dynamic and strategically focussed portfolios aimed at returning a future stream of benefits. A corollary is that marketing and R&D functions should rightfully co-exist within operations as prime customer interfaces supplying today’s needs and tomorrow’s needs

respectively. This is contrary to Mintzberg's (1979) organisation structure model and similar to his 1989 "organic" structure, which better allows organisations to exercise sustainable innovation.

6.5 Techniques Useful to Meet Existing Shortfalls

The problem of planning and scheduling from the present until when innovation project benefits are returned is that of identifying the content and dimensions of future activities. Traditional project management tools deal with planning and scheduling by identifying, but not detailing, distant activities until they are imminent. However, this still incurs difficulty in providing cost and risk estimates. Further, although scope variation is possible it is often deemed less difficult in practice to continue with existing warrants. Creating shorter and simpler incremental projects is a pragmatic solution but this reduces linkage with the future benefit and creates the potential for greater complexity within portfolios.

PERT and CPM have proven themselves useful in accommodating risk, uncertainty and resource optimisation but only where all project activities are well understood. The prospect of resource optimisation for innovation projects is likely limited by the scarcity of specialist resources, particularly in the New Zealand R&D context. Therefore, to have effective and pragmatic management and in spite of a desire by some middle managers to directly control resources, resource optimisation is rarely practised or actually needed.

The mechanics of the recent Critical Chain approach demand clear designation of scope and activities and therefore is not directly applicable to innovation projects. However, the principals of identifying and attending to potential bottlenecks early and trying to finish one (the most important) project at a time is supported in practice and worthy of generic application.

No evidence was found of an existing nationally coherent innovation system suiting both R&D organisations and companies. Integrating innovation into organisational fabric using traditional project management methods has already been done for

R&D organisations (Iyigun, 1999) and for large companies (Jelinek, 1979) and (Englund and Graham, 1999). However, considerable patience, diligence and discipline is needed to implement and operate these approaches. New Zealand managers involved in innovation do not commonly exhibited these attributes unless clear and direct benefit is evident to them.

“Time-boxes” (DSDM, 1999) used for rapid software development projects does not accommodate dynamically changing scope for long projects although it does demonstrate that regular progress review and regular re-assessment of goals for subsequent periods can be used for innovation project management. The “Time-box” method does not provide a way to deal with uncompleted tasks. When time (and money) runs out, the project just stops.

At the start of this research in 1995 the fast speed and convenience of fax communication was a key factor in formatting project summary information. Since then email and “web-based” communication between personal computers has provided even greater convenience. These media also provide easy transition between informal and formal presentation of information and help provide focus for selecting software standards. These new media facilitate monitoring and control as well as encourage the discipline of attending to regular computer interaction. Managers generally have keyboard skills and word processing and spreadsheet software competence. They find the concept of common and wide access to company information more acceptable than in the past.

6.6 An Integrated Solution

Organisations that desire to survive and flourish, if not become legendary, must properly manage technological innovation. Executive management must therefore take responsibility for supplying financial and human resources for innovation and acknowledge its inherent risk. The uncertainty of any one technological innovation project meeting market need at the expected time and with the expected return can be mitigated by managing a portfolio of projects and advancing resources only to a limited number of the most beneficial and strategically important prospects. The

most useful projects, once identified must have adequate resources and be continually monitored and controlled to provide output that meets market needs.

Information useful for project monitoring arrives at anytime at any level of the organisation. From time to time (sensibly on a regular basis) this information must be considered alongside project plans and schedules and the complete project portfolio. A spreadsheet (TIPS) to conveniently do this was proposed during this research. TIPS, a calendar-based project system was outlined to 16 managers involved with managing technological innovation projects. Their response showed that TIPS appeared to offer improvements over existing regimes. However, six out of the fourteen managers who responded positively wanted to see TIPS operating on a “real” project before committing to further investigation. Consequently, TIPS was further developed and a three-month pilot trial was run in mid-2000 successfully implementing it on three projects in each of two companies.

Action research was used to simultaneously refine and implement TIPS, and to determine its potential usefulness and value to the companies. Data from participant managers at the end of the trial indicated that project management information collected by TIPS was adequately comprehensive and very useful. Participants agreed that TIPS was better than existing arrangements at drawing early attention for corrective action.

TIPS methodology was rated very highly by one of the companies, six project managers and five technical managers. The second company rated the value of implementing TIPS as moderate. Respondents considered TIPS could be implemented in their companies within 12 months. One third of the participants thought TIPS might be better implemented in dedicated software.

This research has provided the basis for developing a more effective and more efficient way to manage technological innovation projects in an organisationally holistic context. An informed assessment has been made about what management actually requires and what time and effort all concerned are likely to be willing to contribute to improve present arrangements. System mechanics will undoubtedly

change and become more convenient in the course of time. However, system implementation requires the availability of a practical prototype for testing and trialing. Easy access to TIPS system information is required for widespread dissemination.

6.7 New Contributions from this Research

This research has conceived, created, developed and pilot tested a new way to manage the process of technological innovation (TIPS), from idea through to income or benefit generation. TIPS uses spreadsheets, familiar to all levels and functions of management involved in the innovation process, integrating project management into the operational fabric of organisations. TIPS provides for efficient and timely accountability, reporting and review at appropriate management levels, acknowledges and standardises risk and uncertainty characteristics and enables portfolios of projects to be managed strategically to optimise long term organisational benefit.

This research supports the view that traditional project management approaches are useful where scope and activities are well defined and understood, completion is expected, technologies and markets are stable and projects are very large.

The technological innovation project management approach, TIPS, is useful where the scope is from idea to income (benefit) receipt, idea mortality is high, technologies and markets are unstable and where portfolio management is used to optimise benefits from projects.

It is expected that TIPS will usefully manage non-technological innovation projects and suit the needs of managers and organisations in other countries.

6.8 Recommendations for Future Work

TIPS should be further developed and should consequently provide a useful alternative for managing technological innovation projects. Future work should:

- investigate practicalities and benefits of dedicated software platforms

- review options for web-based, platform integration arrangements used by leading organisations
- simplify and standardise TIPS format and procedures
- make TIPS readily available for comprehensive research trials
- report further advances for peer review.

TIPS may provide the common language for integrating technological innovation projects nationally so should be presented for debate to those who shape New Zealand's future.

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Appendices

APPENDIX A List of R&D Purchasers and Providers

R&D Purchasers	
Government/SOEs	Foundation for Research Science and Technology Coal Corporation Electricity Corporation/Transpower Forestry Corporation Land Information Meteorological Services New Zealand Post Television New Zealand Works and Development
Producer Boards	New Zealand Dairy Board New Zealand Wool Board Meat Research and Development Council New Zealand Kiwifruit Marketing Board Apple & Pear Marketing Board
Other Purchasers	Agricultural Marketing Research and Development Trust Health Research Council Lotteries Board
R&D Providers	
Crown Research Institutes (9)	Agricultural Research Crop and Food Research Institute of Environmental Science and Research Geological and Nuclear Sciences Horticultural and Food Research Industrial Research Landcare Research National Institute for Water and Atmospheric Research New Zealand Forestry Research Institute
Research Associations (10)	Building Research Association of New Zealand Coal Research Association Dairying Research Corporation Dairy Research Institute Heavy Engineering Research Association Leather and Skin Research Association Logging Industry Research Organisation Meat Industry Research Institute of New Zealand Pulp and Paper Research Organisation Wool Research Institute of New Zealand

APPENDIX B Introduction and Questionnaire for R&D Organisations

[On University of Waikato Headed Paper]

Date

Address

Dear [],

Research into Improved Management of Innovative R&D Projects

I am doing a [PhD] degree thesis in technology management on the topic of R&D project management techniques and request your assistance for our mutual benefit.

