INNOVATION DECISION MAKING FRAMEWORK

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ABSTRACT

This thesis accomplishes two major goals: 1. it establishes an innovation decision making framework suitable for the public service sector; and 2. it provides in-depth understanding of the established framework through two detailed accounts of innovation in Saskatchewan Department of Highways and Transportation. The major benefit from applying the findings from this research is a disciplined and structured approach to managing innovation. This in turn significantly increases the chance of innovation's success.

The decision making framework identifies the most important success drivers that influence the innovation process from conceptual ideas to diffusion. The accompanying "idea to launch" innovation stage gate model is a structured and disciplined approach to managing innovation and allocating resources in a most optimized way. Both the guiding innovation framework and the idea to launch process maintain a strong strategic focus and provide an environment for intelligent risk taking.

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CHAPTER 1 INTRODUCTION

1.1 BACKGROUND AND PROBLEM DEFINITION

1.1.1 Role of transportation in Saskatchewan

The welfare of Saskatchewan and its people has always been closely related to the efficiency and effectiveness of the provincial transportation system. A dependable transportation system is crucial for tourism, recreation and leisure activities as well as a timely and effective emergency response. Furthermore, in today's global, competitive and rapidly changing economies, an efficient transportation system is a critical factor for continued and sustainable economic growth. In 2003, Saskatchewan was the world leading exporter of potash, durum, flax, peas, lentils, mustard and canary seed, the second largest exporter of canola / rapeseed, oats and cured pork bellies, and the third largest exporter of crude canola / rapeseed oil and agricultural seeder (SaskTrade 2005). Other non-agricultural major export commodities included crude oil, wood pulp, lumber, and uranium. In a land locked and export-oriented province such as Saskatchewan, transportation costs may indeed quickly become the single highest cost component in moving bulk commodities to export markets, and may also significantly affect domestic and international competitiveness.

1.1.2 Saskatchewan road transportation system

As a result of a small but dispersed population combined with a vast land area and intensive agricultural and mining activities, an extensive road network has been built in Saskatchewan to accommodate economic and social activities. Saskatchewan has more kilometers of road network per capita than any other political jurisdiction in Canada (Atlas of Saskatchewan 1999). Rural Municipalities (RMs) look after more than

159,000 km of rural roads while the provincial government, through its Department of Highways and Transportation (SDHT), is responsible for over 26,000 km of two-lane highways (Figure 1.1), 820 bridges, 11 ferries on the Saskatchewan River system, 1 free floating barge, and 18 northern airports. SDHT's mandate is to optimize transportation's contribution to the social and economic development of Saskatchewan by operating, preserving, enhancing, and guiding the development of the provincial transportation system. This is accomplished through a balance between the department own crews and the private road construction sector. Department crews are mainly responsible for road maintenance activities, snow and ice control, pavement marking, gravel location services, signs repair and replacement, most small bridges and drainage structures, the province's ferries and northern airports. The private sector is contracted for all the major bridge and road construction work including grading, paving and microsurfacing.

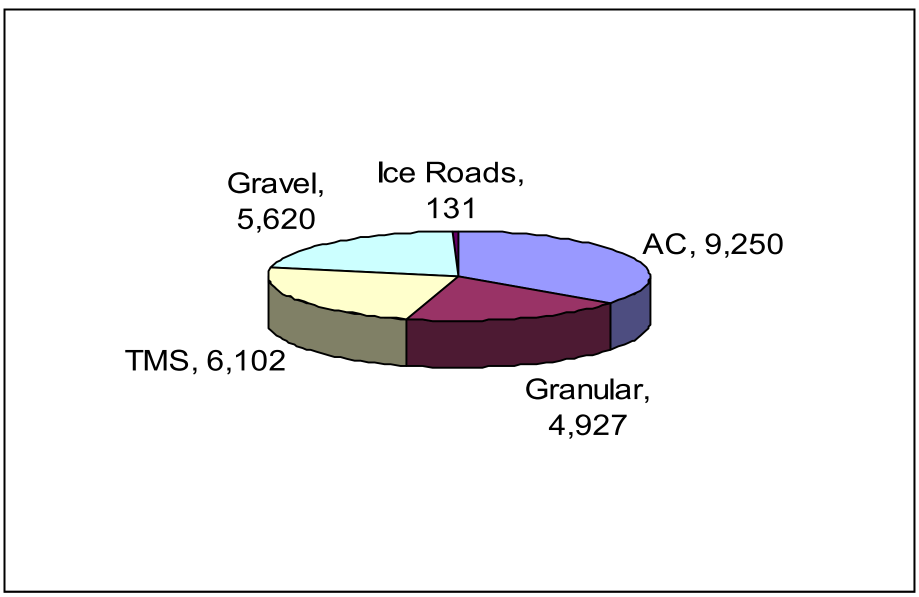

FIGURE 1.1 – SDHT HIGHWAY NETWORK INVENTORY (in km)
Asphalt concrete (AC) and granular highways are considered structural roads; Thin Membrane Structure (TMS) highways and gravel roads are non-structural roads.

In recent decades, the road transportation system has become the dominant transportation mode in the province. This evolution has been promoted by changes in policies at both provincial and federal levels, economic realities resulting in increased mechanization and larger farms, emergence of a strong tourism sector, development of a more diversified economy (forestry, oil and gas, mineral mining, value added agricultural processing, manufacturing, life sciences and biotechnology), on-going consolidation of grain handling facilities, abolishment of the Crow rate (a subsidy on grain shipping by rail, which was replaced by the Western Grain Transportation Act (WGTA) in 1984 and the WGTA was terminated in 1996), and many cases of abandoned railway short lines. These changes have created numerous challenges to sustaining the provincial road transportation system over the long term.

1.1.3 Challenges of managing Saskatchewan highway system

Coincident with the increasing importance and dependence on the road transportation system is pressure from road users and industry to provide an efficient and effective road network to facilitate economic development and enhance leisure and social activities. SDHT experiences numerous pressures and challenges in managing the province's highways network (Figure 1.2). Some pressures are operational in nature; some are due to shifting markets and expanding economy; others can be contributed to policy changes; and the remainder are the result of public expectations that in some instances may be unrealistic.

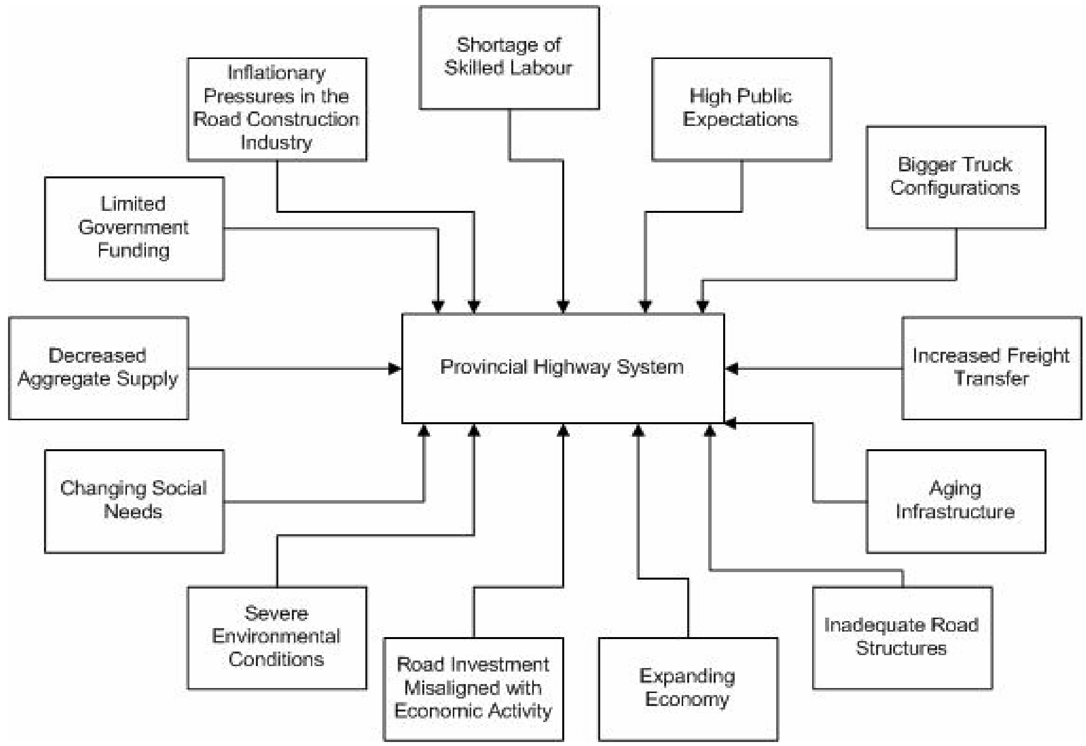

FIGURE 1.2 PRESSURES ON PROVINCIAL HIGHWAY SYSTEM

Dependant upon a small tax base, Saskatchewan's extensive road network is effectively unsustainable. Despite obvious shortcomings in funding levels, road users nonetheless maintain high expectations that may be in stark contrast with the economic reality of publicly funded roads. For instance, low density and declining populations in rural Saskatchewan are coincident with an increased demand for access to services and amenities offered in larger urban centers. The greatest public and industry pressures are probably felt in regards to the most structurally inadequate road type – TMS roads.

The pressures to maintain the aging provincial road system are exacerbated by policy changes that have effectively transferred huge amounts of freight from the railway. Furthermore, the province's primary resources and commodity export oriented economy now requires bigger truck configurations to realize the efficiencies necessary to be competitive in global markets. The resulting increase in truck traffic and loading concentrations over the past few decades presents a special challenge as SDHT attempts to strike an appropriate balance between economic and social needs given limited resources.

Infrastructure requirements demanded by industry to support expanding economic initiatives and diversification are rising sharply. For the most part, the economic growth in oil and gas, mineral mining, industrial metal manufacturing, forestry, and tourism industries is happening in areas misaligned with the existing road transportation system. This creates additional pressures to provide adequate access to these areas. New and expanding industries are also demanding more labour. Coupled with strong economies in adjacent provinces, increased competition has created a labour shortage felt by both the private road construction contractors and SDHT. Consequently, limited funding levels for road maintenance are further stretched by extraordinary inflationary pressures recently experienced in the road construction industry. For example, 2006 construction costs were 55% higher than in 2004 due to increases in fuel costs, increased competition for labour, decreased number of contractors, increased material costs, higher contractor contingencies, and other factors (SDHT 2006).

Lastly, Saskatchewan's climate significantly impacts road conditions, the amount of road work completed in a construction season, and winter snow and ice control expenditures. Weather conditions are hard to predict and mitigate and thus present a major challenge for the department. In particular, increased precipitation in spring and alternating freeze and thaw cycles as well as hazardous blizzard, ice and cold conditions are major considerations in the management of Saskatchewan's highways.

1.1.4 SDHT innovative drive

Saskatchewan Department of Highways and Transportation tries to mitigate pressures and challenges by adopting varied road construction and maintenance treatments, delivering services in a more cost effective way, and applying alternative approaches to managing the transportation system. Many of these approaches created out of necessity are very innovative in nature. Some are continuous refinement and improvement of existing methodologies; the remainder include adaptation of various externally developed techniques and technologies. Regardless of their nature and origin, they all require a high degree of ingenuity to be successfully applied by SDHT.

Technology adoption and innovation by SDHT can be grouped into four broad categories.

(1) *Road construction and maintenance processes, techniques and materials.* The department is actively involved in national research initiatives as well as its own research often in partnership with industry. Research and innovation examples include foamed asphalt cement technology, various subgrade and base material strengthening techniques, materials and additives, rubber asphalt cements, emulsified asphalts, road strengthening with flax straw, road surface sealing materials and techniques, and slope stabilization techniques.

(2) *Machinery and equipment*. SDHT has an intrinsic desire for the work by department crews to be delivered in the most competitive and efficient manner. Examples of innovation and technology adaptation include: transverse crack filling machine, snow removal trucks with numerous incorporated innovative technologies (e.g., auger body dump box, corrosion proof rear fenders, tarp

system, twin drum spreader, adaptation and modifications of the commercial hydraulics control systems, salt spreaders, conveyor systems and other technologies), high capacity pavement line marking equipment, hot asphalt patching box, centerline patcher, bidirectional tractor brooms, and overhead salt silos. Many of these initiatives resulted in patents in Canada and the USA.

(3) *Information technology.* Initiatives in this category range from improvements to the existing financial and management information systems, databases and business processes (e.g., asset management calculators, equipment condition database and calculator), GPS survey technology adaptation and GIS mapping solutions, to transport compliance and enforcement initiatives including remote sensor technologies gathering information on truck weights and dimensions, and scanning and video camera technologies for checking truck registrations and truck drivers' abstracts.

(4) *Organizational and business processes.* Due to a lack of tangible final products, this category is often not recognized as innovation despite tremendous impact on the department's continued ability to fulfill its mandate and move towards its vision. Some examples include the transportation partnership fund mechanism, heavy duty mechanics apprenticeship partnership, truck haul management initiatives, the parts delivery services business model, and the innovation recognition model.

Although some of these innovations are in direct response to the pressures and challenges of managing an extensive highways network with limited resources, many others are the result of employees' intrinsic desire to continually improve the delivery of services to the public.

1.1.5 Challenges associated with innovation

Brilliant insights and ideas that happen from time to time are too infrequent or inconsistent for organizations to rely upon as their sole source of innovation. Fortunately, innovation does not have to be a random phenomenon; rather, research shows successful innovation generally entails systematic ways of bringing ideas to fruition (Drucker 1985, Levitt 1963, Pearson 1988, Cooper et al 2001a, 2002, Fagerberg et al 2005). Most innovations, according to Drucker (1985), are a direct result of a purposeful search for innovation opportunities. Drucker (1985) further argues that successful innovators systematically analyze, in a disciplined way, what the innovation has to be to satisfy an opportunity and then they turn to potential users to study their expectations, values and needs.

Innovating is an inherently risky business with the potential to yield huge rewards for organizations. In the public service sector, however, a prevailing culture of tradition emphasizes caution and risk aversion thus encouraging a uniform, rule-bound and bureaucratic system. This usually results in public service managers perceiving innovation as too risky. In effect, this greatly limits if not kills any initiative that does not fit the current framework developed on rules and regulations. "Most citizens prefer to keep government actions strictly circumscribed by laws and to restrict public servants to the role of complying with rules and regulations" (TBS 1999). These attitudes towards innovation create a dilemma for the public sector innovator. Often, barriers are seen as insurmountable, opposing opinions are more the rule than the exception, and the stakes are high with the organization's (and sometimes innovator's) future possibly in question. Therefore, the challenge for managers in the public service sector is to determine an appropriate level of risk-taking to ensure and maintain innovation in their organizations.

SDHT faces problems and obstacles that sometimes may severely limit the willingness and ability to innovate. Many of these pressures are self-inflicted. In some cases internal pressures may be attributed to the lack of resources for innovation initiatives, a non-existent innovation strategy, poor documentation, organizational misalignment with the corporate strategy, lack of commitment on the part of senior management, "don't rock the boat" and "not invented here" thinking, organizational silo mentality preventing information and expertise sharing, resistance to change, lack of knowledge required to successfully drive a specific innovation, and the lack of a formal innovation "idea to launch" process that provides a disciplined and yet flexible approach to the innovating activity. Among a variety of external pressures impacting SDHT innovative drive, a few are of an especially important nature: general public pressure including various lobby groups, media attention and focus on negative stories, and very strong political pressure and influence. Political pressure and influence alone can have a tremendous impact on SDHT and its employees' willingness to take risk and innovate.

Despite these numerous obstacles, innovation is perceived by many as a critical factor for the department's long-term sustainability and continued success. At least one employee survey (Gerbrandt 2005) confirms this claim. SDHT must continue to be innovative in addressing internal and external pressures to ensure the transportation systems do not hinder the province's competitive advantage in the global market. The key question then becomes how to ensure the continuity and a high rate of success of novel ideas. The starting point is a clear understanding that innovation is a process and as such it can be successfully managed. A leadership and organizational culture that supports innovation through appropriate structures and processes, in combination with a strategy that targets opportunities are necessary for successful and continuous innovation.

There is no one-size-fits-all template for the development of an organizational culture supportive of innovation; organizations must experiment to determine what works best for them. As stated by Peer (2006): “To find the cultural “sweet spot” an organization must constantly fine tune the process, finding ways to encourage changes that produce the best results”. Thus, SDHT must find its own “sweet spot” when it comes to innovating as a way to maintain long-term organizational sustainability. The likelihood of this happening will increase with a better understanding of innovation processes and the development of an innovation decision making framework to ensure the department’s needs are successfully met.

1.2 THESIS OBJECTIVE

The main objective of this research was to develop an innovation decision making framework to facilitate structured and formalized innovation management in Saskatchewan Department of Highways and Transportation.

1.3 THESIS SCOPE

The scope of this thesis was limited to the research of innovation processes at an organizational level. The frame of reference was constrained to the issues and challenges facing managers in the public service sector and more specifically in

Saskatchewan Department of Highways and Transportation. The validity of the established framework and process was tested through the application of two case studies involving different innovations in road construction equipment. Even though briefly referenced, the innovation commercialization issues and marketing mechanisms available to public service organizations remain outside the scope of this thesis.

1.4 METHODOLOGY

The methodology applied in this research consists of the following main elements:

(i) Identify and explore business needs for a formalized and structured innovation management framework in Saskatchewan Department of Highways and Transportation.

(ii) Investigate and describe through a literature review the role innovation plays in organizations and more specifically, how public sector organizations deal with innovation. The literature review should also show how innovation models and processes from the private sector apply to the public sector.

(iii) Develop a strategic framework and evaluation process to enable a formalized and structured approach to evaluating innovation alternatives.

(iv) Test the validity of the established framework and evaluation process through two case studies using innovation from Saskatchewan Department of Highways and Transportation.

CHAPTER 2 LITERATURE REVIEW

2.1 DEFINITION AND TYPES OF INNOVATION

The research literature is not unanimous in defining the term “innovation”. The most prevailing definition however, distinguishes between “creativity” (or invention) as a process of generating new ideas and “innovation” as a process through which creative ideas are realized, implemented and tested (Levitt 1963, Fagerberg et al 2005), and where innovation is not simply an automatic consequence of creative thinking (Levitt 1963). Levitt (1963) also warns that creativity only, without proper implementation, can lead to an organization’s demise. Innovation is a complex social phenomenon that doesn’t simply follow a linear path of research, development, production, and marketing (Kline and Roseberg 1986) and “evolves most successfully in a network in which intensive interaction takes place between those producing and those purchasing and using knowledge” (Hauknes 1999). Drucker (1985) defines innovation as the means of creating new wealth-producing resources or endowing existing resources with enhanced potential for creating wealth. Kline and Rosenberg (1986) argue that firms innovate by combining existing knowledge as a response to a commercial need for something. Sometimes, the existing knowledge is insufficient and there is need to develop new knowledge. This is typically done through scientific research; however, there is generally a significant time leg of approximately 50 years before any important innovation is developed based on this new knowledge (Drucker 1985).

