Improving the Fuzzy Front End of Product Development for Continuous Innovation Incorporating TRIZ

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Abstract

Why have many legacy companies been unable to continuously innovate? A study of several famous companies that have stumbled in innovation reveals that it is not just one activity but a multitude of them that are not executed well. That is why "if it were easy everyone would be doing it". Innovation has been defined as invention brought to the market. The federal government has tried to measure innovation and found it very difficult. Work is ongoing to collect information on important factors for innovation but most measure factors that are results versus critical skills that drive innovation. A model for continuous innovation has been developed from a variety of sources, including the author's 40 years in the appliance industry. The model incorporates four key parts and arguably the most important part is problem solving and problem identification. This is where TRIZ plays a critical role since problems poorly solved or not solved lead to weak invention and innovation that can be easily trumped. The details of the model will be explained with associated forms that are useful for implementation.

Introduction

Why have famous companies failed to innovate on a continuous basis? Putting aside socioeconomic disasters, down stream product development failures, or rollout blunders, many legacy companies have failed because they lack the front end management and technology systems that allow for a continuous flow of new products, processes, or services that outperform their competitors. Many had great beginnings and now have questionable futures. Some legacy companies that started with breakthrough innovations and then nursed them for years are: Polaroid, Kodak, Xerox, Frigidaire, Sears, Hoover, Circuit City, GM, Motorola, etc. Obviously they did not discover the Holy Grail of continuous innovation.

An innovation process model that provides a continuous flow is apparently not available. Popular management books have an assortment of conflicting recommendations. Kim and Maubougne in *Blue Ocean Strategy*[1] indicated company failures are due to too many companies competing in competitive markets while not pursuing unserved markets. On the contrary, Collins in *Good to Great*[2] indicates that great companies must stick to the intersection of their passion, profitable areas, and what they do best. Chesbrough in *Open Innovation*[3] indicates some legacy companies did not embrace open innovation in a changing and shrinking world with many alternatives. All of these references have some validity based on my experience and research[4] but published criticisms by other experts indicate their theories[5, 6] are not the answers to sustained success.

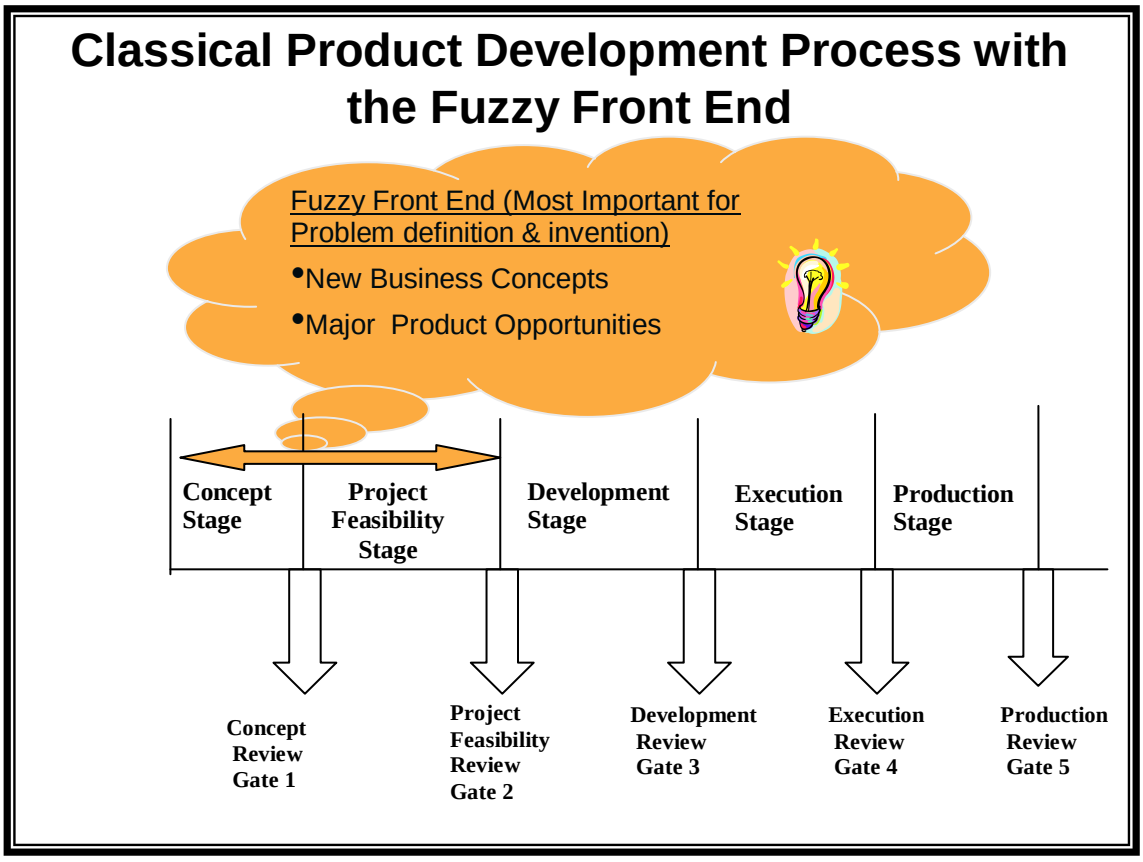
It is logical that in a capitalistic competitive marketplace, for companies to excel, they must invent and innovate continually. How are invention and innovation related? Innovation is defined as invention brought to market.[7] The market and innovation are used in the general sense of general use inside or outside an organization. Invention can occur in business methods, marketing, product design, organization design, etc. Of the two, invention is the first to occur, but only when brought to commercialization or business use and begin to produce a profit will it be called innovation. This linkage is important in any system that promotes innovation, since invention alone is worthless, and innovation cannot exist without a meaningful invention.