I believe there is a need to ensure formal accountability to both purchasers and providers of technological R&D but at the same time provide an environment where innovation can flourish. Project management techniques are normally associated with the delivery of work on time, within budget and at a “known” quality. Techniques span activities from project selection to post-project evaluation, however, quantitative information for innovative R&D projects is not easy to obtain or update. I would like to identify the level of project accountability required and desired by both purchasers and providers of R&D as well as the techniques currently used for its achievement. Mismatches between requirements, desires and actual performance will be identified, investigated and recommendations for alignment made.

I am approaching R&D purchasers including Government, SOE’s and Producer Boards as well as providers including Crown Research Institutes and Industry Research Associations. It is proposed that one hour “in-depth” interview be held with you or a nominated senior manager as a representative of your organisation sometime during late May, June or July 1995 to collect relevant information. A list of guideline questions to be used in the interview is attached.

Information obtained will be held as confidential. It is anticipated that generalised preliminary findings be submitted for publication by the end of 1995 and a copy sent to you for your information. It is expected that the work will be developed to include comparisons with New Zealand companies and investigations overseas. Peter Winsley, Policy Director at FoRST is aware and supportive of this proposal. A copy of my summary CV is attached for your information.

I would appreciate you considering this request and returning the enclosed fax response form at your earliest convenience.

Kind regards,

Bob Mills
Senior Lecturer

APPENDICES

8 May 1995

Bob Mills

Framework for conducting in-depth interviews

R&D (Technological Innovation) Purchasers

1. How does your organisation decide how much it will spend on R&D (technological innovation) projects? How much does it spend?
2. How are project topics and providers selected? How many projects are you funding? How many R&D providers do you use?
3. What tangible and intangible returns/benefits do you expect from your investment in R&D (technological innovation)?
4. How do you measure or assess the returns/benefits from your investment at the project level? How satisfied are you with the measures you use?
5. What organisational structures and management systems do you have in place for the management of the R&D (technological innovation) projects you fund?
6. What forms of agreement do you have with providers?
7. What formal accountability do you require from your providers for reporting achievement (aims, time schedules, expenditure and quality of output)? How satisfied are you with the accountability given for each of these?
8. How do you monitor progress (aims, time schedules, expenditure and quality of output) on each project? How satisfied are you with the techniques used?
9. How do you control progress (aims, time schedules, expenditure and quality of output) from the monitoring information you receive? How satisfied are you with the techniques used?
10. How do you use the project management information you receive? How could you make better use of the information?
11. Does your organisation desire more accountability from providers who work on projects you fund? If so in which areas?
12. In what ways do you think appropriate project management could give you better returns on your investment?

8 May 1995

Bob Mills

Framework for conducting in-depth interviews

R&D (Technological Innovation) Providers

1. How does your organisation decide how much resource it will commit to the R&D (technological innovation) projects they undertake? How much income do you derive from R&D projects?
2. How are project topics and purchasers selected? How many projects are you doing? How many purchasers do you work for?
3. What tangible and intangible returns/benefits do you expect from your investment in R&D (technological innovation)?
4. How do you measure or assess the returns/benefits from your investment at the project level? How satisfied are you with the measures you use?
5. What organisational structures and management systems do you have in place for the management of the R&D (technological innovation) projects you provide?
6. What forms of agreement do you have with purchasers?
7. What formal accountability do you offer purchasers for reporting achievement (aims, time schedules, expenditure and quality of output)? How satisfied are you with the accountability you provide for each of these?
8. How do you monitor progress (aims, time schedules, expenditure and quality of output) on each project? How satisfied are you with the techniques used?
9. How do you control progress (aims, time schedules, expenditure and quality of output) from the monitoring information you receive? How satisfied are you with the techniques used?
10. How do you use the project management information you generate? How could you make better use of the information?
11. Does your organisation desire more accountability from your project teams? If so in which areas?
12. In what ways do you think appropriate project management could give you better returns on your investment?

APPENDIX C Introduction and Questionnaire for Companies

[On University of Waikato Headed Paper]

Date

Address

Dear [],

Research into Improved Management of Technological Innovation Projects

I am doing a [PhD] degree thesis in technology management on the above topic and request your assistance for our mutual benefit.

I believe there is a need to ensure formal accountability for technological innovation projects but at the same time provide an environment where innovation can flourish.

Project management is normally associated with the delivery of work on time, within budget and at a “known” quality. Existing techniques cover activities from project selection right through to post-project evaluation. However, innovative projects are often perceived to be inadequately managed because quantitative information is not easy to obtain or update.

I would like to identify the level of innovation project accountability required and desired by companies. These will be compared to techniques currently used. Mismatches between requirements, desires and actual performance is expected to be identified and better project management regimes will be developed to try and solve these problems.

To this end I have already interviewed and analysed discussions with 13 R&D project managers in Government, Crown Research Institutes and Industry Research Associations. Some findings have already been reported in the enclosed New Zealand Chapter of the Project Management Institute Conference paper. I would now like to get a company perspective on the problem.

To do that I would like to conduct an individual “in-depth” interview, lasting less than one hour with each of 2 managers from your company. One manager should be at a senior level routinely involved in selecting and managing a number of innovative projects (a project portfolio manager) and the other should be someone who manages 2 or 3 of those projects at an operational level. A list of guideline questions to be used in the interview is attached.

Information obtained will be held as confidential. The information is expected to contribute to the development of a practical innovation project management system to be piloted later in 1997 by as yet undefined companies and organisations, your company may be interested in doing this? It is anticipated

APPENDICES

that generalised preliminary findings be submitted for publication by the end of 1997 and a copy be sent to you for comment and information.

I would appreciate you considering this request and returning the enclosed fax response form at your earliest convenience.

A copy of my summary CV is attached for your information.

Kind regards,

Bob Mills CEng., MIMechE., FIPENZ.
Director, TMI Unit,
Senior Lecturer, Centre for Technology and
Technology Management Consultant

APPENDICES

21 January 1997

Framework for conducting in-depth interviews

Technological Innovation Projects in Companies

1. How does your company decide how much it will spend on technological innovation projects? How much does it spend?
2. How are innovation projects and project teams selected? How many innovation projects are being funded within your part of the company? How many innovation project organisations do you currently draw from?
3. What tangible and intangible returns/benefits does your company expect from your investment in technological innovation?
4. How do you measure or assess the returns/benefits from your investment at the project level? How satisfied are you with the measures you use?
5. What organisational structures and management systems do you have in place for the management of technological innovation projects?
6. What forms of agreement do you have for delivery of technological innovation projects?
7. What formal accountability do you require from project teams for reporting achievement (aims, time schedules, expenditure and quality of output)? How satisfied are you with the accountability given for each of these?
8. How do you monitor progress (aims, time schedules, expenditure and quality of output) on each project? How satisfied are you with the techniques used?
9. How do you control progress (aims, time schedules, expenditure and quality of output) from the monitoring information you receive? How satisfied are you with the techniques used?
10. How do you use the project management information you receive? How could you make better use of the information?
11. Does your company desire more accountability from technological innovation project teams? If so in which areas?
12. In what ways do you think appropriate project management could give you better returns on your investment?

APPENDIX D The TIPS Proposal Sent to Interviewees (1999)

[On University of Waikato Headed Paper]

14 October 1999

Address

Dear [],

Time-block Innovation Project Management System (TIPS) Bob Mills PhD Thesis

I have been doing research on managing innovation projects since 1995. Almost everyone I formally interviewed or talked to expressed dissatisfaction with the methods they were using.

I have assembled a method (TIPS) that goes some way to meeting the needs highlighted by my research findings. The method outline is attached for your consideration and interest.

The final part of my thesis data collection is to report feedback on the method. Could I therefore ask you to consider the TIPS method presented here and answer these two questions?