As examples of innovation, Schumpeter cites new products, new production methods, new sources of supply, the exploitation of new markets, and new ways to organize business (Fagerberg et al 2005). According to Dinsdale et al (2002), innovation in the public sector involves an improvement in a product, program, process, service or policy. In addition to distinguishing between different types of innovation based on the final output, it is also common to classify innovation based on how significantly it is different compared to the current products, services or business models. The two major classes include continuous innovation (other terms used are sustaining, incremental, and improvement) and discontinuous innovation (similar terms are radical, revolutionary, disruptive, transformative, and ground-breaking). A number of researchers, as referenced in Fagerberg et al (2005), also add a third class - “technological revolutions” - consisting of clusters of subsequent innovations that may have a long lasting and far-reaching impact.

Even though in the last few years, focus of innovation effort seems to have been on continuous innovation and slight modifications (Cooper et al 2003), discontinuous innovations are in particular the ones that provide a huge competitive advantage and create an enormous value for an organization (Christensen 2005). Moore (2002) considers discontinuous innovation to be any innovation that requires customers to change their behaviour or significantly modify other products and services to accommodate innovation. Dinsdale et al (2002) argue that the long term effectiveness of both public and private sector organizations requires transformative and ground-breaking innovation.

Another innovation concept, relatively recently introduced, is open innovation (Chesbrough 2003). This concept refers to leveraging innovation from external sources or offering one’s intellectual property for others’ use. Bear (2006) cites other similar models including collaborative innovation (sharing of problems, ideas and solutions within a more formal consortium), co-development, joint ventures, and open source software models (e.g. Linux operating system). The challenge, however, in successfully implementing any of these concepts is in networking with the right collaborators.

Finally, much of literature makes distinction (although in very vague terms) regarding the degree of technological innovativeness in different industries based, for the most part, on the industry research and development activities. Accordingly, it is common to distinguish "high-tech", "medium-tech", and "low-tech" industries. Pavitt's taxonomy of innovation, as featured in Fagerberg et al (2005), takes into account not only research and development activities but also experience, experiments, learning by doing, and interacting. An important result of this research is the finding that successful innovation differs across industries depending which factors are the most predominant.

2.2 THE PUBLIC SECTOR INNOVATOR'S DILEMMA

Although organizational and management literature covers a variety of different strategic approaches and management tools for the development of successful organizations, the underlying theme to all of them seems to be innovation. The 2005 innovation excellence study referenced in Cooper and Edgett (2005) reports innovation is thought to be the most important factor in increasing profitability and growth among European businesses. Pearson (1988) argues first, the successful companies understand consistent innovation is critical to their success and second, they understand the importance of creating value for their existing and potential customers. Hillier and MacDonald (2001) claim that value-building growers, companies consistently outperforming others in high annual revenue and shareholder value growth, are clear leaders in innovation and risk taking which are considered one of the major enabling factors for their success. Therefore, innovation not only provides a key competitive advantage but also creates new markets, thus increasing the value of the overall economic pie.

So, given the utmost importance of innovation for the long term viability of organizations of any size competing in global, competitive and rapidly changing markets, the question is whether innovation plays such an important role in the public service sector organizations. Many government organizations are forced to justify their existence and ability to service citizens. Market dynamics, increased societal demands for transparent and responsible management of public resources, a request for more and better quality services responsive to public demands, and constant media attention trying to discover a proof of government inefficiencies in service delivery have created numerous challenges for public sector organizations (McInerney and Barrows 2002). Some of the challenges with any innovation might be the fact that it is hard to demonstrate value of something that does not exist yet or may take some time to accrue some tangible benefits. New ideas are often resisted because they undermine existing power relations, threaten entrenched interests or challenge the deeply ingrained views of others (Stoyko et al 2006). All these pressures and challenges certainly have a major impact on a level of innovation activity in public service.

Obstacles to innovation faced by the public sector could be summarized into two major hurdles. Number one, systemic inertia and complacency often observed in large enterprises operating in mature and relatively stable markets, markets that are government regulated (e.g. monopoly) or perceived as non-competitive. In those organizations, new ideas and innovation are perceived as the challenge to the established, traditional standards and are generally rejected for those reasons. The second hurdle often is the lack of courage, commitment and persistence required to undertake an initiative. Individuals generally perceive risks in terms of negative consequences towards themselves (e.g., reprimand from a manager, loss of reputation among co-workers, and a variety of other psychological and sociological consequences associated with failure). It is also suggested that personal and organizational values have a profound effect on innovation and risk taking (TBS 1999). This is in part, one of the reasons why public service is perceived as compliance oriented and rule bound rather than innovative and creative. An additional dimension that makes the situation even more complex is the influence of political values on public service.

Even the successes in the public sector tell the story about struggles innovators face. Stoyko et al (2006) reference a survey of 436 prize-winning innovations from the U.S. and Commonwealth public institutions. The findings of this survey point to the various obstacles these winning innovations faced: resistance from outside the government (e.g., opposition from interest groups, the general public and private sector companies) was accounted for 24% of obstacles; resistance from "political" forces (e.g. laws, regulations, inadequate resources and opposition from politicians) accounted for 23% of obstacles; and the remaining 53% were contributed to obstacles created within the public service such as coordination problems, logistical obstacles, and obstructive attitudes.

The negative impacts from these obstacles however, can be minimized. Building an innovation culture in an organization requires leadership and more specifically, the kind of leadership that motivates and brings people together to collectively drive innovation. Openness to new ideas and solutions is critical for the successful innovation culture. Cultivating the capacity for absorbing outside knowledge is especially important for government agencies whose research and development funding is typically fairly limited. Taking calculated and intelligent risks is necessary to survive and move forward. In truly innovative organizational cultures even failures are considered an asset that one day might be turned into a success. This is done by establishing a safe environment where ideas are shared and evaluated on their own merits. As evident in some of the most innovative companies (e.g. 3M), mistakes do happen but the organizational culture tolerates “well-intentioned failure” for the sake of the long term success. An infamous example often cited in the innovation research literature is that of Post-It Notes that are essentially a result of a failed project later turned into a product that has become a world-wide success and synonymous with the 3M’s innovative culture (TBS 1999, Collins and Porras 2002). It is therefore crucial to develop a public service organizational culture that tolerates and learns from failure.

Public service organizations need to start looking at problems in terms of opportunities. Taking initiative, thinking up new ideas and implementing them need be done jointly as a team effort (Dinsdale et al 2002). Stoyko et al (2006) point out that “nurturing creativity [in the public sector] is hard work, especially in increasingly transparent public sphere with every activity closely scrutinized”. As the pressures continue to grow, the public service organizations need to find ways to remain relevant and continually evolve and improve with times. This may necessitate taking smart risks in pursuit of opportunities while still ensuring transparency and responsible stewardship of public resources. Therefore, public sector innovators must be willing to resolve their dilemma by understanding the innovation process and associated risks so those can be properly managed.

2.3 INNOVATION ENABLERS

The basic building blocks that enable innovation include networking, management processes that balance freedom and discipline, performance metrics, and an organizational culture that motivates people to take risks (reward system). Basic premise of continuous growth through innovation in an organization is not a single person but a network. The networks include not only internal people but also external parties (suppliers, vendors, professional associations, universities, clients, online forums, groups and unknown partners, etc.). Innovation can certainly benefit from internal structures that encourage interaction and from healthy dose of external exposure. Some companies like Intel, for example, go to the extreme of hiring professionals such as anthropologists and ethnographers to encourage outside of the box thinking or Eli Lilly that posts its problems on the Internet and rewards whoever sends in innovative solutions (Collins and Porras 2002).

Because of the complexity and diversity of issues the public service is dealing with, Dinsdale et al (2002) insist on involving innovative teams as innovation in the complex public service environment is beyond the capacity of a single employee and teams are seen as essential in developing, delivering and fostering innovation. The two key reasons for this are that the teams are central to how public service works and they also bring together people with diverse knowledge, talent, perspectives, values, beliefs, experience, and skills. In addition, teams can re-energize and boost the innovative potential of individuals. Innovation teams “bring together talent and views from across the organization in new ways, while at the same time moving the team outside traditional constraints" of everyday, routine business (Dinsdale et al 2002).

There is obviously no single one-size-fits-all template for innovation. Pearson (1988) suggests the following four elements are necessary for most innovations: 1. a champion who believes in the new idea and will keep pushing ahead; 2. a sponsor in position to allocate organization's resources (people, time, money) to the new idea; 3. a mixed implementation team consisting of creative individuals and experienced hands-on people acting as pragmatists; and 4. a process that moves ideas through quickly. According to Pearson (1988), companies approach these tasks in different ways: some focus on creating multifunctional project teams; some require frequent meetings with top managers to achieve their integration goals; and still some others, especially in private sector, spin off operations and create independent small divisions to act like freestanding enterprises. Dinsdale et al (2002) propose their C-CAR model to deliberately organize for innovation in the public service sector. The C-CAR model is focusing on (C)ommon purpose, (C)reative ideas, (A)pplicability, and (R)esults as a way to ensure innovation is purposeful and strategic. The model enables the team to promote a culture that encourages exploring for ideas and supports sharing among members as well as ensures the creative ideas are relevant to the organization's strategy.

2.3.1 Innovation success factors

Cooper (1999) distinguishes between the group of success factors pertaining to doing the right projects and doing projects right. The former is thought to be external to organizations while the latter is considered internal and therefore, fully controllable by organizations. External factors such as market's characteristics, industries competitive position, and technological arena are leveraged by the company's core competencies. On the other hand, the internal critical success factors (e.g., adequate up-front homework, early innovation definition, understanding of clients' needs, unique value proposition, and a well thought out innovation diffusion plan) can be leveraged successfully through internal management controls.

For many unsuccessful innovations, inadequate up-front homework is considered a major failure reason (Cooper 1999). This is further emphasized by a failure to have a stable and early innovation definition. Coincidentally, Prasad (1996) further exemplifies the importance of up front homework and stable innovation definition by discussing why Japanese manufacturing companies are more successful than their American and British counterparts. The main reason is contributed to the Japanese companies spending about 66% of their design and development cycle time on defining a product and only 10% on redesigning compared to 17% spent on product definition and 50% on redesign for the best USA and British companies.

Another important success factor is the ability to understand clients' business needs. In support of the importance of the voice of customer in new product development and idea generation, Cooper (1999) refers to one study that found that those developments featuring high quality market studies, customer tests, field trials, and test markets in addition to a well thought-out launch plan more than doubled their success rate and achieved 70% higher market shares. Christensen (2005) concurs with the importance of listening to customers when it comes to continuous innovation but warns that this can be a gravely decision regarding discontinuous innovation.

Differentiated, innovative products providing customers with a unique value proposition account for one of the major factors in the creation of the company's competitive advantage (Porter 1980, Cooper 1999). These products also bring in better profits compared to more matured, commodity-like products; therefore, it is important to constantly come up with innovations that compete on the basis of their functionality or reliability (Christensen 2005). Cooper (1999) refers to a research finding of differentiated, superior products being five times more successful, claiming over four times the market share and profitability compared to products with no such characteristics.

To ensure the presence of these success factors, an organization requires a clear strategic plan that dictates spending patterns for different classes of innovation and tough decision making points at which projects are evaluated. Cooper (1999) and Cooper et al (2001a, 2001b, 2002 , 2003) suggest this can be accomplished by using an idea to launch process such as a Stage-Gate model and portfolio management for project ranking and prioritizing.

2.4 OBSERVATIONS FROM LITERATURE REVIEW

Innovation literature does not clearly distinguish between three major phases of an innovation process: creativity, development and diffusion. Therefore, it does not provide adequate and complete understanding of what happens in each phase and how different phases interact with each other. In most cases, a major focus seams to be on creativity processes (e.g. idea generation). Transforming ideas into concrete outputs remains for the most part a "black box" process in the literature on innovation in the public service sector. There is even less emphasis on another very crucial phase to the innovation’s overall success - innovation diffusion. All three innovation phases are unique and should be studied separately since different strategies apply to each.

Furthermore, proposed models seem to be idealistic in terms of their vision of the public sector instead of taking on more of a business approach. Without the concrete and “down the earth” strategic direction and objectives it is hard to target innovation opportunities and know when the goals are achieved. There are no concrete measures of success suggested in the proposed models, thus making it hard to identify whether the process is working well or needs fine-tuning.

Also, there appears to be a limited research on the public service sector innovation that uses actual case studies and discusses experiences with innovation over time. This type of research is common regarding innovation in the private sector. Although some parallels can be drawn from this private sector research and lessons applied to the public sector, caution must be exercised to account for the competitive differences and operating conditions between the two.

CHAPTER 3 STRATEGIC INNOVATION FRAMEWORK

3.1 PHASES OF INNOVATION PROCESS

The innovation process starts with creating an environment for ideas to flourish and then by capturing and evaluating those through the management procedures that ensure the ideas are successfully turned into products or services. The third supporting pillar of this complete process is innovation diffusion; that is, the process of rolling out and adopting fully developed ideas. Although over simplified this model certainly captures well the division of the innovation activity into its major elements. In bringing good ideas to fruition, however, it is important to note that creative thinkers who originally come up with ideas may not necessarily be the ones to implement them. Creative thinkers quite often lack the discipline required to follow through with an idea. Similarly, those who are successful at transforming an idea into innovation may not necessarily be the ones to market or implement innovation in their own organizations.

Innovation is an integrated process that evolves in three main phases (Figure 3.1). Each phase has its own deliverable. Before proceeding to the next phase this deliverable is evaluated against its criteria. For the creativity phase, the deliverable is an idea that holds a certain value proposition. The innovation development phase transforms that creative idea into a concrete product, service or business model. Finally, the deliverable for the diffusion phase is a successful innovation launch. Innovating is an iterative process; in other words, every step of the process brings new insights that are used to refine the idea and the final deliverable. This also may aid organizations in dealing with a path dependency problem by critically assessing their choices and if required, abandoning or radically changing the development project.

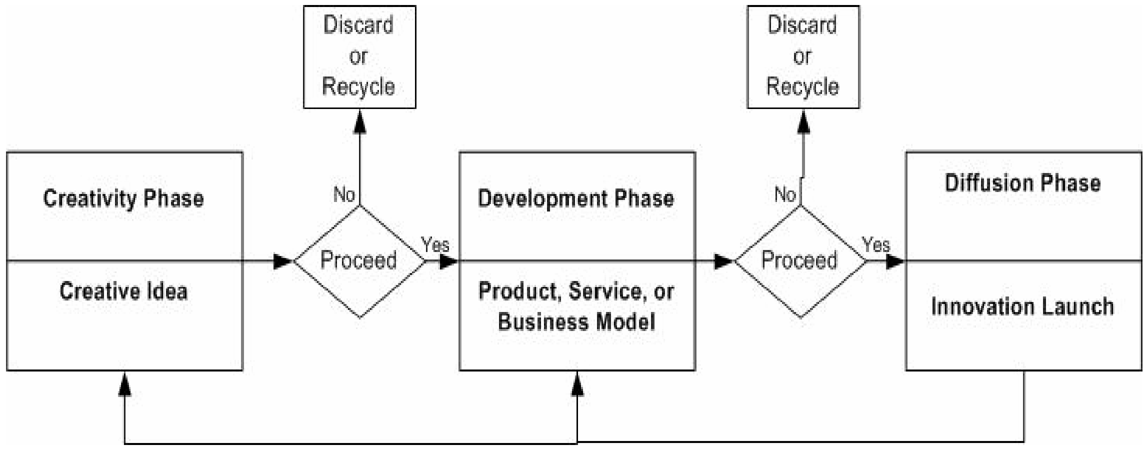

FIGURE 3.1 PHASES OF INNOVATION PROCESS

Typically, innovation process flows from one phase to another although a linear path is not necessarily always followed. Sometimes, different elements of the innovation process might be executed concurrently or a cue might be jumped. Although this may happen for the very justified reasons and is important to maintain that flexibility, it is also crucial to stay as close to the disciplined approach as possible and avoid cutting corners on the key tasks.

3.1.1 Creativity phase

The creativity phase is where an innovation journey starts. It is here ideas occur first as either "eureka" moments or a result of the purposeful search for opportunities. Regardless of the ideas' origin and perceived value proposition, creative ideas and information associated with them should be preserved in a central and common location and made easily accessible to others (Dinsdale et al 2002, Cooper et al 2002). This can help prevent people from re-inventing the wheel and can also provide access to ideas whose time might be ripe due to the changing circumstances. A failed idea may indeed become a star innovation after all.

One of the ways to increase the creativity outputs is through a deliberate search for opportunities (Drucker 1985, TBS 1999, Stoyko et al 2006). The most predominantly practiced technique in this regard is through a frequent interaction with stakeholders and customers. Cooper et al (2002) elaborate on building in voice of customers into a deliberate "discovery stage" by interviewing customers, spending time with them in their own work environment and especially, working with lead or innovative customers. This helps maintain congruence between organizations' goals and strategies and the customers and stakeholders' expectations and desires. The networking with other entities, public organizations, non-profit organizations as well as businesses is another great way for a public service organization to learn and seek innovation opportunities. This "outside in" learning style needs to be properly balanced with a more inwardly "inside out" approach that focuses on the organization's own employees as a continuous source of creativity (TBS 1999). Stoyko et al (2006) provide an exhaustive list of some of the most tried and proved techniques for individuals and teams that might help in generating creative ideas.

3.1.2 Development phase

Creative ideas remain just that – ideas – unless they are implemented. This transformation of ideas to a useful outcome in the form of a product, service or business model happens in the development phase. The development of ideas is not a random process and should not be left to chance. This is where a good innovation project manager plays a crucial role by ensuring the transition from an idea to an innovation flows smoothly. To achieve that over and over, a systematic and disciplined "idea to launch" process is required to ensure a greater rate of success of innovation. A good, effective system provides for a mix of freedom and discipline.

One approach to systematically manage individual innovation projects is a Stage-Gate model. Such a model is used to generate ideas, evaluate them, and move them efficiently and quickly through the development process and into the launch (or implementation) phase. This process is also based on the continuous improvement principles with many loops built into the process to facilitate learning and feedback about the innovation project. It is characterized by the use of a team approach and provides for a systemic, disciplined approach to risk management, project evaluation and decision making.

3.1.3 Diffusion phase

Market's absorption capacity determines the success of innovation (Christensen 2005). For a public service innovator, the market may be internal customers, public in general or a specific social group. Similar to the two previous phases, innovation diffusion should also be a deliberate and well planned activity. A well thought out and executed diffusion greatly increases the chances of innovation's acceptance. In successful organizations, an innovation diffusion execution plan is done up-front even before any development work begins. A good innovation diffusion plan is flexible and accounts for an ever-changing world and evolving social and personal needs and preferences (Moore 2002).

The first step in the diffusion process is awareness of innovation. Choosing an appropriate communication medium to achieve this is crucial. Many different ways of communicating innovation exist; for example, through printed word, verbally, electronically or any meaningful combination of the three. The best medium choice greatly depends on innovation circumstances and complexity.

The next step involves understanding of customers' needs and preferences. Based on the knowledge of the buying hierarchy marketing model (Christensen 2005) focusing on a product's characteristics (functionality, reliability, convenience and price) and the technology adoption marketing model (Moore 2002) focusing on target customers (innovators, early adopters, early majority, late majority, and laggards), a public sector innovation "marketer" must be able to match the right innovation with the right customer. If successful, the follow up steps involve rolling out innovation to other groups of target customers.

3.2 ELEMENTS OF INNOVATION FRAMEWORK

Without doubt, luck plays an important role in innovating; however, companies that simply seem to be consistently "luckier" than others have an established innovation framework that realigns their leadership, culture, and management tools (Davila 2006). The established innovation framework illustrated in Figure 3.2 is an integrative and guiding framework that can enable public service organizations to be consistently "luckier". It identifies the most important success drivers that influence the innovation process from conceptual ideas to diffusion. The framework contains six major focus areas: business strategy linked to innovation strategy, performance metrics, knowledge management, risk management, project management, and change management.

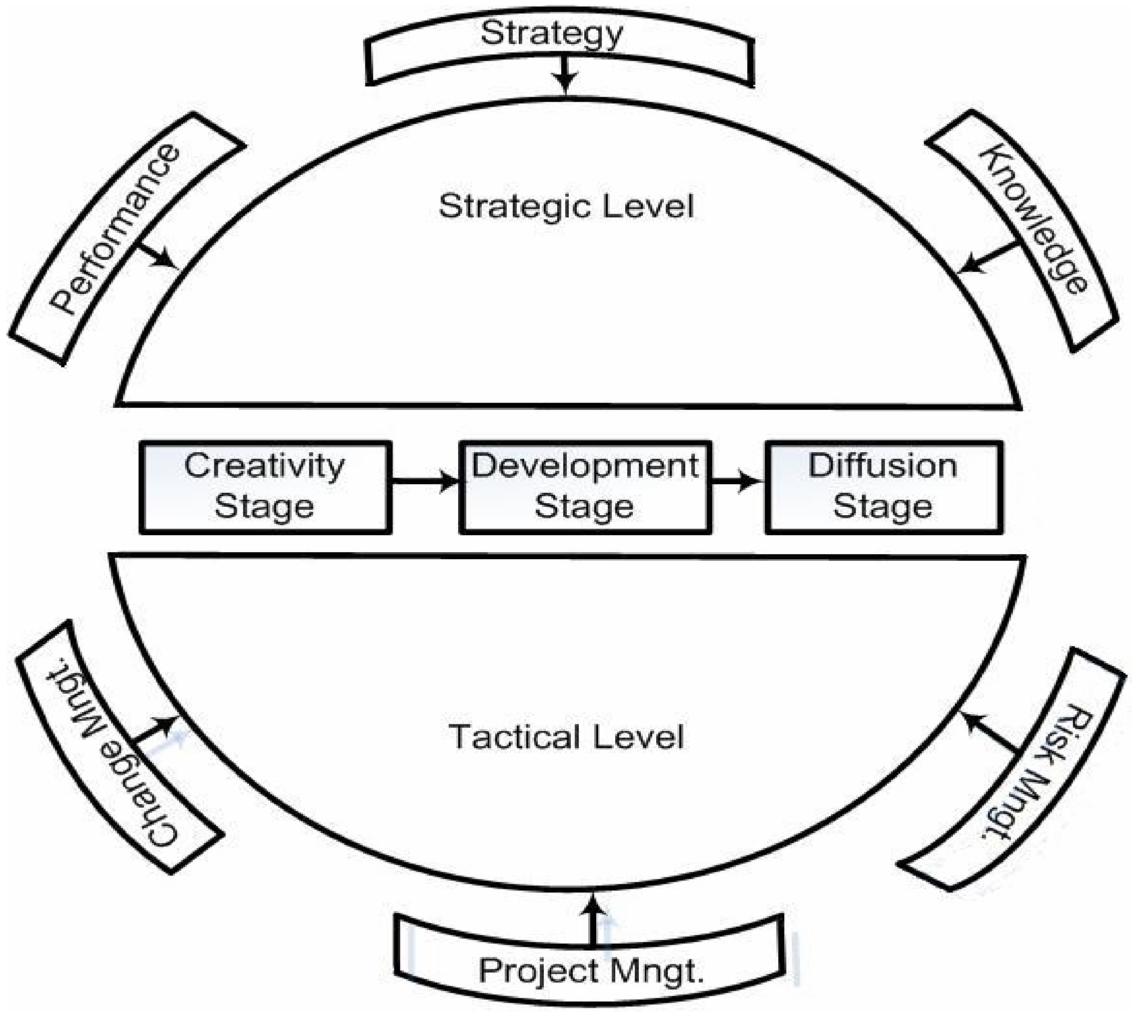

FIGURE 3.2 INTEGRATED INNOVATION FRAMEWORK

The top factors in the framework are more strategically orientated compared to the bottom factors that are most likely applied at the tactical (operational) level. There is no single, standalone driver of the innovation success. All the drivers need to be present and act in the same direction in order for innovation to be consistently successful. Some factors, however, have more profound impact on specific innovation phases. For example, although present in all phases, change management may be the most significant in the diffusion phase.

Strategic level factors aid in the development of an explicit innovation strategy and elicitation of innovation opportunities. At this level, an organization's strengths and weaknesses are well understood so the threats can be minimized and the chance of successfully capturing opportunities maximized. This also includes understanding what resources and knowledge are required and available. With innovation opportunities elicited, the focus increasingly shifts towards the tactical level. The generated ideas are efficiently managed through an innovation development process. This includes constantly evaluating the development progress against the established financial and non-financial evaluation criteria including risk factors too. The final innovation deliverables are then carefully implemented in the organization.

3.2.1 Strategic level elements

3.2.1.1 Strategic management

An explicit innovation strategy guides and focuses an organization's innovation efforts. A clearly defined innovation strategy enables organizations to properly allocate scarce resources to those strategic areas identified as critical. Therefore, the innovation strategy needs to be linked to the business' overall strategy. This link provides a clear direction regarding people's roles and responsibilities and in focusing the organization's efforts in the search for innovation opportunities. With clearly defined strategic goals everybody in the organization has a good sense of common purpose.

Secondly, an effective strategic innovation plan focuses the effort to those areas deemed to yield the greatest benefits. It helps match the most attractive areas to the organization's strengths. This focused approach ensures resources and time are not wasted on strategically irrelevant developments. It is also important for organizations to determine what role they wish to play in each identified innovation area. Different roles might be required for different focus areas.

3.2.1.2 Performance management

Properly chosen and executed performance measures not only help understand if things are being done right but also if the right things are being done in the first place. Therefore, the performance measures are used to improve an organization's strategies in case the focus is not on the right things and also, the operational aspects in case the things are not being done right. According to Kaplan and Norton (1996), this is best accomplished by applying a balanced scorecard. The balanced scorecard approach balances financial measures that mainly focus on past performance with more future oriented measures focused on investments in customer relations, employees, processes, technology and innovation. The financial measures remain vital in evaluating the impact of a company's strategy; however, to avoid an over-emphasis on short term returns and benefits, other non-financial measures are also required. While the balanced scorecard approach is desired at the strategic level, other tactical level innovation metrics could be required to evaluate processes and successes at an operational level. A good performance measurement system does not only focus on the outputs but also is used to track the progress throughout the innovation pipeline. It helps organizations identify the areas that might need further improvements.

Furthermore, performance measures play a central role in any reward system organizations might implement to motivate people to take intelligent risks. The reward system should provide for a fair compensation consistent with the risks and magnitude of innovation. It should also be recognized that the success and impact of an innovation, in some cases, may not be able to be measured until long after its implementation. Although many private sector organizations have employed some kind of a comprehensive reward system for years, many public service organizations (e.g. Saskatchewan Department of Highways and Transportation and Delaware Department of Transportation) are now recognizing the need for it as well.

3.2.1.3 Knowledge management

Organizations create knowledge through the acquisition of individuals (or companies) that posses it, by discovering new knowledge and insights from external sources, and through insights from internal research and other creative activities (McShane 2006). Organizational absorptive capacity that depends on the organization's existing foundation of knowledge determines how much and what type of knowledge that organization may be able to acquire. To optimize the benefits from acquired knowledge, it must be shared throughout the organization (e.g. knowledge repository established on the organization's Intranet). Also, to be truly useful, knowledge present in an organization should always be put to use. Knowledge is a primary determinant of a public service organization's ability to adapt and thrive in a rapidly changing environment (CCMD 1999 and CCMD 2000).

Innovation activities are tightly related to knowledge processes in a learning organization. Knowledge is prerequisite for developing and implementing innovation. A strategic level analysis should identify specific knowledge and skills set required to meet future needs. Once strategic arenas are identified, innovation opportunities elicited and creative ideas generated, acquired knowledge will aid in the transitioning the ideas into fully developed innovation. Knowledge acquired through the innovation development must be shared throughout the organization. Even failures can be used to advance knowledge so mistakes are not repeated.

3.2.2 Tactical level elements

3.2.2.1 Risk management

In an increasingly complex and diversified public service sector it is critical to approach work with an attitude focused on creativity and a willingness to innovate. However, this must be coupled with the prudent protection of public interests and maintenance of public trust, especially in an era of an increased media and public attention on government perceived inefficiencies and possible irregularities. Therefore, it is becoming more important than ever to balance the drive and need for innovating and a prevailing risk-averse attitude in the public service sector. This requires both public service organizations and civil servants to be better able to identify, assess and manage risks in every aspect of their endeavours.

A comprehensive risk management approach includes risk identification, assessment, and mitigation. For each risk identified there is a need to characterize the degree of risk in terms of its probability of occurrence and the potential impact. The probability of risk occurrence is rated on a risk probability scale (for example, 1 – low, 2 – medium, and 3 – high). Similarly, the impact, if risk does occur, is rated on the impact scale (for example, 1 – minor, 2 – moderate, and 3 – significant). The scores for each risk are then multiplied together and this results in an overall risk factor, which in turn determines an appropriate mitigation strategy.

The selected mitigation strategy depends on the overall assessment of the degree of risk. It will also depend if risk can be controlled or avoided and what resources and expertise are required and available. The rule of thumb is the higher the degree of risk the more rigorous the mitigation strategy. Once the mitigation approach is finalized, a mitigation risk factor is calculated based on the new "mitigated" probability of occurrence and the impact. The results of risk analysis determine the course of action regarding creative ideas being evaluated.

3.2.2.2 Project management

Project managers are charged with organizing and directing a group of individuals and delivering a project on time and within budget. Furthermore, they require excellent skills in conducting resource and scheduling analyses, resource allocation, costing, accounting and risk management. On top of all that, successful innovation project management is able to "tap into the creativity and willingness to innovate most people have when they feel confident and comfortable in the surrounding" (Taylor 2006).

Given the complexity of managing innovation projects, organizations must have an effective "idea to launch" process in place founded on best project management practices. Such a process should clearly prescribe all the steps involved in the innovation development and specify the requirements project managers need to meet at each step. Furthermore, it is a valuable guiding tool for project managers that provides for a consistent and fair project assessment. Yet, the process must remain flexible enough to account for various differences associated with different innovations.

3.2.2.3 Change Management

Change management is a key enabler for innovation and its diffusion. It is no doubt the most important aspect of implementing or adopting innovation in a public service organization. Too often good ideas and innovations fail simply because no proper steps are taken to implement change successfully. With the understanding of how change impacts people, organizations can develop strategies to help better deal with the resistance to change. This in turn should greatly increase the likelihood of innovation's success. Senior managers' leadership is critical for successful change management. When innovations are being implemented and changes made, it is important to link them to the organizational strategy and direction. The most important thing for the innovation implementation team is to lead through the transition to this new strategic reality and to remember people move at different speeds for a variety of reasons. It is, therefore, crucial to account for these differences and ensure help is provided to make this transition a success.

CHAPTER 4 INNOVATION EVALUATION PROCESS

4.1 INNOVATION PORTFOLIO MANAGEMENT

Managing innovation mirrors the resource allocation process (Christensen 2005). Innovations given proper attention and adequate resources have greater chances of success. Portfolio management can aid in determining where and how an organization should invest its resources. Cooper et al (2002) define portfolio management as a resource allocation strategy specifying the right strategic mix and the right number of projects. Portfolio management is seen as an answer to a problem many companies experience in having too many projects for the available resources.

An organization's strategy should manifest itself through its portfolio management. Portfolio management is used to maximize the value and return on investment of the portfolio, appropriately balance projects in the portfolio, and ensure investment strategy is in line with the organization's strategic direction. The portfolio management process allows for projects to be compared against each other as well as strategic, financial and other criteria, thus enabling an organization to prioritize their project lists and investment strategy. It also provides for identifying a project mix that best fits an organization's long-term and short-term strategies. The ultimate goal is to have an innovation portfolio that "is strategically driven, is fed by a proactive idea generation process, relies on the right selection criteria to pick projects, and balances quality-of-execution with speed to market" (Cooper 2005).

According to Cooper et al (2001a) and Cooper et al (2001b), the most common challenge in creating an effective portfolio management lies in the creation of a positive, accepting culture and buy-in in the portfolio concept. Other cited challenges include achieving business objectives, obtaining linkages to strategy and achieving balance in the projects. The predominant complaint is the abundance of short term, low risk projects. The most cited benefit is the creation of a consistent basis for analysis and project evaluation using the same criteria.

4.1.1 Methods used in portfolio management

There are a number of portfolio management methods available. Many organizations use multiple methods or different variations of the most popular methods. Cooper et al (2001a) conclude that financial methods are the most dominant portfolio management and project selection method. There are a variety of financial tools grouped under the umbrella of the financial method: expected value, net present value, return on investment, payback period, internal rate of return, etc.

The second most popular portfolio method according to Cooper et al (2001a) is the business' strategy method used to allocate budgets to different projects according to their fit with the business' strategic goals. Cooper et al (2001a) and Cooper et al (2001b) provide a detailed account of one such method – the strategic buckets methods. In essence, a strategic bucket represents a pie chart that identifies resource allocations to different strategic areas. Projects in one bucket do not directly compete for resources with projects in another bucket but rather are prioritized within their own bucket given the financial and other resource constraints. Each bucket is allocated money depending on its strategic importance. Other popular portfolio methods include bubble diagrams or portfolio maps, scoring models (e.g. low-medium-high, 0 to 10 scales, etc.), and check list models that rely on a set of Yes/No questions.

The decision which method to use must be based on the risk and the magnitude of the impact the project may have. It is also important to understand there is no universal single criteria that can be applied to all situations to evaluate, prioritize and select projects. The evaluation model needs to maintain flexibility in the methods used and the details required to move projects through the system. For example, low risk projects such as minor modifications may only require a simple financial model. On the other hand, uncertain true innovation projects may require a more extensive scoring model that is heavily focused on the strategic type metrics in the beginning. As more information becomes available (e.g., by completing feasibility studies, building prototypes, or running pilots for a certain period of time), more elaborate financial metrics and quantitative criteria can be included.

4.2 STAGE-GATE MODEL

Organizations need a disciplined approach to managing innovation so the innovation effort is not left to a mere chance to succeed. Such a disciplined approach increases the likelihood of success of innovation otherwise characterized by its inherent uncertainty. It is also a systematic way to learn from failures if they do happen. Cooper and Mills (2005) claim top performing businesses have an effective and efficient idea-to-launch innovation process in place such as a Stage-Gate model.

Stage-gate process is a formal, documented process designed to increase the success rate of the development of new and innovative products. It introduces discipline into otherwise a chaotic process. The major elements of a stage-gate model are: 1. stages that define what activities and tasks need to be completed in order to gather crucial information; and 2. gates that represent decision making points. The deliverables from the stages are used in the gates and are compared against the criteria for that gate generally consisting of must pass and should have type of criteria. Each subsequent decision to proceed means more incremental commitment in funding. A generic Stage-Gate model (adopted from Cooper and Edgett 2002) is illustrated in Figure 4.1.

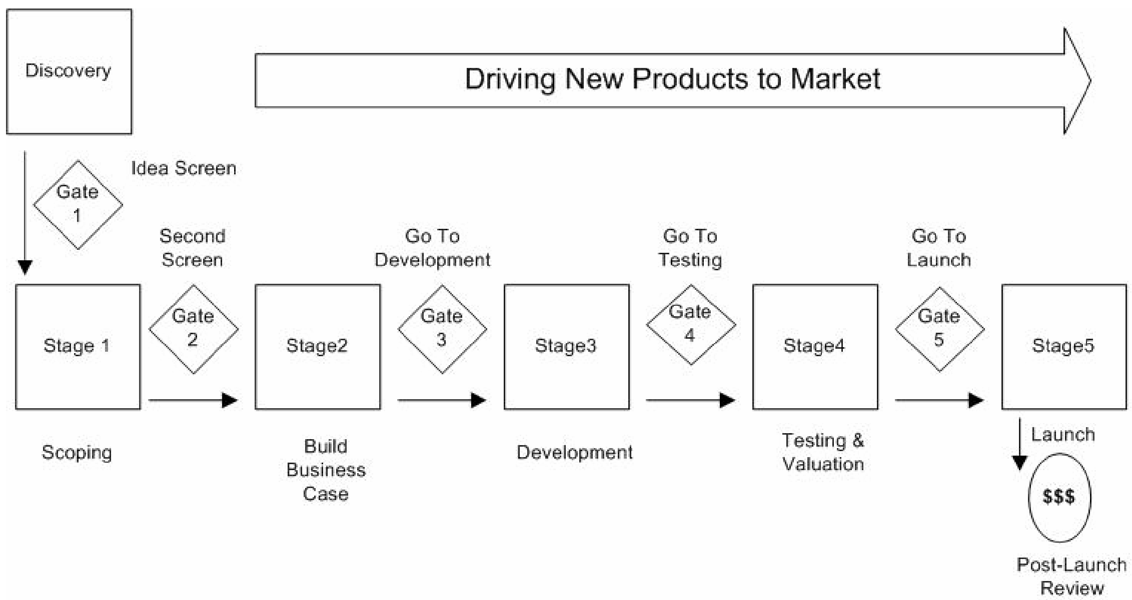

FIGURE 4.1 A GENERIC STAGE-GATE MODEL

This generic model has five stages and five gates plus the discovery and post-launch reviews. Each stage has a prescribed list of tasks to be completed (i.e. information to be gathered). The five stages include scoping, building the business case, development, testing and validation, and launch. The scoping stage involves a quick and basic project definition and gathering general information associated with financial and non-financial impacts. Build the business case stage entails a much more detailed investigation regarding the project and culminates in a business case that includes detailed project definition, project impacts, and a well thought out project plan. This is a critical stage as most up-front homework is completed here. The innovation would be designed and conceptually developed in the development stage and verified in the subsequent testing and validation stage. Finally, the launch stage is crowning of the whole effort with the innovation being rolled out to end users.