- 1. In what ways could TIPS potentially better meet the innovation project management needs of your organisation?**
- 2. What changes or modifications to TIPS are necessary before your organisation could consider implementation?**

I have outlined the TIPS method to project management professionals in New Zealand and last month in the USA at the Portland International Conference on the Management of Engineering and Technology, Oregon. Strong interest was shown from academics, researchers and representatives from high-tech industries (including Hewlett-Packard).

I enclosed a fax sheet for your reply or please email me at: b.mills@waikato.ac.nz. I look forward to hearing from you.

Kind regards,

Bob Mills, CEng, MIMechE, FIPENZ
Senior Lecturer, Department of Materials and Process Engineering

mape

Department of Materials and Process Engineering

Date _____

To: Bob Mills, Fax: 07 838 4835, (as soon as possible)

TIPS Industry Response Survey

1. In what ways could TIPS potentially better meet the innovation project management needs of your organisation?

2. What changes or modifications to TIPS are necessary before your organisation could consider implementation?

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Process Engineering
The University of Waikato
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The
**University
of Waikato**
Te Whare Wānanga
o Waikato

From:
Contact details:

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Department of Materials and Process Engineering

Related Files: Time-blocks.doc, Time-blocks.xls, Time-blocks.ppt
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The
University
of Waikato
Te Whare Wānanga
o Waikato

Time-blocks Innovation Project System (TIPS)

Introduction

TIPS is an innovation project and programme management system developed at the University of Waikato, New Zealand. It is specifically aimed at businesses and organisations that want to better manage the translation of ideas into income.

TIPS has been designed to help link together:

- Individuals, businesses and corporations
- Operations, tactics and strategy
- Accountability, reporting and actions
- Uncertainty, risk and return.

It conveniently uses Microsoft Excel software and can be configured to be web-based.

What TIPS does

TIPS is designed to manage the technological innovation process where technology and markets are changing unpredictably. Each idea is described as a project on a one-page spreadsheet. The sheet provides a customised script for the innovation process and is regularly updated. It shows potential benefits encapsulated as “\$NPV” and the associated uncertainty and risk aggregated in “the probability of completion on time”.

Projects are reviewed for operational, tactical and strategic performance and updated weekly, monthly or quarterly. Individual project data is linked from separate worksheets to a composite one for portfolio analysis and for assigning overall priority.

What TIPS doesn't

TIPS does not integrate project resource management at a detailed level. If required, existing accounting packages or project management tools may be used. Monitoring and control should in any case be done using direct one to one communications on a day to day basis.

What's New

Projects are traditionally described as “specified endeavours bound by limits of time and budget”, where certainty and control are reasonable expectations. But life is not like that. During the past 80 years projects have become increasingly popular for introducing new products, processes, systems and services within the context of organisations and businesses. Projects are usually set apart from normal operations and managed as networks of inter-related but discrete jobs or tasks.

The logic and simplicity of Gantt (bar) and PERT (network) charts have been enduring project management tools reinforced by the general application of computerised charting as early as in the mid-1960s. Starting in the 1970s “Stage-gate” methods also became popular for new product development. Project stages are completed and reviewed at gates to confer approval and comparative ranking. In the 1990s the software industry has developed “Rapid Application Development” methodologies using “time-boxes” to try to bring software in on time.

Since the 1980s innovation has become more widely recognised as a key source of sustainable competitive advantage. The welfare and progress of projects that contribute to the innovative capacity of companies have therefore become of greater tactical and strategic interest to management. Significant innovation projects, however, usually extend into the realms of uncertainty by involving new knowledge and new markets. There is also strong interest in recent literature concerning reduction of time-to-market, increased flexibility to respond to changing market signals and the ability of projects to transfer across organisational barriers. There is now a growing realisation that existing project management methods are inadequate. Innovation project success is about enabling successful business outcomes, not trying to comply with initial time, cost and quality criteria. There is also an increasing pressure for companies to aggregate and better manage portfolios of innovation projects.

Further, the timing of traditional project management decision-making is focused on activities and events rather than on the business calendar. Organisations and businesses therefore contend on the one hand with operational decision-making at times to suit the convenience of various project schedules and on the other with tactical and strategic decision-making to suit the monthly, quarterly and annual demands of accountants, managers and owners. Innovation projects have become an inseparable part of business but the way they are managed does not reflect this fact.

How then can innovation project management methods better fit the needs of today's companies? And how can the effects of change and uncertainty be accommodated?

TIPS has been developed for all types of organisations and businesses involved in the innovation process. It is based on research into the needs of New Zealand managers. And it is intended to become a common vehicle to describe the status of innovations internally and to potential external partners and contributors. TIPS can be simply implemented in Excel. This is how it works.

Managing innovation projects and project portfolios using TIPS

1. Select the appropriate time-block size according to project duration:

Up to 6 months - choose **weekly** (e.g. evolutionary, enhancement, support)

6 months to 2 years - choose **monthly** (e.g. revolutionary, new products)

2 years or more - choose **quarterly** (e.g. R&D, blue skies, curiosity)

- All projects start with Project Sponsor approval and allocation of priority number
- Week-block projects finish, say, 6 weeks after income commencement
- Month-block projects finish, say, 6 months after income commencement
- Quarter-block projects finish, say 6 quarters after Sponsor approval of a tangible business plan.

2. Create and complete the TIPS project Excel worksheet:

Project Description fields are:

Priority (a unique organisation-wide current priority number set quarterly)

Project Name (concise and imaginative)

Project Outcome (e.g. new model, new process, new technology)

Strategic Category (for portfolio analysis: e.g. by market, product type)

Time-block size (week, month, quarter)

Project Sponsor (senior/corporate management/owner)

Project Manager (business management/facilitator)

Unique Resource (a nominated individual considered key to success)

Net Present Value (given success) (\$NPV)

Interest Rate (used for \$NPC and \$NPV calculations)

Worksheet Details (for each sequential time-block):

Block End-date (next rescheduling review date)

Block Managers (responsible for all activities in each time-block)

Block Descriptions (incorporating tangible and challenging milestones)

Optimistic duration (days, only say, 1% of the time would you finish earlier)

Pessimistic duration (days, only say, 1% of the time would you finish later)

Net Cost (\$ cost of all resources and commitments in the block, less sales)

Date to Income Commencement (notional for quarter-block projects)

Worksheet Calculates:

Probability of reaching the completion date on time (aggregates technical and commercial uncertainty and risk on a block by block basis for the project)

Probability of completion after one further time-block (sensitivity)

Net Present Cost to complete (\$NPC)

3. Get Sponsor approval and initial unique priority number

4. Run selected projects (project staff consider priorities to negotiate conflicts)

5. Report/Review as follows:

Daily – individual work allocation, monitoring and control

Weekly - exception, issue and action list reporting to Block Manager

Monthly - resource reporting (financial, human and physical) to Project Manager

Quarterly - general, priority and strategic fit review to Project Sponsor

Annually - fit with company vision and purpose to Governance Board

6. At the end of each time-block re-create the worksheet for each project.

APPENDICES

Bob Mills, University Of Waikato, Revision 1

INPUTS (inside double lined boxes)	
3	Priority (sponsor defined)
Heightech	Project Name (user defined)
New Technology	Project Outcome (user defined)
Blue skies	Strategic Category (sponsor defined)
Quarter	Time-block size (user defined)
B.Wig	Project Sponsor (user defined)
A.Nerd	Project Manager (user defined)
C.Clogs	Unique Resource (project manager defined)
1250	Net Present Value given success (\$'000) (user defined)
10	Interest Rate % for \$NPC and \$NPV calculation (sponsor defined)(Not yet automatically calculated)
31-Dec-06	Date for Income Commencement (Not yet automatically calculated)
RESULTS	
0.255	Probability of success at end date
0.429	Probability of success at end date + 1 time-block
1067	Net Present Cost to Commencement of Income (\$'000)

WORKSHEET

TIPS Project Worksheet (Quarterly)