The complexity of a project generally determines what information may be required at each stage. This information gathering may vary from simple financial impacts in case of a minor improvement to complex feasibility studies and prototype building in case of very uncertain and complex projects. Deliverables from each stage result in a better and more accurate understanding of the project. These deliverables are used in subsequent gates to make the decision whether or not to proceed to the next stage. Gates can also serve as prioritization points where projects are judged against the same criteria and prioritized based on their score. More detailed information regarding Stage-Gate model, individual stages and gates can be found in Cooper et al (2002), Cooper and Mills (2005), and Cooper and Edgett (2005).

4.2.1 Stage-Gate model for the public sector

Public sector organizations must follow best practices used by successful innovating companies. There is no need to re-invent the wheel; rather, managers must focus their attention on creating an environment for intelligent risk taking. An organization's competitive advantages should also be maximized by forming strategic alliances and evaluating promising technologies developed elsewhere. Public sector strengths often lie in continuously improving those external technologies as they are adapted to the organization's business needs. Therefore, public agencies' innovation management processes must provide a good fit for evaluating new and emerging technologies developed both in-house and elsewhere.

Figure 4.2 illustrates a stage gate model for managing the development of major innovation projects in a public service organization. The model covers all three major phases of the innovation process: creativity, development and diffusion. The creativity phase contains one stage and one gate. Although Dinsdale et al (2002) warn against premature rigorous evaluation that could potentially kill good ideas, the idea evaluation process still has to be rigorous enough to eliminate obviously bad ideas right off the start. Ideas generated in an organization or adopted from an outside environment are all funnelled to the idea evaluation and risk assessment stage. At this stage a brief proposal is prepared focusing, in very broad terms, on such elements as alignment to strategic goals, technical feasibility, financial implications, and value proposition. Since the public service sector requires special attention to managing risk properly because of its inherent risk aversion, a preliminary risk identification and assessment are undertaken. Although this analysis is not very detailed at this stage it does nonetheless provide some information to the innovation project team to better understand what may be expected ahead.

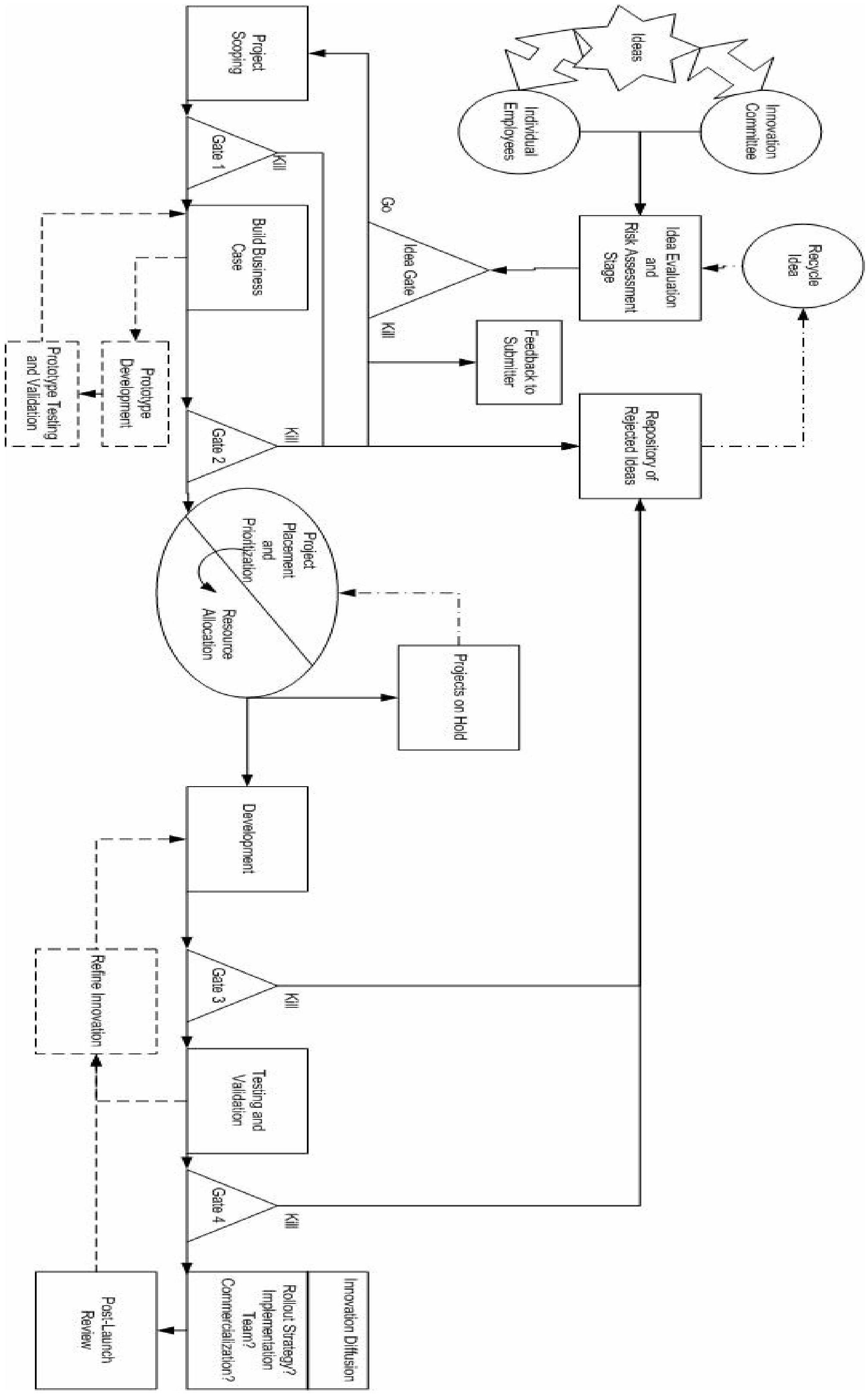

FIGURE 4.2 COMPLETE STAGE GATE MODEL FOR PUBLIC SECTOR

Information gathered at the idea stage is forwarded to the idea gate – initial screen "Go/Kill" gate. Here, a small group of managers with good understanding of the business and organization evaluates the proposed idea using a simple scoring model. This simple scorecard system applies a scale of 0 to 10 and/or a checklist with a number of "Yes / No" questions. Some questions might be considered mandatory. A typical scorecard that might be used at this gate is illustrated in Table 4.1. In designing a scorecard, one should keep in mind that the same criteria, only with more detailed requirements, should also be used in the subsequent evaluations throughout the innovation development phase.

TABLE 4.1 TYPICAL SCORECARD FOR IDEA EVALUATION

Evaluation Criteria	Weighting	Scoring
Strategic Alignment	32%	10
Financial Impact	30%	10
Technical Feasibility	13%	10
Value Proposition	25%	10

In addition to using a scorecard, a checklist or a combination of both, the results from the preliminary risk analysis are considered as well. The results from a typical early risk analysis at this stage might be presented in a format illustrated in Table 4.2 and recommended by Treasury Board Secretariat of Canada (TBS 2001) as a simple model to guide risk management actions.

TABLE 4.2 PRELIMINARY RISK MANAGEMENT MODEL

Impact	Risk Management Actions		
Significant	Considerable management required	Must manage and monitor risks	Extensive management essential
Moderate	Risks may be worth accepting with monitoring	Management effort worthwhile	Management effort required
Minor	Accept risks	Accept, but monitor risks	Manage and monitor risks
	Low	Medium	High
		Likelihood	

The results from the preliminary risk assessment coupled with the results from the scorecard are used to determine the course of further innovation development actions pending the idea passed the evaluation process. In either case, a formal feedback is provided to those who submitted the idea. Also, the rejected ideas are all stored in a central idea repository made available to all employees. These ideas can be pulled out from the repository and re-evaluated if the circumstances change and/or additional information becomes available. Cooper et al (2002) suggest organizations should never toss ideas out just because they may not meet their current strategic orientation; rather, they should explore all possibilities by playing out future scenarios and evaluating their consequences. It is also important to determine scenario markers to monitor where things are moving towards in the future.

The ideas that pass the idea assessment gate are sent further down the innovation development pipeline. Based on the results of an early risk analysis and scorecard evaluation, there are three possible routes for an idea to go through the development phase (Figure 4.3). In case the development of the idea is perceived low risk, its overall score confirms its value and its implementation is deemed simple, the idea may be expedited through the development phase without going through all the stages and gates. In other words, the rules of engagement in the rigorous innovation process are circumvented for the sake of simplicity and expediency.

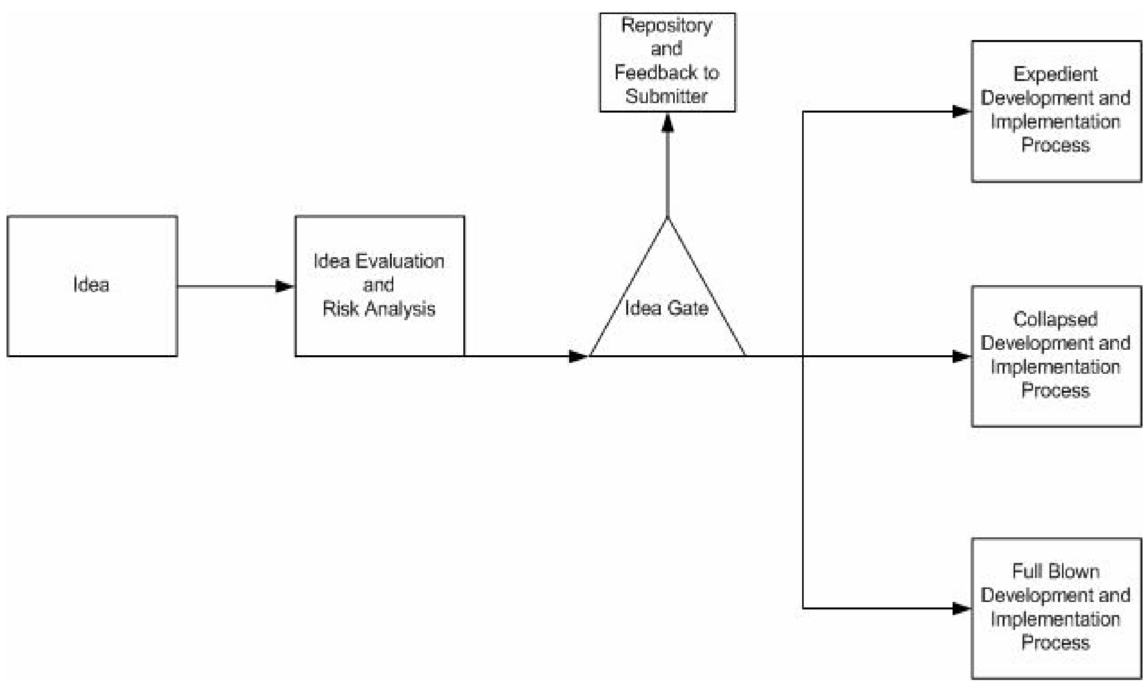

FIGURE 4.3 INNOVATION PROCESS PATHS

On the other hand, if the idea is considered moderately risky (shaded in light grey in Table 4.2), holds a certain value proposition and is deemed as not a major initiative, the subsequent stages and gates of a complete innovation development phase can be collapsed. For example, the scoping and developing business case stages could collapse in one stage and one gate before proceeding to the innovation portfolio management process. Also, the analysis requirements and information deliverables from the collapsed stages may not be as demanding as if the full blown process was followed. Those managing the innovation portfolio should specify what information is required to still be able to properly allocate scarce resources to different projects. If the project successfully gets a go when the portfolio decisions are made, then the subsequent stages and gates may be collapsed as well (e.g. development and testing / validation stages). Again, this decision is made at the innovation portfolio management level.

When the creative idea is defined as high risk / high impact or requires a major resource allocation, it is warranted to proceed through the complete stage gate evaluation process, step by step, as illustrated in Figure 4.2. The first stage involved is the project scoping stage. This stage involves a quick assessment of the technical and economic merits of the proposed project, its commercialization prospects, intellectual property rights issues, and implementation implications including the impact on various stakeholders. It is not meant to be an exhaustive and detailed analysis. Information gathered in this stage is then delivered to the first gate of the development process – project scoping gate. The same evaluation criteria used at the idea gate are also applied here; only this time, more information is available and the expectation is that the scoring will be better and more accurate. Similarly, the same risk management model is utilized again with supposedly better and more accurate information.

Projects that pass the scoping gate are on their way to the next stage that involves building the business case. This is the critical stage where an exhaustive up-front homework is required to define the innovative product or service and justify the project. Also, depending on the size, magnitude, uncertainty and impact of the project it may be warranted to complete a pilot project or develop a prototype product to collect better information and gain insight regarding the innovation's reach. The deliverables from this stage are sent in to the subsequent gate where they are compared against fairly detailed criteria. This is where the original criteria are usually further broken down into more detailed and specific criteria requirements. An exhaustive evaluation schema is developed to properly evaluate the innovation project and its impact. Also, at this gate the original risk management model is expanded to include risk mitigation.

Projects that pass the screening end up placed in the portfolio management tool where they are allocated to different strategic buckets. Each bucket has certain resources assigned to it and here, the projects are prioritized within each bucket until the allocated resources are exhausted. Projects in one bucket compete only against projects in the same bucket. In other words, there is a firewall between buckets. From here, the successful projects proceed to the development stage where the details of the business case are translated into concrete deliverables. New insights from the development process are used to update the original business case. This updated information is then sent to the next gate where it is judged against the criteria developed earlier in the process. If the project passes this gate it goes into the testing and validation stage to ensure the innovation is fully tested and validated. The validation procedure generally entails assessing the innovation technical features, the production or service deployment process, end users acceptance, and the economics of the innovation. The final stage involves implementation of the innovation with a follow up review to gain new insights from the observed performance and acceptance. This new information can then be used to further refine the innovation's features. The entire innovation development process is very iterative in nature, thus further emphasizing a requirement for the continuous improvement culture in the public service sector.

It is worthwhile noticing that as innovation matures through the stages and gates, more emphasis is put on the financial factors as the financial impacts are better understood in time. Consequently, as the innovation moves through the stages, financial commitment incrementally increases. This is in contrast to risk. At the beginning, uncertainty is high and as the project moves through the stages, more information is gathered resulting in diminishing uncertainty.

CHAPTER 5 CASE STUDY: FLEET SERVICES INNOVATION MODEL

5.1 INTRODUCTION

Most innovations in road construction and maintenance machinery and equipment in SDHT involve the Fleet Services branch. Fleet Services' mandate is to provide high quality and cost effective mechanical, fabrication, equipment preservation, and procurement services to the fleet used to deliver the department's programs on the provincial highway system. This is accomplished through strong leadership in fleet services, communicating with internal clients and understanding their business, and providing expertise and innovation to enable the department to be successful in delivering value-for-money service to taxpayers.

The prevailing innovation culture and style of thinking in Fleet Services resembles, to a large degree, the historically prevailing innovation culture associated with innovations in the agricultural machinery and equipment business sector in Saskatchewan. This culture generally involves continuous improvements to existing equipment originally manufactured somewhere else outside the province. Consequently, a certain degree of adaptation to Saskatchewan specific conditions is usually required. Majority of innovations can be tracked to ingenuity of SDHT's front line employees innovating out of necessity to make their work easier and improve productivity. This, at least in part, is a direct result of being away from the major equipment manufacturers and having to rely heavily on themselves. There is also a strong evidence of a lack of documentation regarding many innovative products or processes thought out and developed in the department. A great amount of knowledge regarding many innovation developments remains stored in their innovators' heads. Furthermore, for the most part, innovating tends to be predominantly based on a trial and error approach as opposed to putting more emphasis on up front design and project definition.

Although praised for its many successes this innovation culture and thinking style also leave room for significant improvements. Therefore, understanding of this innovation culture and its characteristics is a crucial first step in an attempt to improve the innovation process. This thesis attempts to accomplish exactly this by providing two detailed accounts of, by all measures very successful, innovation in road construction equipment and illustrating how the research findings (framework and idea to launch process) can further strengthen innovation in Fleet Services and SDHT.

5.2 FLEET SERVICES' STRATEGIC FRAMEWORK

The uniqueness of Fleet Services organization and position within the department makes it necessary to develop its own mission, vision, strategic goals and objectives. Those need to remain closely related to the department overall strategy, mission, vision and values. The Fleet Services strategy must fit well with the department's strategy and contribute towards its corporate strategic goals. Similarly, the Fleet Services' innovation strategy and focus must be in line with the department's innovation strategy.

A critical role in developing corporate or organizational strategy is good understanding of one's industry, competitive drivers in that industry and the organization's own strengths and weaknesses. A SWOT analysis is a simple, strategic tool used to accomplish this. SWOT is an abbreviation for Strengths, Weaknesses, Opportunities and Threats analysis. It is a subjective assessment of information organized into a logical template that aids in better understanding, presentation and decision making. The outcomes of the analysis enable organizations to focus on strengths, minimize weaknesses, address threats, and take the greatest possible advantage of opportunities available. Generally speaking, the OT part is done prior to the SW because the competitive strengths and weaknesses are examined in relation to the opportunities and threats that are present in the firm's competitive environment. Table 5.1 presents the results of the SWOT analysis for the Fleet Services branch.

TABLE 5.1 SWOT ANALYSIS FOR FLEET SERVICES BRANCH

Strengths	**Weaknesses**
• Expertise in transportation and construction equipment • Strategically located throughout the province • Organizational values and behaviours • Acceptance of workforce diversity • Intrinsic innovation drive • Superb know-how repair and fabrication	• Communication (both horizontally and vertically) • Public tendering requirements • Understanding of strategic alignment to corporate vision • "Silo" mentality • Capturing tacit and mobile knowledge to build organizational memory
Opportunities	**Threats**
• Growing young Aboriginal labour pool • Commercialization of existing innovation • Exploring new road treatments and equipment • Improving capabilities of snowplow truck fleet • Exploring different business models to better meet service demands • Developing strategic partnerships with external experts	• Failure to successfully communicate, implement and manage change • Inadequate pool of future leaders • Inefficient organizational structure and operations • Failure to stay abreast of technological developments • Substandard quality assurance and documentation • Inadequate innovation process

The SWOT analysis reveals areas that Fleet Services can focus on in the search for strategic opportunities. These opportunities are further explored and usually result in a number of ideas that are in turn processed through the innovation stage gate “idea to launch” process. For example, as a primarily winter service driven organization, the department requires, among other things, an efficient and effective snowplow truck fleet. Therefore, improving the department’s truck fleet would be identified as a strategic opportunity to successfully meet future service demands. For this strategic opportunity to be realized, it must be explored in more detail. In doing so, many ideas can be generated that could potentially lead to capturing this opportunity (e.g., develop a system of alternating salt discharge between front and rear depending on the conditions and road characteristics; develop a mechanism for spreading salt either on the driver’s or passenger’s side; and implement truck tender evaluation criteria that provides incentives for vendors to submit innovative suggestions). This information flow from a strategic to a tactical level is illustrated in Figure 5.1.

The tactical process begins at the idea evaluation stage and gate where each idea is assessed for its potential value and risk. This is accomplished through a simple scorecard system and a preliminary risk assessment. Based on these analyses, the decision is made on how to proceed with that specific idea. Ideas could be rejected and placed in the idea repository or may be deemed valuable enough to further explore. Less risky ideas with no significant resource impacts and with a value proposition above the established threshold are expedited into the innovation portfolio management tool. Those ideas that are deemed to hold a certain value proposition but may be somewhat riskier or have more significant impact on resources would end up going through a collapsed stage gate process. The collapsing of specific stages and gates would generally be determined on a case by case basis. And finally, a certain number of ideas with the characteristics of a higher risk or a fairly significant impact on resources would go through a complete stage gate evaluation process.

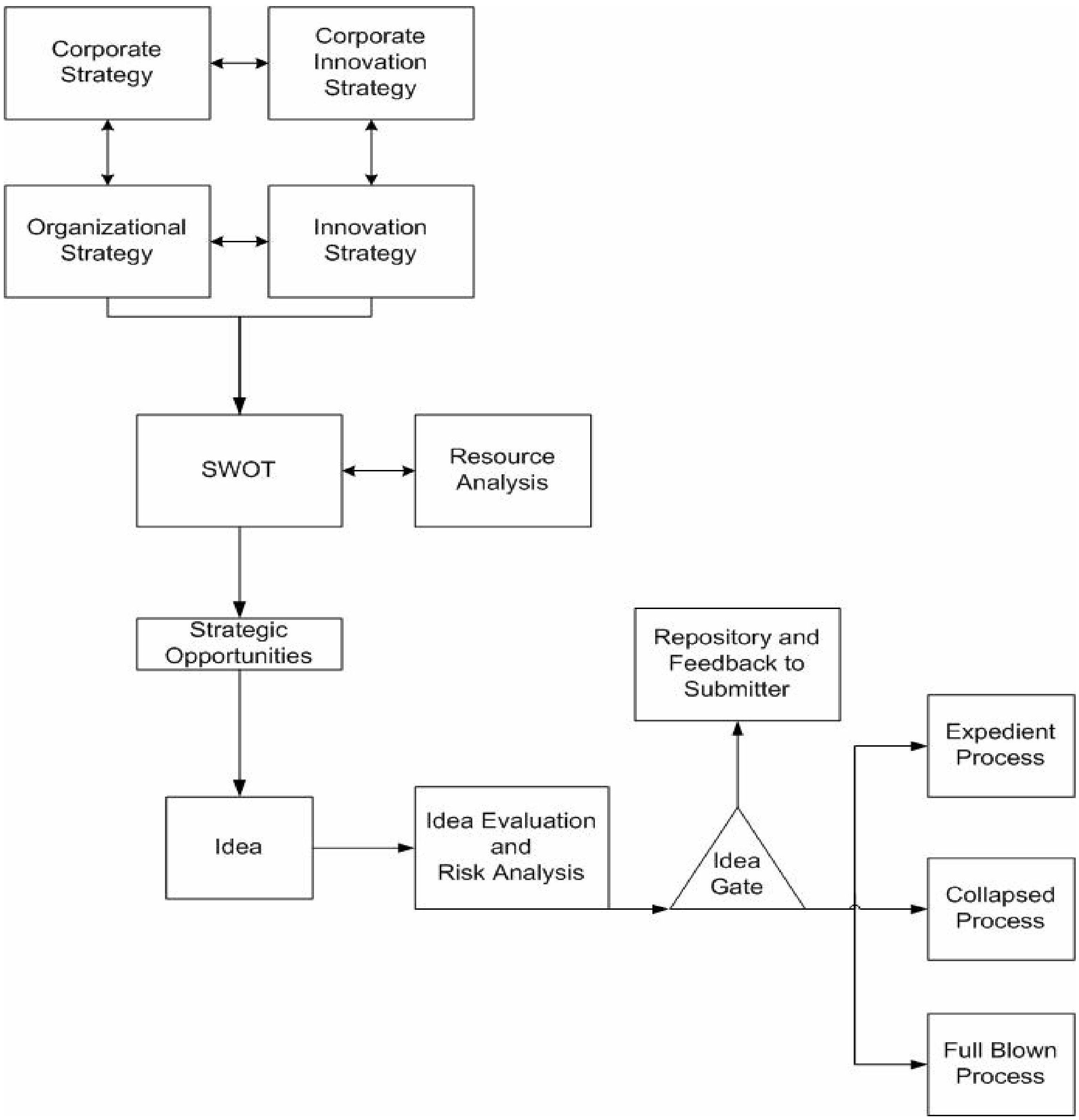

FIGURE 5.1 INNOVATION PROCESS FLOW

Two detailed case studies regarding innovation in road construction equipment illustrate this transformation process from a strategic to a tactical level. The case studies describe how these innovations were originally developed; then, the thesis research is applied to demonstrate the usefulness of the proposed approach in further improving the innovation process in Fleet Services and the department.

5.3 TRANSVERSE CRACK-FILLING MACHINE – TCM 8000

5.3.1 Introduction

The Thin Membrane Structure (TMS) roads were built in the 1960's and 70's as an inexpensive "mud-free" surface by placing approximately an inch or less of cold bituminous asphalt oil on a prepared subgrade. This provided very little structural strength. As a consequence, TMS roads have historically required high maintenance efforts to provide an adequate level of service. Accordingly, the SDHT maintenance crews had adopted treatments and procedures to meet their objective of continually patching these roads. This was possible at the time as there was much less freight going over those structurally inadequate roads; however, with changes in traffic patterns, loading and significant increases in truck configurations and weights, this proved to be a futile effort in many cases. The result has been an on-going campaign that for the most part has contributed to upgrading of many kilometres of TMS roads into a paved standard. A certain number of kilometres is also managed through alternative haul management programs and a lesser number has been converted to gravel surface. Therefore, with the changing distribution of surface types and the decline in the number of kilometres in the TMS system, as illustrated in Figure 5.2, the maintenance crews have also started changing their focus. More attention was now directed to maintaining and preserving the asphalt concrete (AC) and granular systems. To be able to do this the maintenance crews required new treatments, equipment and materials that could effectively be applied to the paved road network.

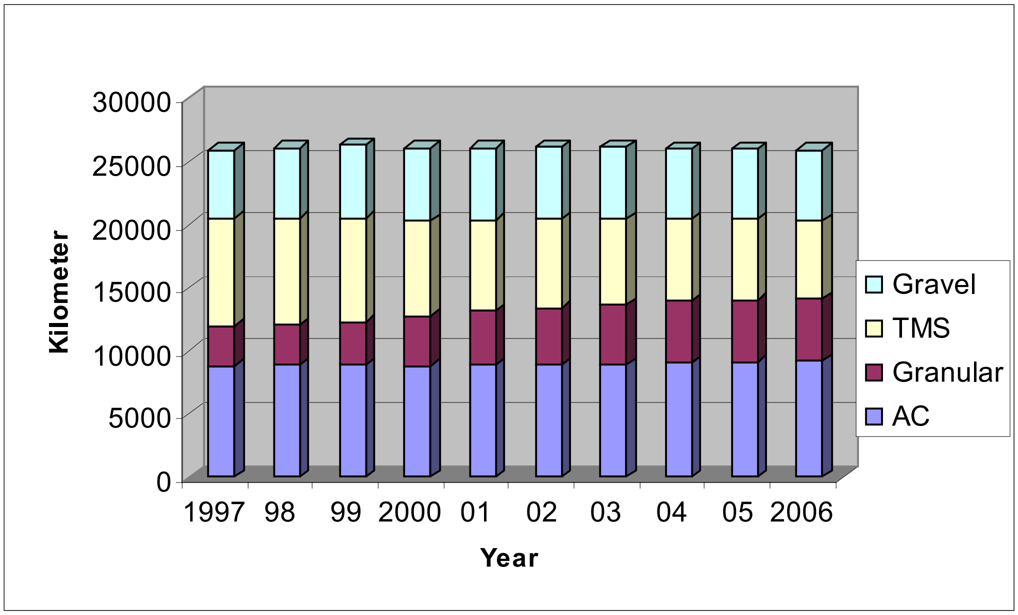

FIGURE 5.2 PROVINCIAL HIGHWAYS INVENTORY CHANGES 1997-2006

Even though the crews have developed and improved various treatments over the past few decades to help them achieve their goals of adequately maintaining all types of roads in the system, they had continually struggled in dealing with localized rutting, environmental thermal cracking (depressed transverse cracking), and centerline cracking. Consequently, in 2002, a small group of SDHT employees embarked upon an initiative to research different materials and technologies to provide a more efficient and effective means of preserving AC and granular roads. The efforts of this small committee resulted in the TCM 8000 technology.

The TCM 8000 treatment is used for filling depressed transverse cracks, localized ruts, centerline joint cracks and other minor highway surface defects, all with a cold asphalt mix. The mix is a cold mixture of polymer-modified asphalt emulsion, mineral aggregate, air entrained Portland cement type 10, water, and set-retarding additive properly proportioned and thoroughly mixed. The mix is modified to obtain "slow set-quick traffic" characteristics so it is suitable for its intended application of treating depressed transverse cracks that can be some distance apart on a highway.

The development of the new equipment followed the development of the modified microsurfacing mix. The guiding idea was to build a self-contained unit that would eliminate the need to have too many pieces of construction equipment on site. The fabrication process involved a typical trial and error approach relying heavily on the in-house welding and mechanical expertise. The final outcome was the TCM 8000 technology consisting of a trailer with storage and mixing facilities for the material (Figure 5.3) and a skid steer-mounted screed box for applying the mix to the road surface (Figure 5.4). The machine is designed for speed of application. The TCM 8000 mixing operation is fully automated. The ingredients are proportioned and mixed in the mixing bowl and then, dumped into the screed box hydraulically attached to a skid-steer. The mix is kept agitated in the screed box and is laid down by opening the gate on the backside of the box. It is then spread and squeezed out at the bottom of the screed box. Lazic (2004) provides detailed description of the development of the modified microsurfacing mix, TCM 8000 technology, its application and field performance.

FIGURE 5.3 TCM 8000 MIXING PLANT

FIGURE 5.4 DETACHABLE SCREED BOX

SDHT has built and now owns two TCM 8000 machines. The department also holds the U.S. patent for this technology and currently has Canadian patent pending. Since its inception, this technology has generated significant interest from other highway jurisdictions and private contractors in Saskatchewan, other parts of Canada and the States. As a result, in 2006 SDHT entered into an exclusive licensing agreement with a local Saskatchewan manufacturer. This agreement effectively transfers the intellectual property rights from the department to the private entity allowing them to manufacture, market and sell the TCM 8000 technology in exchange for royalties paid back annually to the department based on sales. In this way, the TCM 8000 technology can be manufactured on a larger scale and marketed all over the world.

5.3.2 Characteristics of the TCM 8000 innovation

The development of the TCM 8000 technology was not a mere continuous improvement to existing equipment or a road maintenance process. Some components of the technology development, however, do have the prevailing characteristics of continuous improvement (e.g. modified microsurfacing mixes with "slow set – quick traffic" characteristics). Others, on the other hand, resulted in a new and unique piece of road maintenance equipment. Such innovations are typically considered riskier because of a large degree of uncertainty associated with them.

This innovation was a direct result of the purposeful focus of SDHT employees to satisfy a specific need that would improve their work and increase their productivity. It is a good example of strategic planning that linked the corporate and lower level organizational units' strategies. The result was a partly explicit innovation strategy that guided the innovative efforts throughout the whole project. This strategy defined the problem and identified opportunities for innovation.

The TCM 8000 innovative effort was characterized by the use of an innovation team consisting of employees from different functional areas. The members of the team were selected for their knowledge and expertise as well as positive attitude towards change and willingness to experiment with new things. In addition to this diversity, the development team was relatively small which provided the required focus and decision making effectiveness. Furthermore, the external services and expertise were utilized by cooperating with a private, local emulsion supplier and using their lab and equipment in testing various modified microsurfacing mixes. By accessing this external pool of knowledge the innovation team was able to minimize some of the perceived internal “knowledge weaknesses”.

Consistent with so many typical machinery and equipment innovative activities in SDHT, this project was also characterized by a lack of proper documentation and inadequate up front homework. This lack of documentation is more related to the equipment development than the modified microsurfacing mix testing. There is very little of a paper trail left behind to follow the steps and processes involved in fabricating the TCM 8000 machine, thus making it difficult to transfer this knowledge onto other employees in Fleet Services. Some additional documentation however, had to be developed at a later date for the purpose of applying for patent.

Furthermore, the TCM 8000 machine development can be described as a typical trial and error one. A lot of hard work and re-work went into developing each component, then, assembling and testing it to see how it all performs together. No design and modeling software was used to aid in this process mainly due to a lack of knowledge and expertise with such software at the time of the TCM 8000 development.

Another characteristic of this project is the on-going, continued improvement and refinement of the performance of the TCM 8000 technology as more expertise is gained by working with it in the field conditions. This has resulted in numerous features being added or refined such as, among other examples, the configuration of the mixing paddles in the screed box, innovation of a cement metering device and the installation of sensors in the material pre-measuring tanks.

5.3.3 Lessons learned

This thesis poses a question: "If the development of the TCM 8000 technology were to be done all over again what would be different this time?". Answers may help with improving the innovation process in Fleet Services and are provided in light of the research work discussed in the thesis.

5.3.3.1 Strategic level

The TCM 8000 technology was developed without following any formal innovation process as, for example, the one described in Chapter 3 and Chapter 4; however, many crucial elements of the innovation framework illustrated in Figure 3.2, especially at the strategic level, were present although maybe not always in a completely explicit way. This strategic orientation was accomplished through the long-term focus on the changing surface type inventories and road surface distresses. Through this strategic focus, it was realized the trend of increasing asphalt concrete and sealed granular road kilometres would be continuing in the foreseeable future and SDHT maintenance crews would continue to struggle with localized surface distresses. This purposefully concentrated the search for innovation opportunities on a number of specific distresses and road surface types. Therefore, although done in a somewhat less explicit way, the strategic part would be fairly consistent with the proposed innovation management approach.

Furthermore, no comprehensive, explicit performance measures were considered for the innovation development up front. This is especially true for the development of the TCM 8000 machine. However, although not explicitly measured it was fairly well understood what such a machine was supposed to accomplish. This understanding was based on the required field performance as observed in the field try outs as well as during the lab material testing. Performance of mixes in the lab did indeed follow the strict procedures for microsurfacing mix design as described in the International Slurry Seal Association's "Recommended Performance Guidelines for Micro-Surfacing A143 (Revised)". Further, the established field test sections were monitored regarding their performance in terms of wheel rut depth as well as width and depth of transverse cracks.

Had the strategic innovation framework been in place and followed at the time of the TCM 8000 technology development, the whole process would have been more streamlined and focused. This would have potentially resulted in time savings and a reduced probability of failure. The major benefit, however, would have been the knowledge gap assessment identifying knowledge and skills requirements deemed crucial for the successful innovation development and diffusion. That would have also enabled the project team to focus on developing the required knowledge and skills ahead of time rather than working on those simultaneously during the actual field application. Although certainly not explicit, the other two elements (strategic focus and performance requirements), were indeed present; however, both would have somewhat benefited from a formal and streamlined approach.

5.3.3.2 Tactical level

One great advantage of following a formal innovation evaluation process is the fact that fairly exhaustive, up-front homework is required. With this work done ahead of time, there is generally a much better understanding of the financial and technical implications, and risks. For the TCM 8000 development, such an approach would have resulted in more time spent up front on the design and project definition as opposed to an applied trial and error approach that in some instances required re-working a feature numerous times to “get it right”.

The TCM 8000 technology strategic level analysis would focus the research on maintenance treatments for a paved system (i.e. depressed transverse cracks and localized ruts). As an innovation opportunity is identified and a creative idea presented, it is then evaluated against a set of criteria including strategic alignment, risk, financial impact, technical feasibility, and value proposition. This information is then passed on to the idea gate for the decision to be made whether to proceed with the project or not. Due to a huge uncertainty at this time, this evaluation is by no means exhaustive but rather, is a first step in a more detailed analysis pending the decision is made to further proceed with the idea. Table 5.2 illustrates the use of this evaluation process for the TCM 8000 technology. A total score of 2 points is used as a threshold to determine which projects are to be further considered.

TABLE 5.2 PRELIMINARY EVALUATION CRITERIA

Evaluation Criteria	Weighting	Scoring	Weighted Score
Strategic Alignment	**32%**	**8**	**2.56**
Financial Impact	**30%**	**4**	**1.20**
Technical Feasibility	**13%**	**4**	**0.52**
Value Proposition	**25%**	**8**	**2.00**
			6.28

Similarly, a preliminary risk assessment is conducted to get a feel for how risky the proposition may be. Addressing risk this early in the innovation development is a wise idea especially in the public service sector where risk aversion is much more prevalent. Table 5.3 illustrates the preliminary risk assessment conducted for the TCM 8000 technology. Fields coloured in green are low risk, those in yellow pose fair risk that requires some attention and those in red are high risk ones that would require significant attention. The TCM 8000 technology development would qualify as a high risk category project.