Activity Block Data Input Section						Activity Block Calculated values				
Block End-Date	Block Manager	Block Name or Milestone	Duration Estimates (Days)		Net Nom. Cost \$ ('000)	Calculated Duration, Te	Completion probability, p			\$ before income NPC\$('000)
			Optimistic, a	Pessimistic, b			at 90 days	at 100 days	Difference	
31-Mar-00	I.First	Preliminaries	80	90	3	84	1.00	1.00	0.00	1067
30-Jun-00	T.Me	Market Research	60	120	8	84	0.69	0.69	0.20	1064
30-Sep-00	M.Turn	Literature Search	80	150	18	108	0.10	0.32	0.22	1057
31-Dec-00	M.Next	Competitors	60	90	28	72	1.00	1.00	0.00	1040
31-Mar-01	M.Next	Technical Options	60	450	40	216	0.03	0.05	0.02	1015
30-Jun-01	M.Next	Market Options	30	150	18	78	0.69	0.80	0.11	979
30-Sep-01	M.Next	Market Sizing	30	150	25	78	0.69	0.80	0.11	964
31-Dec-01	M.Next	Draft Product Specs	60	90	43	72	1.00	1.00	0.00	943
31-Mar-02	M.Next	Technology Forecast	80	150	18	108	0.10	0.32	0.22	908
30-Jun-02	M.Next	Research Proposal	60	100	18	75	0.95	1.00	0.05	893
30-Sep-02	M.Turn	Bench Trials	60	150	28	96	0.41	0.60	0.19	879
31-Dec-02	M.Turn	QFD Analysis	80	120	35	96	0.26	0.69	0.43	868
31-Mar-03	M.Turn	Proto. Design	60	180	55	108	0.26	0.41	0.15	832
30-Jun-03	M.Turn	Proto. Fab.	30	150	55	78	0.69	0.80	0.11	792
30-Sep-03	T.Me	Proto. Test	30	180	75	90	0.52	0.64	0.11	753
31-Dec-03	T.Me	Proto. Optimize	30	150	38	78	0.69	0.80	0.11	701
31-Mar-04	T.Me	Lead User Trial	60	150	50	96	0.41	0.60	0.19	676
30-Jun-04	T.Me	Production Options	60	120	45	84	0.69	0.69	0.20	643
30-Sep-04	T.Me	Tool Options	60	110	53	80	0.82	0.97	0.15	614
31-Dec-04	T.Me	Assembly Options	60	135	33	90	0.52	0.74	0.21	581
31-Mar-05	T.Me	Marketing Options	60	150	40	96	0.41	0.60	0.19	561
30-Jun-05	T.Me	Draft Business Plan	80	100	68	88	0.69	1.00	0.31	537
30-Sep-05	A.Mine	New Product Design	80	100	100	88	0.69	1.00	0.31	497
31-Dec-05	A.Mine	Engineering	80	100	200	88	0.69	1.00	0.31	441
31-Mar-06	A.Mine	Production Setup	80	100	300	88	0.69	1.00	0.31	330
30-Jun-06	A.Mine	Production	80	100	300	88	0.69	1.00	0.31	168
30-Sep-06	A.Mine	On Sale	80	120	20	96	0.26	0.69	0.43	10
31-Dec-06	A.Mine	Sell Offshore	80	120	-100	96	0.26	0.69	0.43	
31-Mar-07		Extra period	0	90	60	36	1.00	1.00	0.00	

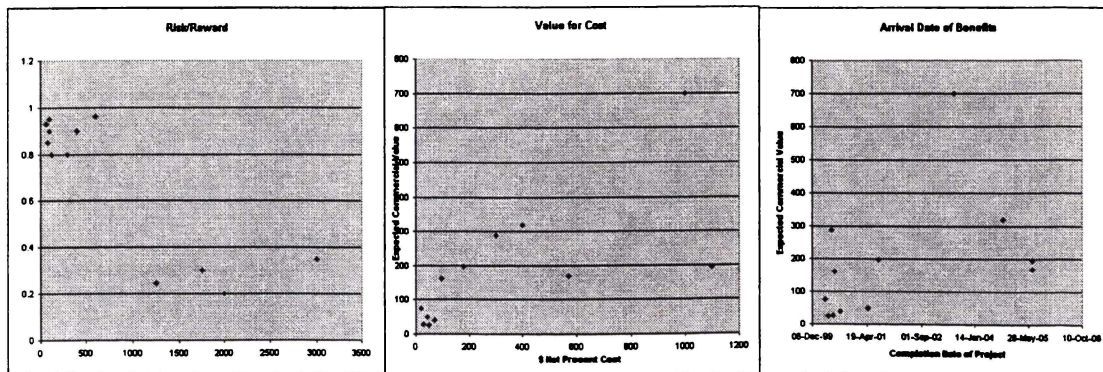
Calculated Values	Actual	Project Completion Probability, P
Number of activity blocks, n	27	within n activity blocks 0.255
		within (n+1) activity block 0.429

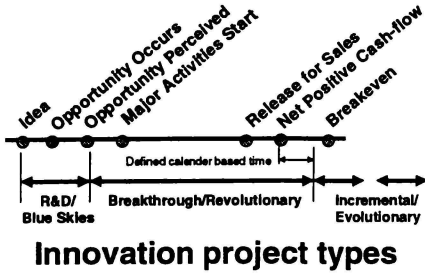
Bob Mills, University Of Waikato, Revision 1

Priority	Project Name	Project Outcome	Strategic Category	Time-block size	Project Sponsor	Project Manager	Unique Resource	NPV (\$'000)	Interest Rate %	Completion Date	P	P @ +1 time-block	NPC (\$'000)	ECV
1	Aris	New Model	Competitor response	Week	W.Tail	G.Going	Y.Khol	300	10	30-Jun-00	0.8	0.95	98	162
2	Bags	Process upgrade	Cost reduction	Month	I.Too	V.Smart		100	10	30-Apr-01	0.9	0.97	45	50
3	Heightech	New Technology	Blue skies	Quarter	B.Wig	A.Nerd	C.Clogs	1250	10	31-Dec-06	0.26	0.43	1067	47
4	Drongo	New Technology	Blue skies	Quarter	G.Gelum	I.Brow	G.Maller	1750	10	30-Jun-05	0.3	0.35	1100	195
5	Ethel	New Market	Market expansion	Week	W.Tail	G.Going		80	10	30-Apr-00	0.85	0.9	50	26
6	Fumbles	Product Upgrade	Market support	Week	B.Wig	A.Nerd	A.Mine	100	10	31-Mar-00	0.96	0.99	20	76
7	Groovy	Process Upgrade	Cost reduction	Week	W.Tail	V.Smart		60	10	15-Jun-00	0.99	1	30	28
8	Harry	New Market	Market expansion	Week	W.Tail	G.Going		120	10	20-Aug-00	0.8	0.85	70	40
9	Ima	New Technology	Blue skies	Quarter	G.Gelum	I.Brow	C.Clogs	3000	10	30-Jun-03	0.35	0.37	1000	700
10	Jools	New Product	Competitor response	Month	W.Tail	V.Smart		400	10	31-Jul-01	0.9	0.95	180	198
11	Keyway	New Model	Competitor response	Week	B.Wig	G.Going		800	10	31-May-00	0.96	0.99	300	288
12	Loopy	New Technology	Blue skies	Quarter	I.Too	A.Nerd	G.Maller	2000	10	30-Sep-04	0.2	0.22	400	320

Example Portfolio dimensions:

- Probability of success at completion/NPV given success (\$'000)
- Expected Commercial Value (NPV-NPC)*Probability/NPC
- Expected Commercial Value (NPV-NPC)*Probability/Date of Completion
- Probability of completion after one extra time-block/Probability of completion on time