TABLE 5.3 TCM 8000 PRELIMINARY RISK ASSESSMENT

Impact	**Risk Management Action**		
Significant			
Moderate			**X**
Minor			
	Low	Medium	High
	Likelihood		

Information from Table 5.2 and Table 5.3 is used at the idea gate for the "Go / Kill" decision. Additional information required at this time is also the impact on resources (both financial and human resources) to determine if the project represents a major, medium or minor development. The TCM 8000 technology development would be considered a major development as per this criterion. Different thresholds are established to aid in decision making as illustrated in Figure 5.5.

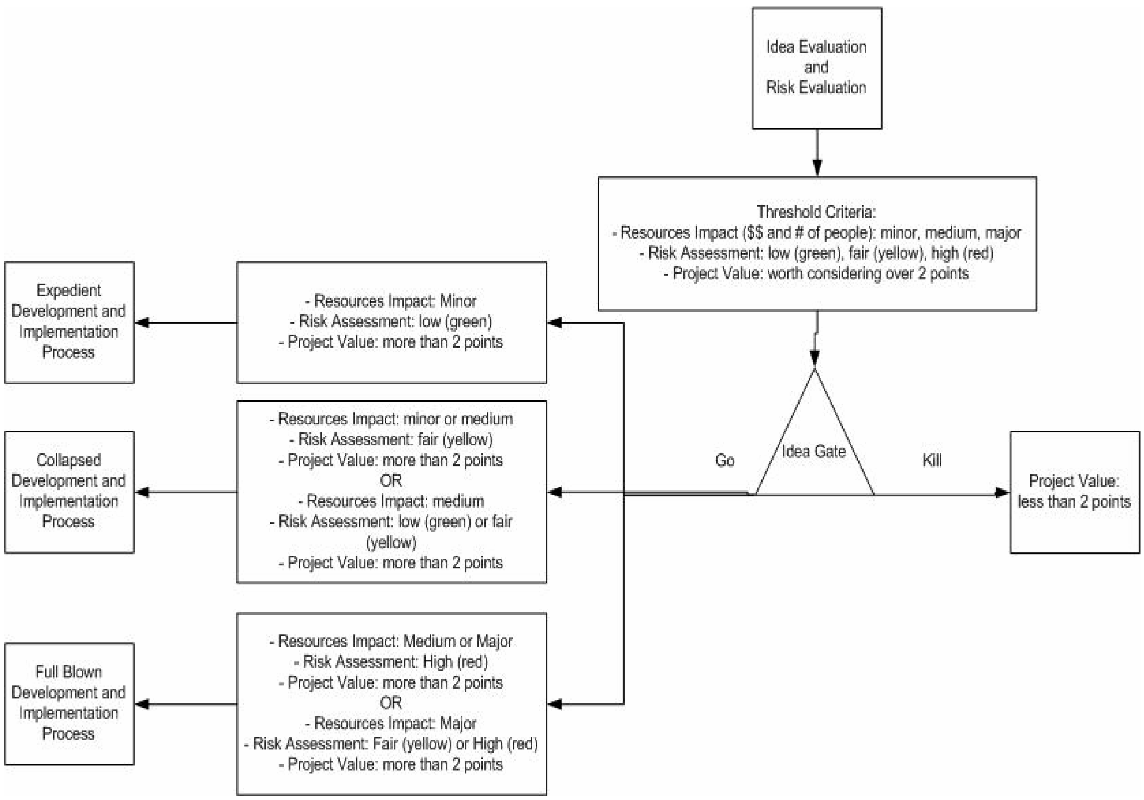

FIGURE 5.5 IDEA GATE EVALUATION PROCESS

Based on the idea gate evaluation, the TCM 8000 project would proceed as a full blown development and implementation project thus, following the innovation process similar to the one illustrated in Figure 4.2 in Chapter 4. Certain adjustments, however, would be made to account for a small scale production and uniqueness of developing this technology. Figure 5.6 illustrates the resulting innovation development process for the development of the TCM 8000 innovation.

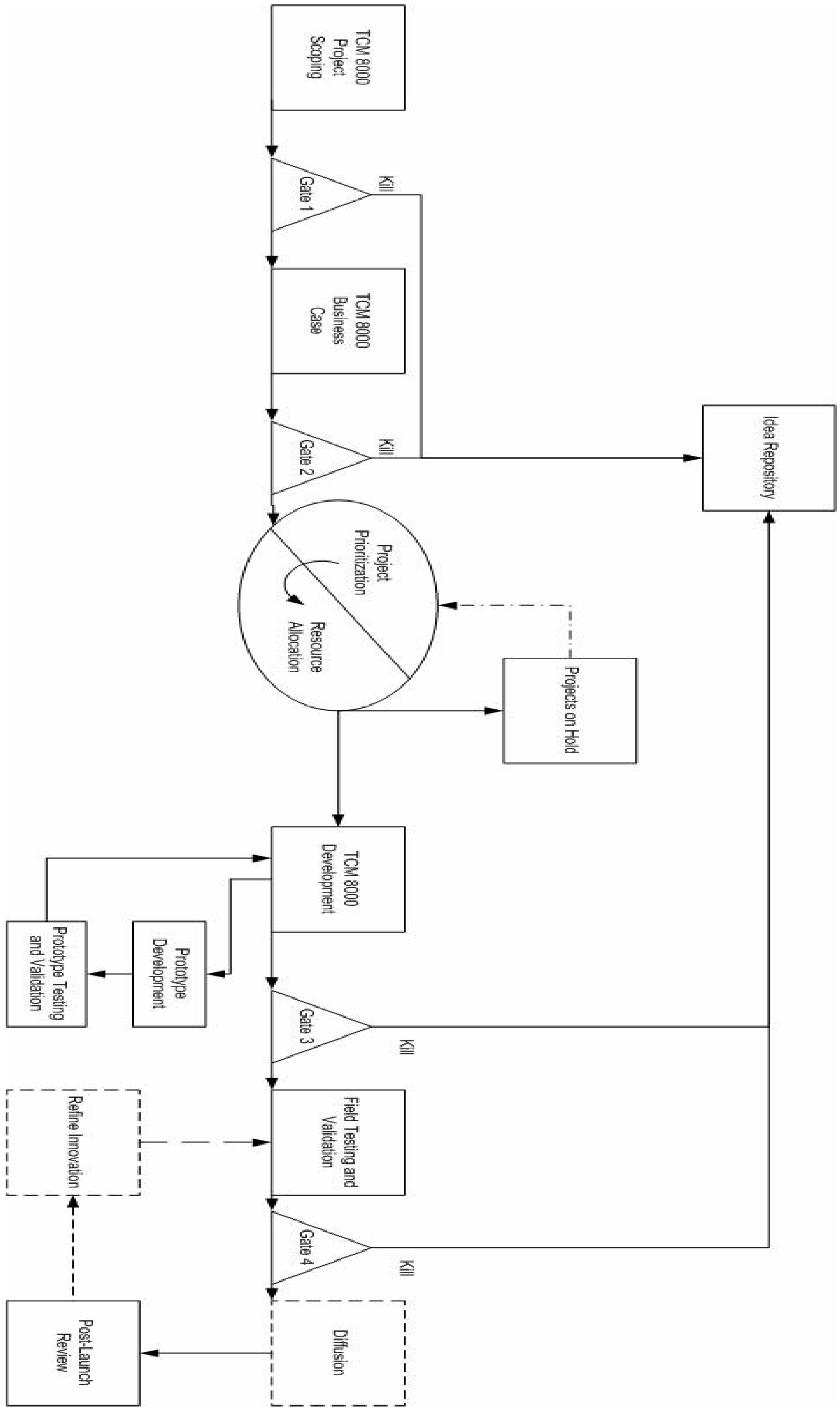

FIGURE 5.6 TCM 8000 STAGE GATE INNOVATION PROCESS

Although during the actual TCM 8000 technology development some type of an informal innovation review process was followed, there was no formal assessment at various gates especially at the later stages of the innovation development. Therefore, once an early commitment was made to proceed with a prototype building, there was no communicated way how the further evaluation would be conducted. If the project were unsuccessful there would be no good formal way of killing it.

However, if the proposed innovation stage gate process were in place at the time of the TCM 8000 development, more emphasis would have been on up front homework and design. This requirement would result in a better understanding of the project through a more elaborate effort placed on defining the scope of the project and developing the business case to justify it. A good business case would most likely contain the following elements: executive summary, business concept (business need, project definition, objectives, scope, and stakeholders impacted) and a detailed analysis part (proposed solution, alternatives considered, stakeholders impact analysis, resource analysis, risk analysis and detailed evaluation criteria / scorecard including a financial impact analysis). In addition, issues regarding intellectual property rights, commercialization potential, selecting the development and implementation team, innovation diffusion plan, potential strategic alliances, knowledge requirements and shortcomings would also be briefly discussed in the business case.

The original criteria from the idea gate would be expanded to include more detail as illustrated in Table 5.4. The very same criteria would be universally applied throughout all the gates; the only difference being that more updated and accurate information would be gathered at each subsequent stage making the decision making less and less uncertain. The expanded version of the original scorecard has 11 criteria summarized in four main categories. Each criterion is clearly defined and is evaluated on a scale of 0 to 10 where a score of 0 is worst and 10 best. In the end, weighted scores are calculated and summarized for all criteria. The threshold that determines a minimum acceptable value of the proposed innovation remains 2 points, just the same as in the preliminary idea evaluation.

TABLE 5.4 TCM 8000 EXPANDED EVALUATION CRITERIA

Evaluation Criteria	Weighting	Scoring	Points	Weighted Score
Strategic Alignment	**32%**		**8.25**	**2.64**
Strategic Fit and Impact	55%	9	4.95	
Proprietary Position	15%	10	1.5	
Synergy with Existing Knowledge	20%	4	0.8	
Potential for Commercialization	10%	10	1	
Financial Impact	**30%**		**7.2**	**2.16**
Net Present Value	80%	8	6.4	
Time to Implement	20%	4	0.8	
Technical Feasibility	**13%**		**5.3**	**0.69**
Resources Availability	40%	5	2	
External Support	30%	4	1.2	
Project Complexity	30%	7	2.1	
Value Proposition	**25%**		**7.6**	**1.90**
Impact on Stakeholders	60%	8	4.8	
Business Service Transformation	40%	7	2.8	
				7.39

To enable an easy and quick sensitivity analysis, these same criteria can be transferred from the spreadsheet to an evaluation model such as the one illustrated in Figure 5.7. The model is set to export criteria values back to the spreadsheet and import the total score from the spreadsheet. This simple model is designed in Decision Programming Language (DPL) software. This software package uses decision trees and a graphical method, called influence diagram, to construct a decision problem. Clemen (1996) provides an excellent overview of the method. Also, a DPL manual (1998) provides very good practical examples using influence diagrams.

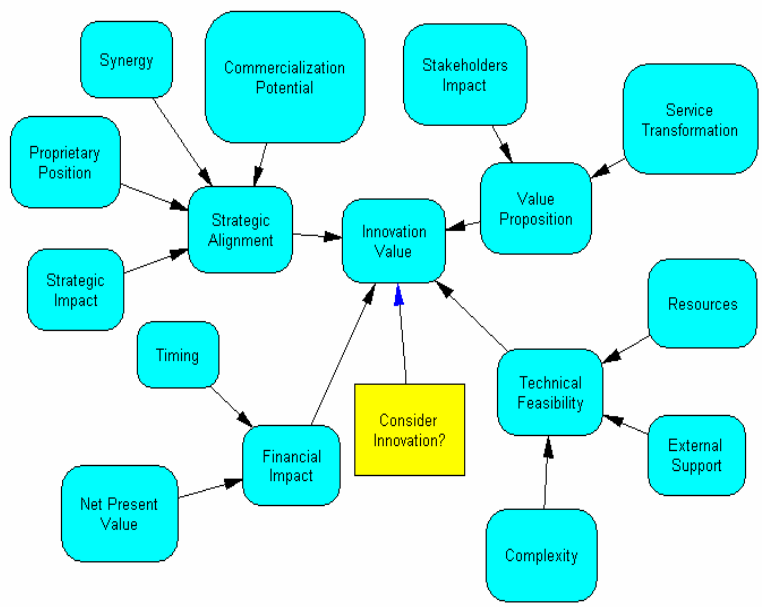

FIGURE 5.7 EVALUATION CRITERIA CONVERTED INTO A DPL MODEL

The true value of this modeling tool lies in its ability to quickly conduct a sensitivity analysis on the innovation evaluation criteria. This in turn provides better understanding regarding uncertainties of the modeling inputs and their impact on the "Go/Kill" decision at different gates. These insights can also be further used to build a valuable probabilistic decision model to better reflect and model the significant uncertainties. Figure 5.8 illustrates one of the sensitivity analysis methods available in this software package – Expected Value Tornado Diagram.

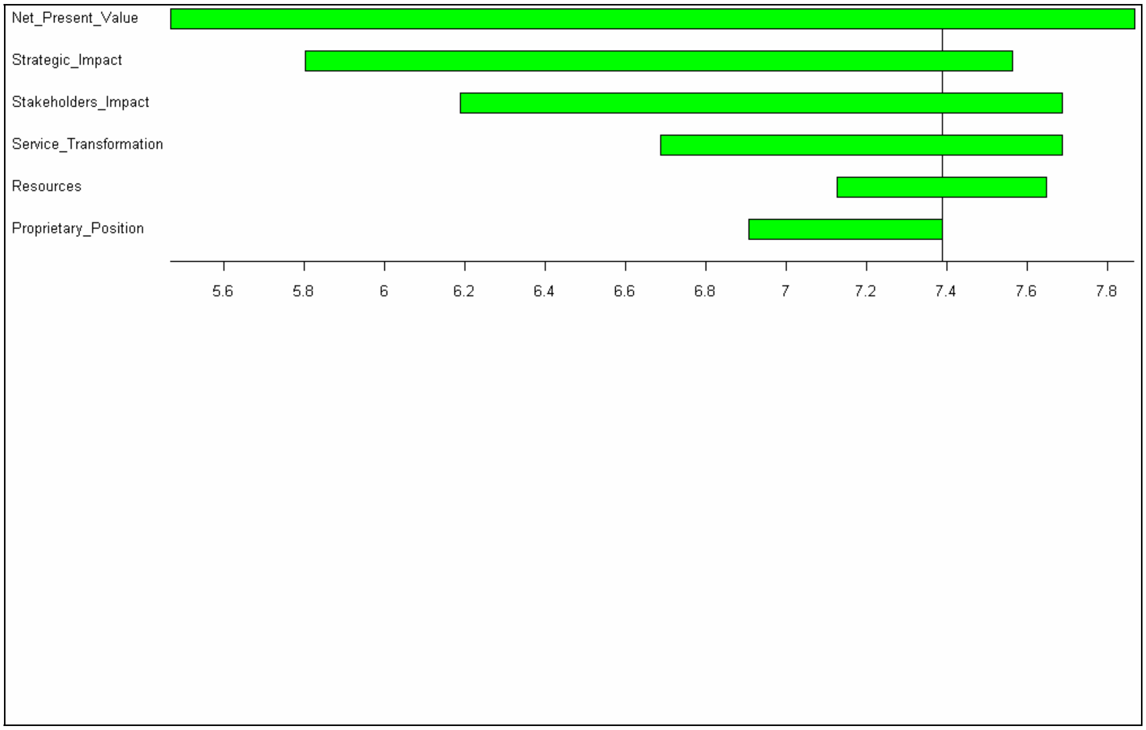

FIGURE 5.8 EXPECTED VALUE TORNADO SENSITIVITY ANALYSIS

The expected value tornado diagrams are a very useful and versatile sensitivity analysis tool. Their major benefit is in determining which factors may have an impact on the final decision. With this tool, the value for a number of criteria can be varied at the same time, hence speeding up the evaluation process and allowing comparisons. The variables that are deemed more uncertain (i.e. having a potential to change the decision) will have a change in colour on their bar. From Figure 5.8 it is obvious no single variable has such an impact on the TCM 8000 development decision.

It is also important to note that each evaluation criterion is modeled on its own through a separate analysis. For example, the cost effectiveness of the proposed innovation still remains vital for a decision maker. For the TCM 8000, it would be important to compare it to its main substitute treatments. In case of depressed transverse cracks, this would be the thermopatching treatment. Table 5.5 captures all of the costs and work accomplishments recorded for the two treatments in the 2006 construction season. This information was obtained from the department's maintenance management system used to record all financial and non-financial info regarding different road maintenance activities.

TABLE 5.5 COMPARISON OF TCM 8000 AND THERMOPATCHING COSTS

Treatment	Total cost	Work accomplished (lineal metres)	$ / lin m
TCM 8000 micropatching	$658,633	162,388	$4.06
Thermopatching	$501,159	63,947	$7.84

Similarly, in case of spot sealing, a comparison between seal aggregate treatment and TCM 8000 micropatching can be done. Table 5.6 and Table 5.7 illustrate the treatment costs (data obtained from a test section constructed by the North Battleford maintenance crew in the 2005 construction season to compare the two treatments).

TABLE 5.6 SPOT SEAL AGGREGATE COSTS

Pieces of equipment	Equipment type	Equipment cost ($/hr)	Equipment usage (# of hours)	Total $$$
1	Oil distributor	$54.45	1	$54.45
2	Tandem truck	$44.56	1	$89.12
1	One-tonne truck	$30.76	1	$30.76
1	Broom tractor	$43.72	2	$87.44
1	Packer	$4.36	1	$4.36

# of Workers	Labour Cost ($/hr)	# of hours	Total $$$
4	$28.50	1	$114.00

Material type	Material cost ($/litre)	# of litres	Total $$$
Emulsion HF 150S	$0.30	400	$120.00

Material type	Material cost ($/tonne)	# of tonnes	Total $$$
Seal aggregate	$11.00	12	$132.00
		Grand total	**$632.13**
		Area accomplished (m2)	**218.88**
		Cost per m2	**$2.89**

TABLE 5.7 TCM 8000 SPOT SEALING COSTS

Pieces of equipment	Equipment type	Equipment cost ($/hr)	Equipment usage (# of hours)	Total $$$
1	TCM 8000	$27.69	2	$55.38
1	Tandem truck	$44.56	2	$89.12
1	One-tonne truck	$30.76	2	$61.52
1	Bobcat	$9.17	2	$18.34

# of Workers	Labour Cost ($/hr)	# of hours	Total $$$
4	$28.50	1	$114.00

Material type	Material cost ($/litre)	# of litres	Total $$$
Emulsion CQS 1P	$0.52	450	$234.00

Material type	Material cost ($/tonne)	# of tonnes	Total $$$
Microsurfacing aggregate	$9.00	3	$27.00

Material type	Material cost ($/kg)	# of kilograms	Total $$$
Portland cement	$0.24	55	$13.04
		Grand total	**$612.40**
		Area accomplished (m2)	**331.5**
		Cost per m2	**$1.85**

In addition to evaluating the value of the innovation proposition, it is crucial not to forget about risks. At this stage, the preliminary risk assessment would be completed in more detail and would also include a risk mitigation strategy (Table 5.8). The effectiveness and the cost of the proposed mitigation strategy are carefully considered. From Table 5.8, it is obvious that a good and detailed up-front homework should help with almost all of the identified risks associated with the TCM 8000 innovation development. This also emphasizes the importance of documenting all the phases of the development process. Emphasis on a conceptual design and virtual modeling would aid in the development of a reliable and maintainable product that significantly reduces safety risks to the end user as well as mechanical maintenance personnel. The proper paper trail can also be a very effective defence against all sorts of political pressures.

TABLE 5.8 RISK ASSESSMENT AND MITIGATION STRATEGY

Project Risk	**Risk Factor**			**Mitigation Strategy**	**Mitigated Risk Factor**		
	Probability	Impact	Risk Factor		Probability	Impact	Risk Factor
Loss of a key resource may significantly delay the development	2	3	6	Arrange for a "back up" resource, regular updates on progress and detailed documentation	2	1	2
Equipment may not perform and do the job as required	2	3	6	Work out as many "bugs" as possible at the design stage	1	3	3
Backlash from private sector / political pressure	2	2	4	Prepare business case addressing why innovation is required	2	1	2

Product does not meet client's needs / expectations	2	3	6	Extensive consultation with client / field testing and valuation	1	2	2
Equipment is unsafe to run and somebody gets injured	1	3	3	Build safe features into the design	1	2	2

If the decision at the business case gate, based on the scorecard and risk evaluation, is to further proceed with the project, the next step involves the portfolio management process. The results obtained from the innovation scoring model can also be used in the portfolio management for the project prioritization and resource allocation within each strategic bucket. For example, as simplistically illustrated in Figure 5.9, the strategic executive decision may be to allocate a certain amount of funding and employees time to each of the following strategic buckets: winter service related innovation, summer service related innovation, and service delivery innovation.

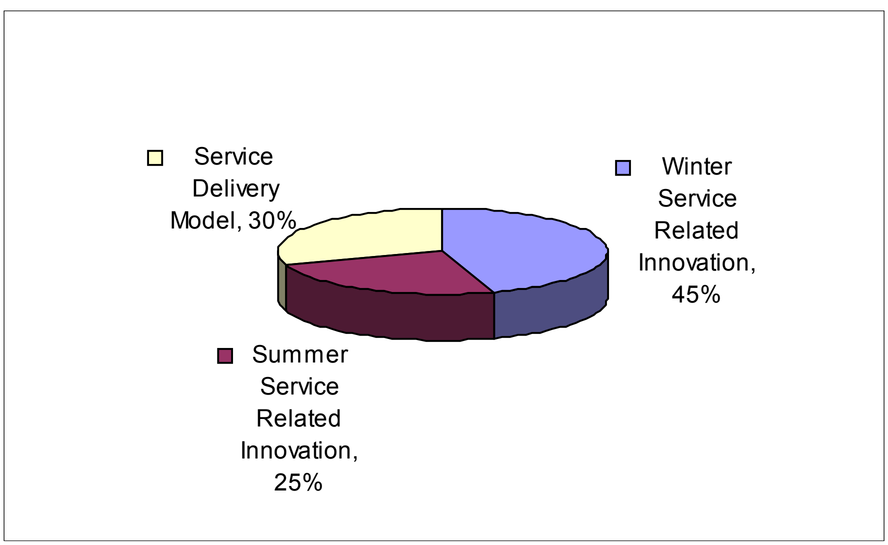

FIGURE 5.9 STRATEGIC BUCKET PORTFOLIO METHOD

Consequently, each innovation project would be placed in one of the three buckets (e.g. TCM 8000 could fall in the summer related innovation bucket). Each strategic bucket is assigned appropriate resources that are all expensed out on the projects in that specific bucket. This is done through prioritizing projects based on their perceived values determined through the scorecard and risk assessment. TCM 8000 technology development project therefore, would compete for funding within its own bucket.

Projects that end up properly funded would proceed to the next step – development stage. The very same criteria from the previous stage continue to be used here as well. However, a TCM 8000 conceptual design and the prototype would eliminate many uncertainties and provide better and more accurate information. In case the decision at the subsequent gate is to proceed, additional testing and validation would clarify any remaining issues regarding the final innovation deliverable, production process and methods, and field performance.

The final crowning of the whole innovation effort comes with its diffusion. In many instances this is the moment of truth that confirms if the original assumptions were indeed correct. The TCM 8000 development had a very strong "customer" involvement from the very beginning. The intended innovation users were pretty much involved in every aspect of the development. Therefore, the innovation diffusion stage, in this case, did not exist in its conventional form but rather, was blurred with the previous stages. This was particularly evident in the development and testing/validating stages. Also, continuous innovation refinements and testing continued well into the equipment's service life.

5.3.3.3 Conclusions

With the innovation process in place like the one described that heavily focuses on up-front homework and risk assessment, the number of trials and errors as well as retrofitting specific features afterwards would be reduced. That would directly result in significant cost and time savings in addition to reducing frustrations. It would also result in a more design-engineering focused approach with a better documentation at the end of the process. Furthermore, this focused and more proactive approach to innovation development would plant early seeds of thinking about protecting intellectual property or potential commercialization of it, so an early opportunity of a strategic alignment with a third party could be explored if it does present itself. Another benefit is that good paper trail left behind would mitigate many of the perceived risks, most likely including the political pressure as well.

5.4 AUGER TRUCK BOX

5.4.1 Background

SDHT owns a fleet of approximately 300 trucks that are used as snow removal equipment in winter and for road surface maintenance in summer. All the trucks are built by the department after basic, bare-bone cab and chassis configurations are acquired from original equipment manufacturers through the public tendering process. The snowplow tandem axle trucks as up fitted by the department contain many innovative features thought out by the department's employees over many years. Some of these innovative features are adaptations of commercially available technology and some are true innovations resulting in Canadian and the U.S. patents. The most prominent innovations found on the department's snowplow trucks include foot-applied salt spinner switch, twin drum spreader, corrosion proof rear fenders, and side dump box tarp system. One of the most recent examples of department's innovation impacting its truck fleet is the development of the auger dump box technology.

5.4.2 Auger dump box innovation

The auger box is a combination of the sand/salt spreader and U-shaped body dump box featuring an auger conveying system and continuous welded construction for increased durability (Figure 5.10). This unique concept was developed in early 2002 by a specially formed cross-functional project team as a response to the department's search for a light and economical truck box. Consulting services were also acquired from an external party to assist with engineering design and drawings. The first prototype was built in early 2003. Based on the feedback from the initial testing phase, three additional upgraded prototypes were built in 2004. The testing of these prototypes facilitated further design and production improvements. In the meantime, Fleet Services has properly tooled up and developed the expertise required to efficiently build all auger boxes to satisfy the requirements for the new tandem truck production. Consequently, some thirty auger boxes were built for the 2006 and 2007 truck builds and additional twenty boxes are in the planning stage for the 2008 truck build. In addition, the department has sold one auger box to a local municipal government entity and a few more purchase orders are currently being negotiated with several other jurisdictions.

FIGURE 5.10 AUGER TRUCK BOX

One of the major advantages of the auger dump box comes from the totally enclosed auger conveying system that prevents material leakage and salt contamination of the truck chassis. The box also features good safety advantages in terms of the traction on icy surfaces and visibility of material spreading. Also, the auger conveying system can be used in summer months to auger out cold or hot asphalt mix for the purpose of patching roads. Furthermore, it has excellent maintainability characteristics (e.g. easily accessible for washing, lubrication and for making operational adjustments). The resulting innovation is also very cost competitive compared to other commercial products available for the similar use.

Data showcased in Table 5.9 are obtained from various sources including the results from the department’s public tenders over the past few years, fleet maintenance information system, and interviews with the experienced equipment operators and Fleet

Services' personnel that are members of the equipment standards committee. The department has all the featured box styles in its fleet with the exception of the conventional box with a rear discharge sander; however, department's experience with the rear discharge changeover hopper is very limited as there is only one such unit in the fleet, relatively recently acquired. In addition, this single unit is used as a changeover box, meaning that the box is lifted off the truck in summer and an asphalt oil distributor tank is mounted instead. This limits the use of this box in its present configuration to only a small number of the changeover trucks in the department's fleet.

It should be also noted that the costs of the auger box design and material acquisition tenders are not included in the auger box cost as they are deemed minor when applied over many manufactured units. Similarly, the initial investment of $20,000 for the production tools and jigs is not included as it becomes insignificant when distributed over all the manufactured units, present and future. In addition, all other commercially available boxes do not include the costs of preparing public tenders, evaluating bids, and quality assurance and specifications verification as those administrative costs are hard to capture and are considered minor when assigned on a per unit basis. Furthermore, for the practical purposes, the center conveyor box completely ignores the tangible and intangible costs resulting from poor workmanship the department had dealt with over many years of experience with this type of box. This poor workmanship is contributed to a single, out-of-province supplier who managed to win numerous contracts with the department by consistently underbidding its main competitors by a significant dollar margin. On the other hand, the auger box specifies better quality, more durable Hardox steel material than the center conveyor, side dump, and rear discharge changeover hopper options. The specification of this material would increase the cost of those boxes by approximately $1,300 per unit; therefore, this amount is added to the original bid.

TABLE 5.9 COMPARISON OF ALTERNATIVE BOX STYLES

	Auger Box	Side Dump	Center Conveyor	Conventional with Slide In Rear Discharge Sander	Rear Discharge Changeover Hopper
Box weight (lb)	5,340	6,670	5,200	4,500	4,675
Struck volume capacity (yards)	11	12.35	11	7-10	12
Initial capital cost	$22,225	$23,300*	$18,024	$25,000* plus	$20,090
Repairs over 10 years	$3,400*	$9,121	$6,845	$3,400*	$3,400*
Traction on icy surfaces	Good	Good	Good	Poor	Poor
Visibility of material spreading	Good	Good	Good	Poor	Poor
Maintainability	Good	Fair	Fair	Good	Good
Downtime factor	Good	Poor	Fair	Good	Good
Salt containment	Good	Poor	Poor	Good	Good

* means estimates due to limited or obsolete data

Based on this information, a direct, one-on-one comparison between the alternatives is possible. The conventional box with a slide-in rear discharge sander is practically dominated by the auger box alternative; in other words, it has one or more disadvantages with no advantages. Similarly, the auger box option is more superior to the side dump box on practically all objectives (note, initial capital and repair costs are combined); therefore, the side dump alternative can also be eliminated. The decision between the auger box and center conveyor box boils down to a consideration whether having better maintainability characteristics, less downtime, and more superior salt containment for the auger box is worth $756 in cost difference (note, capital and repair costs are combined). Similarly, in comparing the auger box to the rear discharge hopper the questions is whether better traction on icy surfaces and visibility of material spreading are worth $2,135 in cost difference between the two.

The comparison of the auger box to the remaining alternatives features subjective evaluation and trade-offs of various objectives using a variation of the even swap method. More information regarding the even swap technique can be found in Hammond et al (1999). In brief, an even swap increases the value of an alternative in terms of one objective while decreasing its value by an equivalent amount in terms of another objective. As a result, it is determined that improving from poor traction on icy surfaces to good would be worth $4,000; improving from poor visibility of material spreading to good would be equivalent to $1,500; improving maintainability from fair to good would provide a benefit worth $1,000; improving downtime from fair to good $1,500; and improving salt containment from poor to good would be worth $3,000. The box weight and capacity are considered adequate for all three options and there are no benefits of further trading off their values. Table 5.10 illustrates new value propositions. It is clear that the center conveyor and rear discharge changeover hopper alternatives are dominated by the auger box option.

TABLE 5.10 ALTERNATIVES COMPARISON AFTER EVEN SWAP ANALYSIS

	Auger Box	**Center Conveyor**	**Rear Discharge Changeover Hopper**
Initial capital cost	$22,225	$18,024	$20,090
Repairs over 10 years	$3,400*	$6,845	$3,400*
Traction on icy surfaces	Good	Good	Poor to Good $4,000
Visibility of material spreading	Good	Good	Poor to Good $1,500

Maintainability	Good	Fair to Good $1,000	Good
Downtime factor	Good	Fair to Good $1,500	Good
Salt containment	Good	Poor to Good $3,000	Good
Total cost	$25,625	$30,369	$28,990

5.4.3 Auger box innovation process

5.4.3.1 Creativity phase

The auger box development started at the strategic level by evaluating the department's business of winter maintenance, and its strengths and weaknesses as related to snow removal equipment used at that time. This analysis identified innovation opportunities at the corporate level such as a need for reliable, economical and efficient snow removal equipment. This opportunity was further translated into an idea of developing a dump box that would meet the department's identified objectives of economical, reliable and light boxes that also contained salt well. As soon as the innovation opportunity requirements were specified, a small cross-functional project team was established to forward the research in this area, gather ideas, present recommendations, and overlook the transition from the idea to the final product. Through the efforts of this team, important criteria were established for a reliable, lightweight design that would provide long service in a highly corrosive environment.

As the initial, informal strengths and weaknesses analysis pointed out to a need for consulting services in the area of structural engineering, an external engineering consulting company was commissioned to detail the design and provide drawings required to build a prototype box. Also, this strategic level analysis of organizational strengths, weaknesses and future performance requirements pointed to areas that required the development of specialized knowledge to further support various Fleet Services' activities including also the auger box development. This resulted in acquiring of this knowledge through the hiring process when opportunities arose to replace employees who retired or pursued other employment opportunities.

Although no formal innovation process was in place at the time, almost all elements associated with an effective creativity process were present. The strategic level analysis identified an opportunity that was explored by a small, strategically selected, cross-functional project team. The result was an idea and a set of design criteria that idea was evaluated against. Based on this evaluation the idea was forwarded into the development stage. The formal evaluation process, however, would have streamlined these efforts even more efficiently by focusing explicitly on strategic alignment, financial impacts, technical feasibility and value proposition. These criteria therefore would be consistent with other innovation proposals and a direct comparison for the project prioritization and resource allocation purposes would be possible. The proposed approach would also require an early risk analysis. The final result of this more formal approach would most likely be the same - a major project undertaking that would require going through a full innovation development process.

5.4.3.2 Development phase

The actual auger box development had involved an extensive and detailed up front work focusing on technical feasibility, value proposition and financial impacts. Although done in a somewhat informal fashion, many of the elements of a good innovation process were indeed followed. Exhaustive up front homework resulted in a fairly good project definition and business case. An original prototype was developed to gather more accurate information at these early stages. Proper resources were assigned to carry out subsequent research and product refinement. Subsequent analyses included more detailed 3D modeling using ProEngineer software as the department acquired this expertise through the hiring process. Additional prototypes were built to include lessons learned from the early development and testing. Proper tooling and jigs were built to increase the manufacturing productivity. The project team constantly worked on further design refinements.

When the steps of the development phase are reconstructed, the process would be approximated as illustrated in Figure 5.11 although, in reality, the stages and gates were not so clearly defined. The actual auger box innovation process could have been improved if an explicit idea to launch process were in place. This improvement would have resulted in a clear definition of roles and responsibilities as well as defined expectations at each step. As a consequence, decision making would be improved at all gates which probably would be considered the greatest weakness of the actual implicit process. In addition, an early focus would also be on the potential commercialization and protection of the department's intellectual property rights. Another benefit of the explicit stage gate process would be the use of criteria consistent with other projects, thus allowing for a direct comparison, project prioritization and resource allocation through portfolio management. Furthermore, a proper risk assessment would be required to identify all the perceived risks associated with this development, so an early mitigation strategy could be developed to aid in dealing with those risks.

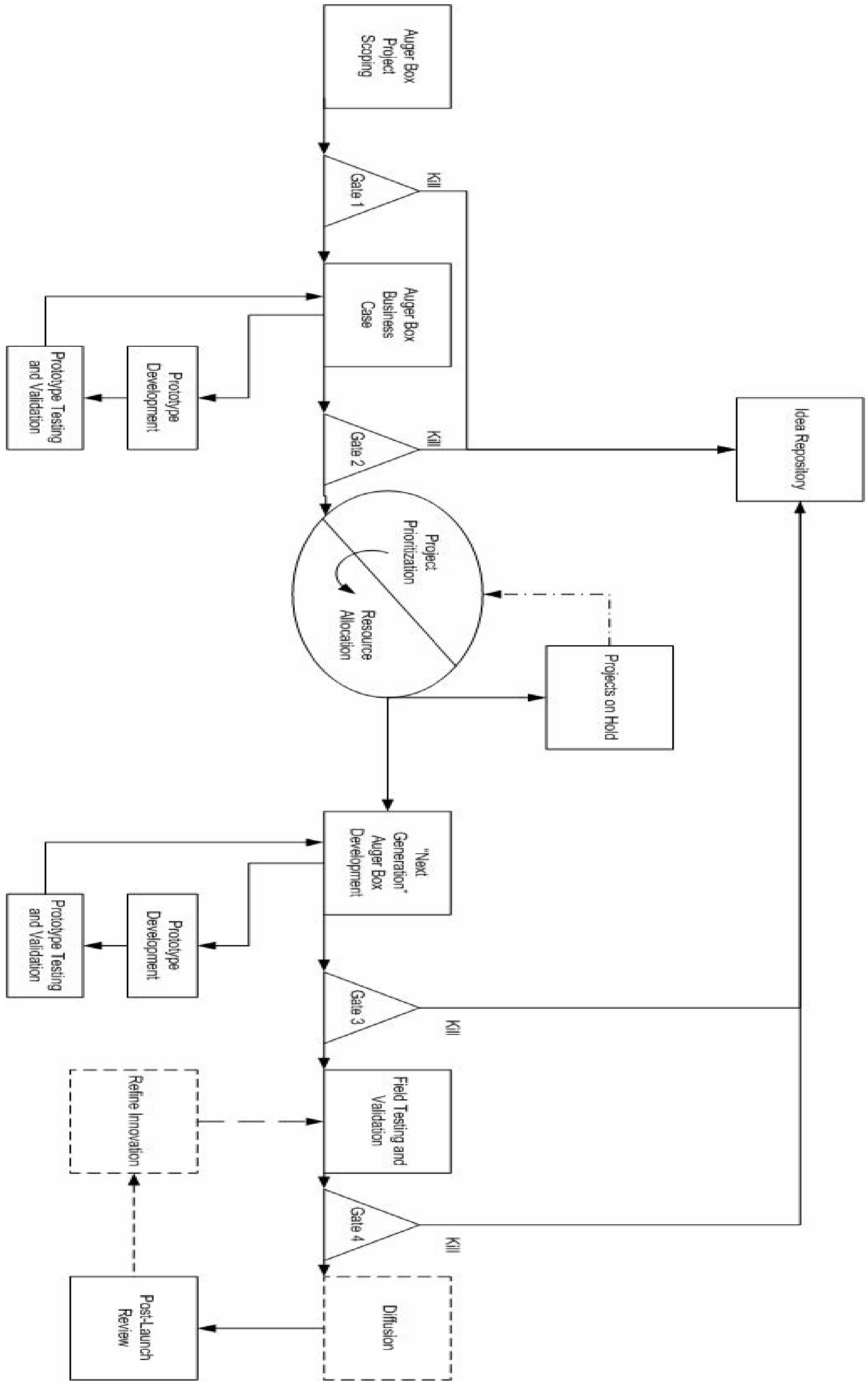

FIGURE 5.11 AUGER BOX DEVELOPMENT PHASE

5.4.3.3 Diffusion phase

In case of the auger box production, the diffusion process was very much blurred with the development and test/validation stages for the simple reason that the entire development project involved the intended users from the very beginning. Furthermore, all the developed prototypes were deployed in the field from the start, thus enabling the innovation users to acquire knowledge and skills required to efficiently operate this box. This was coupled with numerous presentations about the product given to a diverse group of equipment operators at various occasions by the project team and involving the equipment users themselves in many instances. Also, prior to delivering the product to the end user, an orientation was provided focusing on the main auger box features.