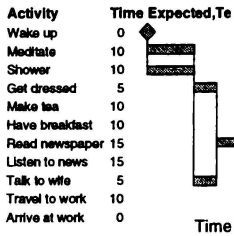




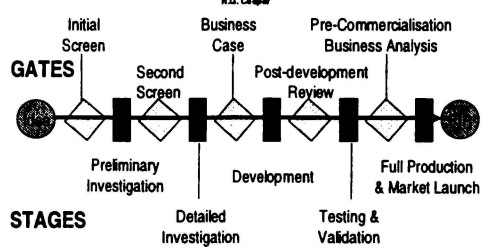
The difference

- **Traditional:**
 - Sequential activities and events (Gantt/PERT)
- **Stage Gate:**
 - Sequential stages and review gates
- **Rapid Application Development:**
 - Fixed dates for reviews of individual projects
- **This new TIPS approach:**
 - Sequential calendar-defined work blocks (time-blocks) and regular multi-level reviews

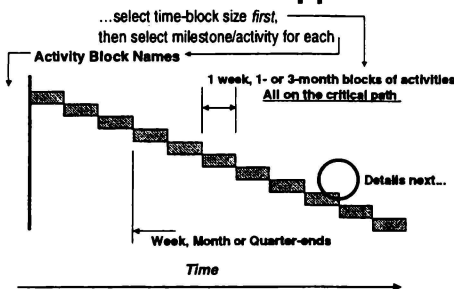
Traditional PM Methods: Gantt Chart



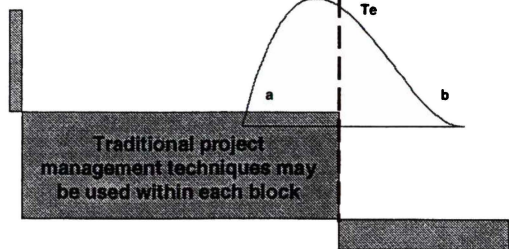
Newer Method: The Stage-Gate Process for New Product Development



For this new TIPS approach...



we use two duration estimates to find the Time-block Duration End-point



APPENDIX E TIPS Pilot Trials Survey (Ratings only)

Bob Mills, The University of Waikato, TIPS Pilot Trial Questionnaire
14-Oct-00

#1 #2 #3 #4/#6 #5 #6 #9 #10 #11 All By Company By Level By Function Section Means
R1 R1 R1 R1 R1 R1 E1 E1 E1 E1 E1 R1 E1 G ABC Operations Technical

Section 1 - Information useful for managing innovation projects

Please rate the "usefulness" of information collected in TIPS using the following 1 - 5 scale:

(Not at all useful) 1 2 3 4 5 (Extremely useful)

Information Item

1.1 Company's Priority Rank Number for this project	5	3	1	4	1	4	1	1	2	2.4	2.8	2.0	4.5	1.5	3.3	1.8
1.2 Company's Strategic Category for this project	5	3	1	2	1	1	1	1	4	2.1	2.4	1.8	3.0	1.8	2.5	1.8
1.3 Target Market	5	4	1	2	4	4	1	2	4	3.0	3.2	2.8	4.5	2.7	3.5	2.6
1.4 Customer/Voice of Customer	5	4	4	4	4	4	1	4	3.8	4.2	3.0	4.5	3.4	4.3	3.3	3.3
1.5 End User	4	4	1	4	4	4	3	2	3.3	3.4	3.0	4.0	2.8	3.3	3.3	3.3
1.6 Project Output	4	4	5	2	1	3	4	3.3	3.2	3.5	4.0	3.4	4.3	2.5	4.0	4.0
1.7 Project Name	5	3	5	5	4	3	3	4	4.0	4.4	3.5	4.0	3.8	4.0	4.0	4.0
1.8 Project Sponsor	3	4	4	4	1	N/A	3	3	4	3.3	3.2	3.3	3.0	3.2	3.7	3.0
1.9 Project Manager	5	4	5	2	2	4	3	3	4	3.6	3.6	3.5	4.5	3.5	4.5	2.8
1.10 Interest Rate for using money (%)	4	5	5	1	4	3	3	5	3.8	3.8	3.8	4.0	3.7	4.5	3.0	3.0
1.11 Date Output is required	4	5	5	4	4	5	3	4	4	4.2	4.4	4.0	4.5	4.2	4.8	3.8
1.12 Calculated Date of First Sales Income receipt	3	4	5	3	1	3.5	1	3	4	3.1	3.2	2.9	3.3	3.0	3.9	2.4
1.13 Calculated Probability that project is achievable	5	4	5	1	5	1	3	4	1	3.2	4.0	2.3	3.0	3.7	3.8	2.8
1.14 Calculated Probability that project is achievable on time	5	4	5	5	3	4	3	4	3.0	4.4	3.5	4.5	3.7	4.5	3.6	3.6
1.15 Calculated Project Costs before sales income, NPC (\$'000)	4	4	5	4	1	5	1	3	3	3.3	3.6	3.0	4.5	2.6	4.5	2.4
1.16 Calculated Sales Income given project is achieved on time, NPV (\$'000)	3	5	5	1	5	1	3	3	3.3	3.5	3.0	4.0	3.0	4.5	2.0	2.0
1.17 Company Specified Data	5	4	1	1	1	3	2	2.4	2.4	2.5	5.0	2.2	3.3	1.8	4.2	1.8
1.18 Block End Date	5	4	4	5	5	3	4	4	4.3	4.6	3.7	5.0	4.0	4.3	4.2	4.2
1.19 Block Manager	5	5	3	4	1	3	4	2	3.4	3.6	3.0	5.0	3.0	4.3	2.8	2.8
1.20 Block Goal	5	3	3	5	3	3	4	3	3.6	3.8	3.3	5.0	3.2	3.7	3.6	3.6
1.21 Probability Block Goal Achievable	5	4	2	1	5	2	4	3	3.3	3.4	3.0	5.0	3.3	3.7	3.0	3.0
1.22 Optimistic Elapsed Time (days)	5	3	2	5	2	3	3	4	3	3.3	3.4	3.3	4.0	2.8	3.3	3.4
1.23 Pessimistic Elapsed Time (days)	5	3	2	5	2	3	3	4	3	3.3	3.4	3.3	4.0	2.8	3.3	3.4
1.24 Net PV Cost (\$'000)	3	5	5	4	4	2	3	4	2	3.6	4.2	2.8	2.5	3.8	3.8	3.4
1.25 Probability of finishing within specified block duration (week, month or quarter)	4	4	4	4	2	3	2	4	3	3.3	3.6	3.0	3.5	3.2	3.8	3.0
1.26 Net Income (\$'000)	4	5	5	4	5	1	2	5	3.9	4.5	3.3	4.5	3.7	4.8	3.0	3.0
1.27 Expected Commercial Value (\$'000)	4	5	5	4	4	1	2	5	3.7	4.5	2.7	4.0	3.7	4.7	3.0	3.0

Section 2 - TIPS Format

Rate the "usefulness" of the TIPS format for your organisation for managing innovation projects using the following 1-5 scale:

(Not at all useful) 1 2 3 4 5 (Extremely useful)