5.4.4 Conclusions

Many main characteristics of the actual auger box development are in line with the proposed innovation approach. For example, there is a direct link to the corporate strategy; innovation resulted from a purposeful search for opportunities; exhaustive, up front homework was conducted and detailed documentation trail, especially related to the design, left behind; many wasteful trial and error approach mistakes were minimized by conducting different scenario analyses at the design stage and using sophisticated modeling software; financial commitments were incrementally increased as the innovation project was advanced through the development stages and more accurate information became available; and the ultimate innovation users were directly involved in the whole process from the very beginning. The result is a successful innovation fully embraced by the intended users and sought after by external parties. The greatest shortcomings of the actual, implicit innovation development process were a lack of focused, effective, formal decision making points before moving on to the next development stage and the use of criteria not completely consistent with other development projects.

CHAPTER 6 RESEARCH SUMMARY AND CONCLUSIONS

6.1 RESEARCH SUMMARY

The purpose of this thesis was to develop a decision making framework to facilitate structured and formalized innovation management in the public service organizations and more specifically, Saskatchewan Department of Highways and Transportation. This was primarily accomplished through a comprehensive literature review of innovation and its role in organizations and by investigating various management models. The major contributions from this research include: 1. comprehensive literature review regarding innovation in both private and public sectors and the comparison of the two; 2. clear distinction between different phases of the innovation process (creativity, development, and diffusion) and strategies associated with each phase; 3. design of a strategic level innovation framework; 4. adaptation and development of an innovation idea to launch model suitable for the public service sector; and 5. understanding of the benefits of the proposed approach through two detailed case studies involving different innovation from Saskatchewan Department of Highways and Transportation.

The literature review revealed that the prevailing attitude towards innovation in the public service sector is one of risk aversion. Such an attitude is further encouraged by pressures from the general public, politicians, and lobbyists insisting on the public service organizations' role of simply complying with the established rules and regulations. Public service sector organizations are inherently risk averse; however, to ensure the long term sustainability in an ever changing world, they are required to take calculated risks and be innovative. A too restrictive approach could hinder creativity and create an excessive burden for the innovators. On the other hand, a too loose approach to innovating could create a chaotic situation with little accountability. The challenge, therefore, is to determine a level of reasonable risk taking required to engage in to ensure and maintain innovation in public sector organizations.

To help resolve this dilemma, the thesis offers a comprehensive, guiding decision making framework focusing on innovation success drivers at both the strategic and tactical levels. The proposed framework contains six major elements: business strategy including innovation strategy, performance metrics, knowledge management, risk management, project management, and change management. There is no single, standalone driver that would guarantee the innovation success. All the innovation elements need to be well understood and included in the process for innovation to be consistently successful.

The development of the accompanying idea to launch innovation model draws heavily on the principles and research found in the new product development field. The model combines the elements of a stage gate model and portfolio management and keeps an emphasis on a public service innovator's needs. The result is a structured and disciplined approach to managing innovation and allocating resources. This approach increases the likelihood of success of innovation. It is also a systematic way to learn from the successes and even failures. This in turn creates an organizational memory of best practices and positions the organization to be adaptable to changing needs and conditions. Recognizing the importance of risk in the public service sector, the proposed evaluation process also builds in the risk management principles.

Both the guiding framework and idea to launch process are further verified through two case studies describing different innovation developed in Saskatchewan Department of Highways and Transportation. The two innovations feature success stories involving the road maintenance equipment and machinery development. The case studies detail the actual development of the two products; then, the proposed approach is applied to learn what would be different if it were in place at the time. The "lessons learned" confirm the benefits of using the suggested framework and idea to launch process as tools to manage innovation in a structured and disciplined way. The ultimate outcome is a balance between freedom and discipline in managing innovation.

The case studies also support Pearson's argument (Pearson 1988) for four elements necessary for most innovations.

(1) *A champion who believes in the new idea and will keep pushing ahead.* The champion's conviction and perseverance are critical for innovation's success. This championship had been crucial for the development of the TCM 8000 and the auger truck box technologies. The champion was the one who organized the development team's activities and acted as the primary contact with the senior management and the third party experts. The TCM technology champion also worked with the lawyers in preparing the patent application. The auger box champion ensured design reviews were completed when required and input received from those involved including the various innovation users. It is also important to be aware that the champion is not necessarily the one who has to come up with the novel idea; rather, as was the case with the TCM and auger box technologies, the champion is the

person who harvests the team's creativity and ensures other elements are in place to transform that creative drive into a concrete innovation.

(2) *A sponsor in place to allocate resources to the new idea.* Although in a small, private enterprise or a start-up business it may not be unusual that the same person fulfills the role of a champion and a sponsor, given the diversity and complexity of the services provided by the public sector organizations, and especially in Saskatchewan Department of Highways and Transportation, it is rare that the champion is also the one with the authority to allocate all the necessary resources to the new idea. This authority traditionally resides with somebody in a senior management role. In both the TCM and auger box technology development cases, the commitment from senior management for necessary resources was obtained before proceeding with the prototype development and after the preliminary analyses were completed. In obtaining these resource commitments, the TCM and auger box champions only went to the level of authority necessary to provide enough resources to complete the required tasks. Going out too broadly (or publicly) might bring on too many questions when only a few answers may be available so, in many instances in the public sector, during the early phases of innovation development, it may be necessary to guard the development of an innovative idea from too much exposure.

(3) *A mixed implementation team consisting of creative individuals and hands-on experienced pragmatists.* Being that teams are central to the delivery of public services, this reliance on teams is even more evident when it comes to

transforming creative ideas to innovative outputs. The innovation champion has to be in charge of selecting the development team. Both the TCM 8000 and the auger truck box developments were characterized by the use of small and diverse teams that included the intended users as well. The relatively small size of the teams, consisting of five to six people, contributed to an effective decision making and provided for a needed diversity to encourage open dialogue. A mix of pragmatism and creativity was critical in ensuring that numerous ideas were generated and properly evaluated from their implementation point of view.

(4) *A process that moves ideas through quickly.* In developing TCM 8000 and the auger truck box innovations, the fourth element of the Pearson's framework was not in place in its formal form; however, many of the elements of such an approach existed informally. Although it is clear that innovation can be successfully developed even without a formal idea to launch process, such a framework would greatly increase chances of innovation success and establish a learning environment to capture and constantly improve organizational memory. In return, this can position public service organizations to better generate and evaluate ideas as well as transform those ideas into innovative outputs in the most cost effective and timely fashion. It can also assist organizations to better cope with risk. A formalized approach that balances freedom and discipline and prescribes the necessary development steps also provides an excellent reference to the

innovation champion to work within the framework established on the proven strategies and tactics.

6.2 CONCLUSIONS

Both case studies confirm the benefit of an explicit strategic approach that identifies the areas of innovation focus. This directed strategic focus appears to be a crucial first step in eliciting innovation opportunities and generating creative ideas. Another major benefit comes from applying a structured and formalized process that grabs the ideas and moves them through the innovation development process in an efficient manner with an improved quality of decision making and execution. It results in a more streamlined process with all the tasks as well as roles and responsibilities clearly defined every step of the process, and the likelihood of innovation success significantly increased.

The observed benefits of the structured innovation management are numerous. The leading proof is in an enormous benefit from conducting exhaustive up front homework. The case studies demonstrate that this approach is more cost-effective as it saves time and resources compared to a merely trial and error approach. The TCM 8000 technology development is a good illustration of this. The important side benefit from this up front focus is good documentation that can be further used to mitigate many of the potential risks including “political” risk. In addition, the standardization of evaluation criteria provides for an objective assessment and prioritization of the projects going through the innovation pipeline. Furthermore, the innovation diffusion strategy employed by the department appears to be working well. It heavily relies on the involvement of intended users which in turn builds a strong support and a sense of ownership of the innovation. This helps enormously with not only successfully diffusing the innovation but also any subsequent continuous improvements.

For the reason of the many benefits cited, Saskatchewan Department of Highways and Transportation should implement a comprehensive innovation decision making framework to provide for a better and formalized strategic focus, and an effective idea to final output delivery. This focused approach has the potential to improve the department's innovation efforts and success rate, and thus, further aid in addressing numerous pressures and challenges associated with managing the Saskatchewan provincial transportation system.

6.3 FUTURE RESEARCH

The research conducted in this thesis points to a few areas that might be worthwhile investigating as subsequent research in the future. Those include:

1. modeling a mix of product, service and business model innovations to prove the suggested approach is robust enough for all the different types; 2. establishing a framework for risk profiling of the key decision makers in public sector organizations to better understand how different risk attitudes influence innovation culture and an organization's innovative drive; 3. focusing on the innovation diffusion phase in more detail.

It would be beneficial to have the proposed decision making framework implemented in a public service organization (e.g. Fleet Services with Saskatchewan Department of Highways and Transportation) to observe its effectiveness over a long run. The two case studies showcased in this research suggest that the proposed approach involving structured and disciplined management of innovation is indeed beneficial. The final proof, however, is in applying the proposed framework and evaluation process to the variety of new ideas that need to be yet developed into concrete products, services, processes, and business models.

Establishing risk profiling of the key decision makers in the public sector is another area of research that would complement the findings discussed in this thesis. Understanding risk attitudes of various decision makers at all levels in a public service organization including those in politically appointed positions is especially important for an innovation champion. Once these risk attitudes are well understood, the champion can complete all the necessary analyses, gather required information, and properly custom-tailor his plea for the resources necessary to carry out the innovation development and diffusion.

Although critically important for the overall success of innovation the diffusion phase appears to be the least researched area. Additional research needs to focus not only on issues related to the innovation implementation but also should explore commercialization possibilities and marketing mechanisms available to public sector organizations. Saskatchewan Department of Highways and Transportation, for example, is in position to offer a great variety of high quality road construction equipment to the commercial road construction industry and other government agencies. The sales of these technologies, developed in the course of normal business to satisfy the department's needs, could generate revenues for the department and ensure its facilities and workforce are utilized to their fullest potential. What's needed, however, is better understanding and more research regarding an effective financial and marketing strategy.

This research should also be expanded to include the topic of strategic alliances. Strategic alliances are important to the business success of both private and public enterprises and maybe even more so for the success of innovation in the public service sector. Quite often it is perceived that innovation thought out in a public sector organization and having involvement of a private enterprise is more worthwhile pursuing. In some instances public service organizations are in better position to identify their needs and serve as a source of creative ideas that can be then further developed, refined and implemented in a partnership with a private entity. Such a strategic alliance may also provide for a synergistic relationship that compensates for weaknesses exhibited by the parties. That is why it is important to consider strategic alliances quite early in the development of innovation. This consideration should be as early the idea evaluation stage and more elaborated in the business case. It is also important to thoroughly think about what such a strategic alliance would encompass in terms of its structure, risks and incentives, level and timing of involvement, scale of production, required expertise, and roles and responsibilities of each party. Therefore, more research is required to better understand all these issues associated with innovation diffusion and potential commercialization.

REFERENCES

Applied Decision Analysis LLC, “DPL 4.0 Professional Decision Analysis Software”, Duxbury Press, 1998

Bear, Donna J., “Pardon the Disruption … We’re Innovating”, article featured in Canadian Management Centre Seminar Guide, 2006

Canadian Centre for Management Development, “A Primer on Knowledge Management in the Public Service”, A Working Paper for the CCMD’s Action-Research Roundtable on the Learning Organization, 1999

Canadian Centre for Management Development, “A Discussion Paper for the CCMD Action-Research Roundtable on the Learning Organization”, working paper, 2000

Chesbrough, Henry William, “Open Innovation”, Harvard Business School Press, Boston, MA, 2003

Christensen, Clayton M., “The Innovator’s Dilemma”, Collins Business Essentials edition published in 2005

Clemen, Robert T., “Making Hard Decisions”, Duxbury Press, 1996

Collins, Jim and Porras, Jerry I., “Built to Last”, HarperCollins Publishers Inc., New York, 2002

Cooper R.G. “The invisible success factors in product innovation”, Journal of Product Innovation Management, 16, 2, April 1999, 115 – 133

Cooper Robert G., Edgett Scott J., and Kleinschmidt Elko J., “Portfolio Management for New Product Development: Results of an Industry Practices Study”, R&D Management, Volume 31, No. 4, 2001a

Cooper Robert G., Edgett Scott J., and Kleinschmidt Elko J., “Portfolio Management for New Products”, Perseus Publishing, Cambridge, MA, 2001b

Cooper, Robert G., Edgett, Scott J., and Kleinschmidt, E.J., “Optimizing the Stage-Gate Process: What Best Practice Companies Are Doing”, Research Technology Management, Volume 45, Number 5, 2002

Cooper, Robert G. and Edgett, Scott J., “The Dark Side of Time and Time Metrics in Product Innovation”, PDMA Visions Magazine, XXVI: 22, April/May 2002

Cooper, Robert G., Edgett, Scott J., and Kleinschmidt, E.J., "Best Practices in Product Innovation: What Distinguishes the Top Performers", 2003 whitepaper available at the Product Development Institute website (www.prod-dev.com)

Cooper, Robert G. and Mills, Michael, S., "Succeeding at New Products the P&G Way: Work the Innovation Diamond", PDMA Visions Magazine, XXIX, 4, October 2005

Cooper, Robert G. and Edgett, Scott J., "Lean, Rapid, and Profitable New Product Development", published by the Product Development Institute, 2005

Davila, Tony, " How to Make Innovation Work in Your Company", article featured in Canadian Management Centre Seminar Guide, 2006 and spring 2006 edition of MWorld Journal

Dinsdale Geoff, Moore Mary and Gaudes Andrew, "Organizing for Deliberate Innovation: A Toolkit for Teams", Canadian Centre for Management Development, 2002, ISBN 0-662-66531-7

Drucker, Peter F., "The Discipline of Innovation", Harvard Business Review, 1985

Fagerberg, Jan, Mowery, David C. and Nelson, Richard R., editors, "The Oxford Handbook of Innovation", Oxford University Press, New York, 2005

Gerbrandt, Ron, "MBA 992 Project – Technology Feasibility and Adoption Study", Master of Business Administration Program, University of Saskatchewan, 2005

Hammond, John S., Keeney, Ralph L., and Raiffa, Howard, "Smart Choices", Harvard Business School Press, 1999

Hauknes, Johan, "Innovation Systems and Capabilities of Firms", 1999, University of Brighton (research funded under the TSER programme by DGxii of the European Commission)

Hillier, Dean and MacDonald, Tim, "Value-Building Growth A Canadian Challenge", Ivey Business Journal, London, Nov./Dec. 2001

Kline S. and Rosenberg N., "An Overview of the Process of Innovation", in Landau R. and Rosenberg S. (eds.) The Positive Sum Strategy: Harnessing Technology for Economic Growth, National Academy Press, Washington, D.C., 1986

Lazic, Zvjezdan, "Innovative Road Maintenance Treatments – Micropatching with TCM 8000", Canadian Technical Asphalt Association conference proceedings, Montreal 2004

Levitt, Theodore, "Creativity is Not Enough", Harvard Business Review, 1963

McInerney, Rosemary and Barrows, David, “Management Tools for Creating Government Responsiveness – The Liquor Control Board of Ontario as a Context for Creating Change”, The Public Sector Innovation Journal – Canadian Case Studies Subsection, 2002

McShane Steven L., “Canadian Organizational Behaviour”, McGraw-Hill Ryerson, sixth edition, 2006

Moore, Geoffrey A., “Crossing the Chasm”, revised edition, HarperCollins Publishers, New York, 2002

Pearson, Andrall E., “Tough Minded Ways to Get Innovative”, Harvard Business Review, 1988

Peer, Bruce, “Creating a Culture of Innovation”, article featured in Canadian Management Centre Seminar Guide, 2006

Porter, Michael E., “Competitive Strategy”, The Free Press, A Division of MacMillan Publishing Co., New York, 1980

Prasad, Biren, “Concurrent Engineering Fundamentals”, Prentice Hall PTR, Upper Saddle River, New Jersey, 1996

Saskatchewan Department of Highways and Transportation, “2007-08 Financial Plan”, internal document, 2006

SaskTrade, “Saskatchewan’s State of Trade Detailed Analysis”, April 2005 report prepared by SJT Solutions

Stoyko, Peter, Henning, Keith, and McCaughey, Deirdre, “Creativity at Work: A Leadership Guide – Success Belongs to Me!”, Action-Research Roundtable, Canada School of Public Service, 2006

Taylor, Peter S., “Successful Project Managers are Emotionally Intelligent”, article featured in Canadian Management Centre Seminar Guide, 2006

Treasury Board of Canada Secretariat, “Risk, Innovation and Value – Examining the Tensions”, 1999

Treasury Board of Canada Secretariat, “Integrated Risk Management Framework”, 2001

University of Saskatchewan, “Atlas of Saskatchewan”, 1999