TIPS Format Item

2.1 TIPS uses a Microsoft Excel spreadsheet	5	4	1	4	5	1	3	4	2	3.2	3.8	2.5	3.0	3.2	2.8	3.6
2.2 The Microsoft Excel format is familiar to managers from all functions and levels	5	4	1	5	5	1	3	2	3	3.2	4.0	2.3	3.0	3.0	2.8	3.6
2.3 TIPS can be used and customised by non-specialists	4	4	1	3	5	1	3	3	3	3.0	3.4	2.5	2.5	3.2	2.5	3.4
2.4 TIPS incorporates project goals, schedules and costs for all functions	4	4	5	4	1	1	4	3	4	3.3	3.6	3.0	2.5	3.5	3.5	3.2
2.5 TIPS time-blocks/reviews tie into calendar dates	4	4	2	4	3	1	3	3	5	3.2	3.4	3.0	2.5	3.3	2.8	3.6
2.6 TIPS uses goals (achievements)	5	3	4	5	1	1	3	4	5	3.4	3.6	3.3	3.0	3.3	3.3	3.6
2.7 TIPS only collects projected performance information	4	2	5	3	1	3	3	3	3.0	3.5	2.5	2.5	3.2	3.0	3.0	3.0
2.8 Project achievability risk is always calculated from aggregated block achievability	5	4	5	4	1	1	1	3	3.0	3.8	1.0	3.0	2.8	3.8	2.0	2.0
2.9 Schedule risk is always calculated from optimistic and pessimistic time estimates	4	4	5	5	1	1	3	3	3.3	3.8	2.3	2.5	3.2	3.5	3.0	3.0
2.10 Income risk is always built into the dollar sales estimates	3	4	4	1	1	1	4	4	2.8	3.0	2.5	2.0	3.0	3.0	2.5	2.5
2.11 Expected Commercial Value is expressed by multiplying risk and expected income	4	4	5	5	5	1	1	4	3.4	4.5	2.0	2.5	3.8	3.5	3.3	3.3
2.12 Detailed information can be noted in the Comments field of any Excel cell	3	4	1	4	5	1	3	5	2	3.1	3.4	2.8	2.0	3.3	2.3	3.8
2.13 The project and portfolio sheets can be printed and read on A4 paper	4	5	5	5	5	1	3	4	2	3.8	4.8	2.5	2.5	4.0	3.8	3.8
2.14 Before First Income information can be updated easily	4	4	5	5	5	1	3	4	4	3.9	4.6	3.0	2.5	4.2	3.5	4.2
2.15 Project summary/specified information can be pasted easily to a portfolio sheet	5	4	3	4	5	1	1	5	3	3.4	4.2	2.5	3.0	3.5	3.3	3.6

Section 3 - Project Management Information

Please rate the following statements about project management information using the following 5-point scale:

(Strongly disagree) 1 2 3 4 5 (Strongly agree)

Project Information statement

3.1 "TIPS identifies project information requiring attention more effectively than our usual arrangements"	4	4	5	5	5	3	4	3	2	3.9	4.6	3.0	3.5	3.8	4.0	3.8
3.2 "TIPS draws early attention to project situations requiring action"	5	4	4	4	2	3	4	4	3.7	3.8	3.7	4.0	3.5	4.0	3.5	3.5
3.3 "Our usual project management arrangements provide satisfactory information exchange between R&D and marketing"	4	1	1	2	1	4	4	4	4	2.8	1.8	4.0	4.0	2.5	2.5	3.0
3.4 "Our usual project management arrangements provide satisfactory information exchange between lower, middle and upper managers"	2	1	3	2	1	3	4	3	2	2.3	1.8	3.0	2.5	2.3	2.3	2.4
3.5 "I expect the amount of useful project management information exchanged in my organisation to increase when using TIPS"	3	2	4	5	1	4	2	4	3.1	3.5	2.8	1.0	3.3	2.0	3.8	3.8
3.6 "I expect useful communications between R&D and marketing functions to improve when using TIPS"	4	3	2	3	3	3	4	3	3	3.1	3.0	3.3	3.5	3.0	3.0	3.2
3.7 "I expect useful communications between lower, middle and upper managers to improve when using TIPS"	4	2	3	4	4	1	3	4	3.1	3.4	2.7	2.5	3.2	2.5	3.8	3.8

Section 4 - TIPS Implementation

Please give your views on the following:

4.3 3.2 3.0 4.0 3.8 2.2 4.0 3.0 3.3 3.4 3.7 3.1 2.9 3.4 3.1 3.6 TIPS+ MEANS
3.0 1.0 2.0 2.0 1.0 3.5 4.0 3.5 3.0 2.6 1.8 3.5 3.3 2.4 2.4 2.7 EXISTING+ MEANS

4.1 To enable TIPS to be successfully implemented into your organisation:

- 4.1.1 Identify any other project information required (additional to that listed in Section 1 of this questionnaire)
- 4.1.2 Identify formatting changes that are required
- 4.1.3 Identify organisational information technology system changes that are required
- 4.1.4 Identify what type of staff education and training is required
- 4.1.5 Identify which staff need to be educated or trained?
- 4.1.6 How long do you expect it might take to establish an operational system?

4.2 TIPS in your organisation

Rate the potential use of TIPS in your organisation using the following 1-5 scale.

(Nil) 1 2 3 4 5 (Extremely high)

Value statement

4.2.1 I rate the value of implementing TIPS at	3	3	5	4	5	1	4	3	4	3.6	4.0	3.0	2.0	4.0	3.0	4.0
4.2.2 I rate the overall probability that TIPS or a system using a similar approach would be implemented in our organisation within the next 2 years at	4	4	2	4	1	1	4	1	3	2.9	3.0	2.7	4.0	2.5	3.3	2.6

Thank you for your willing co-operation and collaboration in the TIPS Pilot Trial.

Please email a soft copy of your completed questionnaire to b.mills@waikato.ac.nz on or before 6 October 2000.

APPENDIX F TIPS Format at the End of the Pilot Trials

[On University of Waikato Headed Paper]

20 September 2000

Time-blocks Innovation Project System (TIPS)

Introduction

TIPS is an innovation project and programme management system being developed at the University of Waikato, New Zealand. It is specifically designed for helping businesses and organisations to better manage the translation of ideas into income.

TIPS has been designed to help link:

- Individuals, businesses and corporations
- Operations, tactics and strategy
- Accountability, reporting and actions
- Uncertainty, risk and return
- Projects, portfolios and priorities.

TIPS is implemented in Microsoft Excel software for convenient use, widespread understanding by all managers and to simplify communication.

What TIPS does

TIPS assists management to compare and rank innovation projects. It assists project staff by identifying project priority so that they can appropriately allocate effort. TIPS is particularly useful where knowledge about how an idea might be translated into income is incomplete and where technology and markets are changing unpredictably. The current implementation plan of each idea is described as a project on a one-page spreadsheet. The sheet plots out the currently expected innovation process in a form that can be readily updated or rewritten. TIPS shows the costs before first income and the potential benefits (encapsulated as "\$NPV"). Two risk and uncertainty factors are calculated: "the probability that the project is achievable" and "the probability that the project is achievable on time".

Projects are reviewed for operational, tactical and strategic performance and updated weekly, monthly or quarterly. Individual project data is pasted from separate worksheets to a composite portfolio worksheet for analysis and for assigning overall priority. Worksheets are provided to keep together workings for individual goals, project costs and sales income (sales and marketing projections).

What TIPS doesn't

TIPS does not attempt to integrate the management of all project resources at a detailed level. Individuals and their supervisors are delegated the responsibility to optimise the best use of their time given project rank. Monitoring and control should in any case be done using direct one to one communications on a day to day basis.

Background

Innovation projects by their nature are much more likely to be stopped, delayed, drastically changed and fail than most other projects. Success for an innovation project is not about compliance with schedules, budgets and specifications but about deriving more benefit than cost.

During the past 80 years projects have become an increasingly popular vehicle for introducing new products, processes, systems and services within the context of organisations and businesses. Projects are usually set apart from normal operations in an attempt to contain and control exposure to uncertainty and risk. Projects have been managed as networks of inter-related but discrete jobs, activities or tasks.

The logic and simplicity of Gantt (bar) and PERT (network) charts have been enduring project management tools reinforced by the general application of computerised charting as early as in the mid-1960s. Starting in the 1970s “Stage-gate” methods also became popular for new product development. Project stages are completed and reviewed at gates to confer approval and comparative ranking. In the 1990s the software industry developed “Rapid Application Development” methodologies using “time-boxes” to subjugate functionality to try to bring software in on time.

Since the 1980s innovation has become more widely recognised as a key source of sustainable competitive advantage. The welfare and progress of projects that contribute to the innovative capacity of companies have therefore become of greater tactical and strategic interest to management. Significant innovation projects, however, usually extend into the realms of uncertainty by involving new knowledge, new technology and new markets. There is also strong interest in recent literature concerning reduction of time-to-market, increased flexibility to respond to changing market signals and the ability of projects to transfer across organisational barriers. There is now a growing realisation that existing project management methods are inadequate. Innovation project success is about enabling successful business outcomes, not trying to comply with time, cost and quality criteria conceived before the true extent of required activities could be identified. There is also an increasing pressure for companies to aggregate and better manage portfolios of innovation projects.

Further, the timing of traditional project management decision-making is focused on activities and events rather than on the business calendar. Organisations and businesses therefore contend on the one hand with operational decision-making at times to suit the convenience of various project schedules and on the other with tactical and strategic decision-making to suit the weekly, monthly, quarterly and annual demands of project staff, accountants, managers and owners respectively. Innovation projects have become an inseparable part of business but the way they are traditionally managed does not reflect this change.

How then can innovation project management methods better fit the needs of today's companies? And how can the effects of change and uncertainty be accommodated?

TIPS has been developed for all types of organisations and businesses involved in the innovation process. It is based on research into the needs of New Zealand managers. And it is intended to become a common vehicle to describe the status of innovations internally (both technical and commercial input is required) and to potential external partners and contributors. TIPS can be simply implemented in Excel. This is how it works.

Procedure

1. Select the appropriate time-block size according to project duration:

Say up to 6 months - choose **weekly** (e.g. evolutionary, enhancement, support)

6 months to 2 years - choose **monthly** (e.g. revolutionary, new products)

2 years or more - choose **quarterly** (e.g. R&D, blue skies, curiosity-driven)

- All projects start with a completed TIPS Project Sheet with the Sponsor's allocation of a company priority rank number
- Projects finish once first sales income is actually received

2. Complete a week, month or quarter TIPS Project Excel worksheet:

There are five blocks of information on each project sheet:-

Summary data entry fields are:

Company Priority (a unique current priority rank number set quarterly)

Company Strategic Category (for portfolio analysis: e.g. short term, long term)

Target Market

Customer/Voice of Customer

End User

Project Output (e.g. new model, new process, new technology)

Project Name (concise and imaginative)

Project Sponsor (senior/corporate management/owner)

Project Manager (business management/facilitator)

Interest Rate (cost of money for \$NPC and \$NPV calculations)

Date Output is required

Summary calculations:

Date of first sales income receipt

Probability that the project is achievable (aggregates go/no go probabilities of block by block goal achievement for the project)

Probability that the project is achievable on time (aggregates the probability of the project being achievable and being done on time)

Net Present Cost to complete (NPC\$'000)

Net Present Value of sales (given success) (NPV\$'000)

Organisation Specified data fields: (16 custom data or calculated fields available)

Before First Income: (for each sequential time-block)

End-date (next rescheduling review date)

Block Managers (responsible for all activities in each time-block)

Block Goal (identifies the key project goals for the block)

Probability of Block Achievement (probability of project continuation)

Optimistic duration (days, only say, 1% of the time would you finish earlier)

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Pessimistic duration (days, only say, 1% of the time would you finish later)

Cost (PV\$'000 net cost of resources and commitments made in the block)

Calculated probability estimate of achieving block goal on time

After First Income: (for the next 15 years).

Income (PV\$'000 of net sales income for each year).

3. Get Sponsor approval

4. Run selected projects

5. Report/Review/Update as follows:

Daily - individual work allocation, monitoring and control

Weekly - exception, issue and action list reporting to Block Manager

Monthly - resource reporting (financial, human and physical) to Project Manager

Quarterly - general, priority and strategic fit review to Project Sponsor

Annually - fit with company vision and purpose to Governance Board

6. At the end of each time-block - update/re-create TIPS project and portfolio sheet.

Notes

Worksheet Templates

Seven worksheets have been assembled in the TIPS Excel workbook. The first four sheets cover weekly, monthly and quarterly time-blocked projects (these three are password protected), and the portfolio. The next three sheets are for keeping your workings of individual goals, block costs and income estimates. The implementation of the workbook is not yet very robust, therefore care must be taken to retain cell relationships and calculation integrity. The most important advice when editing is:

- **DO NOT USE "CUT AND PASTE" OR "DRAG AND DROP"!**
- **USE COPY AND PASTE SPECIAL/VALUES (AND COMMENTS).**
- **USE CLEAR/CONTENTS OR DELETE COMMENTS) TO TIDY UP.**

Note: When using the "cut and paste" or "drag and drop" approach cells are ripped out of the sheet and then reinserted, so cell references get disrupted!

Project Sheets

The project worksheets are formatted and displayed to enable key information to be seen clearly on screen and printed legibly onto one A4 sized page side. Data entry cells have double lined boundaries. A "First Income" block goal must be the final block goal (because it triggers some calculations) and has been parked at the bottom of the sheet for you to copy and paste special/values into position.

Key project information for the portfolio sheet is displayed in the top left corner (and shaded). Company customised data and calculations are at top right.

To paste the summary and company specified data and calculated fields to the Portfolio sheet use "Ctrl-w" from week time-block sheets, "Ctrl-m" from month time-block sheets and "Ctrl-q" from quarter time-block sheets.

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To automatically update the “Before First Income” area in any project sheet press “Ctrl-u” (moves all data and Comments up one row). (Note the top row gets overwritten so copy or note any data or comments from the top line beforehand!)

Portfolio Sheets

The portfolio sheet is intended to help management confer and adjust innovation project priorities for the organisation. It is expected that the priority numbers will be shuffled for projects at review meetings. When finalised, a “sort” would be done on the Priority (first) column. At this stage of implementation revised priority numbers (after the portfolio review) would be transferred back to individual project spreadsheets manually.

Examples of chart arrays that may be useful in assessing portfolio ranking have been provided. Additional arrays including data from the company-specified fields can be implemented without change to the basic format.

The organisation could have several project portfolios, perhaps sorted into a number of “strategic buckets”. It may be possible for this to be done by using the sort facility on columns (e.g. by strategic category, by time-block size or by probability of first income on time). However, an overall (unique) organisational priority should be retained for each project so that resource allocation can be unequivocal. Note that two sheets are printed for the portfolio, one for generic data, the other for company specified data.

Other Worksheets

Other worksheets are named for the convenience of working out values to put in the project sheets but are not customised.

Portfolio Management

The literature suggests the following might be a typical “strategic bucket” allocation regime:

<i>Innovation type</i>	<i>Resource allocation</i>	<i>Project type (TIPS size?)</i>
Derivative (customised) products	70%	evolutionary innovation (weekly)
New product platforms	20%	revolutionary innovation (monthly)
Breakthrough products	5%	revolutionary innovation (monthly)
Company R&D	3%	R&D (quarterly)
Industry partnership R&D	2%	R&D (quarterly)

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TIPS Month-block Project Sheet, Bob Mills, University of Waikato, 29 Sept 2000

SUMMARY		COMPANY SPECIFIED DATA
<p>Jan-03 1.00 Check Data 0 0</p>	<p><i>(Enter your data inside the double lined boxes)</i></p> <p>Company's Priority Rank Number for this project Company's Strategic Category for this project Target Market Customer/Voice of Customer End User Project Output Project Name Project Sponsor Project Manager Interest Rate for using money (%) Date Output is required Calculated Date of First Sales Income receipt expected Calculated Probability that project is achievable Calculated Probability that project is achievable on time Calculated Project Costs before sales income, NPC (\$'000) Calculated Sales Income given project is achieved on time, NPV (\$'000)</p>	<div style="border: 1px solid black; height: 100%; width: 100%;"></div>

(Transfer Summary and Company Specified Data to Portfolio sheet automatically by pressing "Ctrl-m")

BEFORE FIRST INCOME						Probability of finishing within 30 days	
Block End-Date	Block Manager	Block Goal <small>(The final block goal is "First Income")</small>	Probability Block Goal Achievable	Elapsed Time (Days)			Net PV Cost \$ ('000)
				Optimistic<=30	Pessimistic=>30		
Sep-00			1.00				
Oct-00			1.00				
Nov-00			1.00				
Dec-00			1.00				
Jan-01			1.00				
Feb-01			1.00				
Mar-01			1.00				
Apr-01			1.00				
May-01			1.00				
Jun-01			1.00				
Jul-01			1.00				
Aug-01			1.00				
Sep-01			1.00				
Oct-01			1.00				
Nov-01			1.00				
Dec-01			1.00				
Jan-02			1.00				
Feb-02			1.00				
Mar-02			1.00				
Apr-02			1.00				
May-02			1.00				
Jun-02			1.00				
Jul-02			1.00				
Aug-02			1.00				
Sep-02			1.00				
Oct-02			1.00				
Nov-02			1.00				
Dec-02			1.00				
Jan-03		First Income	1.00				

(Update one time-block automatically by pressing "Ctrl-u")

AFTER FIRST INCOME	
Sales NPV (\$'000) Calculation	
Year (from now)	Net Income
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	

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TIPS Quarter-block Project Sheet, Bob Mills, University of Waikato, 29 Sept 2000

SUMMARY	(Enter your data inside the double lined boxes) Company's Priority Rank Number for this project Company's Strategic Category for this project Target Market Customer/Voice of Customer End User Project Output Project Name Project Sponsor Project Manager Interest Rate for using money (%) Date Output is required	COMPANY SPECIFIED DATA
Sep-07 1.00 Check Data 0 0	Calculated Date of First Sales Income receipt Calculated Probability that project is achievable Calculated Probability that project is achievable on time Calculated Project Costs before sales income, NPC (\$'000) Calculated Sales Income given project is achieved on time, NPV (\$'000)	

(Transfer Summary and Company Specified Data to Portfolio sheet automatically by pressing "Ctrl-q")

BEFORE FIRST INCOME						Probability of finishing within 90 days	
Block End-Date	Block Manager	Block Goal (The final block goal is "First Income")	Probability Block Goal Achievable	Elapsed Time (Days)			Net PV Cost \$ ('000)
				Optimistic<=>90	Pessimistic=>90		
Sep-00			1.00				
Dec-00			1.00				
Mar-01			1.00				
Jun-01			1.00				
Sep-01			1.00				
Dec-01			1.00				
Mar-02			1.00				
Jun-02			1.00				
Sep-02			1.00				
Dec-02			1.00				
Mar-03			1.00				
Jun-03			1.00				
Sep-03			1.00				
Dec-03			1.00				
Mar-04			1.00				
Jun-04			1.00				
Sep-04			1.00				
Dec-04			1.00				
Mar-05			1.00				
Jun-05			1.00				
Sep-05			1.00				
Dec-05			1.00				
Mar-06			1.00				
Jun-06			1.00				
Sep-06			1.00				
Dec-06			1.00				
Mar-07			1.00				
Jun-07			1.00				
Sep-07		First Income	1.00				

(Update one time-block automatically by pressing "Ctrl-u")

AFTER FIRST INCOME	
Sales NPV (\$'000) Calculation	
Year (from now)	Net Income
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	

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TIPS Project Portfolio, Bob Mills, University Of Waikato, 20 Sept 2000

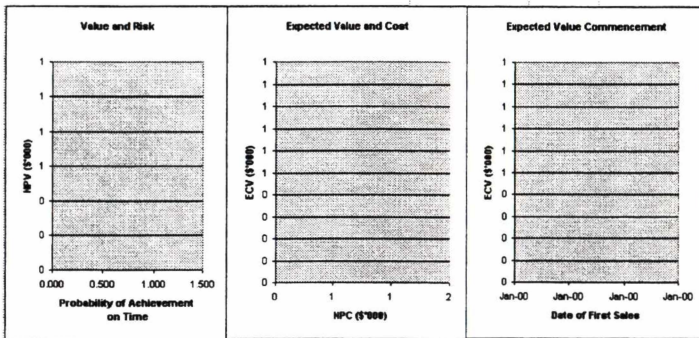
Priority	Category	Market	Customer	End User	Output	Project Name	Sponsor	Manager	Interest (%)	Date Required	First Income Date	p	p on time	NPC (\$'000)	NPV (\$'000)	ECV (\$'000)
																0
																0
																0

Example Portfolio dimensions for charting:

Probability of achievement on time (p on time)/Sales NPV given achievement on time (\$'000)

Expected Commercial Value ((NPV-NPC)*p on time)/Project NPC

Expected Commercial Value ((NPV-NPC)*p on time)/Date of first sales income



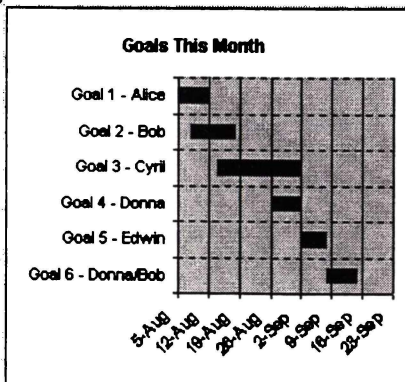
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Bob Mills, 2 August 2000

EXAMPLE 1

Individual Goals	Start Date	Duration (days)	End Date
Goal 1 - Alice	5-Aug	7	11-Aug
Goal 2 - Bob	8-Aug	10	17-Aug
Goal 3 - Cyril	14-Aug	19	1-Sep
Goal 4 - Donna	26-Aug	7	1-Sep
Goal 5 - Edwin	2-Sep	6	7-Sep
Goal 6 - Donna/Bob	8-Sep	7	14-Sep

(Enter data within double line borders)

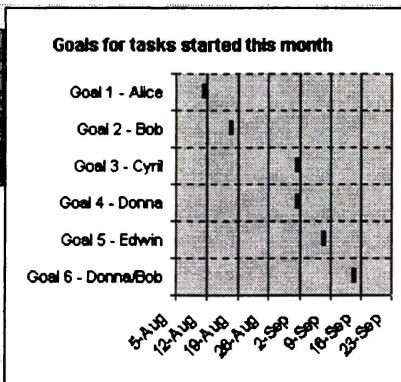


Example of how Excel could be used to plan goals for individual resources in a Gantt Chart form

EXAMPLE 2

Individual Goals	By
Goal 1 - Alice	11-Aug
Goal 2 - Bob	17-Aug
Goal 3 - Cyril	1-Sep
Goal 4 - Donna	1-Sep
Goal 5 - Edwin	7-Sep
Goal 6 - Donna/Bob	14-Sep

(Enter data within double lines)

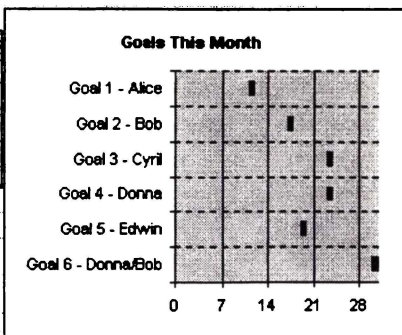


Example of how Excel could be used to plan goals for individual resources in milestone form

EXAMPLE 3

Individual Goals	Day
Goal 1 - Alice	11
Goal 2 - Bob	17
Goal 3 - Cyril	23
Goal 4 - Donna	23
Goal 5 - Edwin	19
Goal 6 - Donna/Bob	30

(Enter data within double lines)



Example of how Excel could be used to plan goals for individual resources in day of month milestone form

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