Some experts have promoted ideation methods which focus mainly on singular approaches versus a method integrated into the business to support their recommendations[8, 9, 10]. These do not incorporates many aspects of business such as planning, business analysis, and environment that are key to successful innovation. Good invention and innovation require multiple methodologies with their concomitant level of skill. Let's face it: "If innovation were easy, everyone would be doing it!"

The Context for the Innovation Process Model

The Fuzzy Front End is critical for great invention and innovation. It is shown in Figure 1 as the Concept and Feasibility Stages of an overall product development process. Unfortunately it has become vogue for many companies and experts to have a stage gate product development process that focuses on stages after the invention is created[11,12]. These systems do little if anything to help the Fuzzy Front End. In fact engineers have been directed at times with good intentions to ignore the front end and focus on the development stages of a stage gate process. The belief is that fast cycle time was the key.[13] Invention was left to the researchers in the back room. However, the researchers are not always consistent, can get stuck in a rut, do not have good methods always for solving problems, and may not get the support from management that is needed. Under pressure, the researchers can throw a partially solved invention over the wall to the development stage of the gate process, leaving that stage to solve significant problems. Often this leads to schedule delays and finger pointing that can demoralize workers. The lack of a documented system in the Fuzzy Front End is maybe why it got its name. The Fuzzy Front End needs more structure which can help its consistency. The result of no system can be, "garbage into development is garbage out."

Figure 1. Invention starts at the Fuzzy Front End of the development process



As explained in Open Innovations[14] many good concepts are discarded as not appropriate for the business. Dinisorauritis sets in many ways: NSH-not sold here, NIH-not invented here, too much risk, no method to attack the tough problems, companies retreat to easier solutions, poor long term planning ("you don't have a long term plan if you want it all at once[15]", good concepts not introduced in a planned fashion), etc.

I postulate the following elements based on my 40 years in the appliance industry, and university research into innovation. These elements form the pillars of an Innovation Process Model focused on the Fuzzy Front End of development. An innovation process model is proposed that is a foundation for a system of continuous innovation. I propose a holistic front end Innovation Process Model that embraces elements of what others have proposed but prescribes these elements in a new system. The four key elements are:

1. **Identify and solve the tough problems.** This is arguably the most important part of the IPM (Innovation Process Model). Truly it separates the "good from the great" solutions, since no solution or a weak solution leads to little innovation. Although there are many problem solving techniques available, and more will be mentioned later, TRIZ, The Theory of Inventive Problem Solving, offers a powerful approach that, in my experience, should be at the top of every inventor's repertoire. Without innovation, a company's products or services become commodities. This can be very dangerous for the company and require a change in strategy to survive.[16] Commodity products are usually the purview of the lowest cost producer.
2. **Perform good business analysis.** This determines the link from the technical domain to the socioeconomic domain as Chesbrough[17] has written. A good invention can fail without a solid plan for entry and performance into the social world.
3. **Perform good business planning.** This is different from the short term business analysis and looks at the longer term survival of a company. It uses data generated from many sources including the business analysis to develop multifamily planning for consistent innovation.
4. **Provide good environment for innovation.** The environment can improve the productivity for invention and innovation through a stimulating physical environment, to management vision and resource support, to psychological support.

These elements are part of a holistic Innovation Process Model in a new prescriptive system. Literature has support for having such a process.[18] As Jim Collins in *Good to Great* said, "The good-to-great companies built a consistent system…"[19] (underline added). As he implies, these companies do not necessarily stand out for doing one thing. Instead they do a lot of things right. I call this "hitting on all cylinders." He also advocates a system that is based on reality which results in internalizing the facts. I support this with the old adage "if you cannot measure it, you cannot manage it." The IPM process is the result of my experience and study of innovation while directing advanced development, initial survey work, and during five years teaching graduate courses on innovation.

Introducing the Innovation Process Model

The Innovation Process Model (IPM) is basically a clockwise circle of activities as shown in Figure 2. IPM is a process for the Fuzzy Front End of a typical product development process as shown in one representation in Figure 1. The first element of four is the process of Problem Solving. In this first element, the identification of a customer need (ID in the diagram), the conception of a solution (Conception/Problem Solving), the discovery of a valuable solution, and the reduction to practice are considered part of the overall problem solving element. The potential solutions need to have utility. They need documentation for a quality definition, analysis, and solution but also for subsequent consideration by the business. For novel and nonobvious solutions, the inventor should write an Invention Disclosure (considered part of the Problem Solving element). The Invention Disclosure is a witnessed statement of the concept. This will establish an invention date if a patent is recommended.

The Business Analysis element depends on data in the form of documentation. The Business Analysis Team, patent council (which may received the concept documents), or management can recommend that patent protection be pursued. Intellectual Property Prosecution and Business Analysis are part of the Business Analysis (BA) element. The concept documentations may also be submitted directly to a Business Analysis Team for review and disposition. The outcome of the Business Analysis can be the assignment of resources for a Reduction to Practice (creation of a crude early prototype which is considered part of Project Feasibility). Alternatively, the outcome may be to put it into a business portfolio for planning consideration, to have it recycled and researched further, or pronounced dead on arrival.

The third element is Business Planning (BP) primarily utilizes the portfolio results of the Business Analysis Team. The frequency of BP can vary. Quarterly meetings to review progress-to-plan and yearly planning meetings are typical. The planning will drive the long term decisions and disposition of the ideas either placing them in an internal stage gate Development/Execution/Production process or look to External organizations, Licensees, Partnerships, or Venture Capital Relationships.

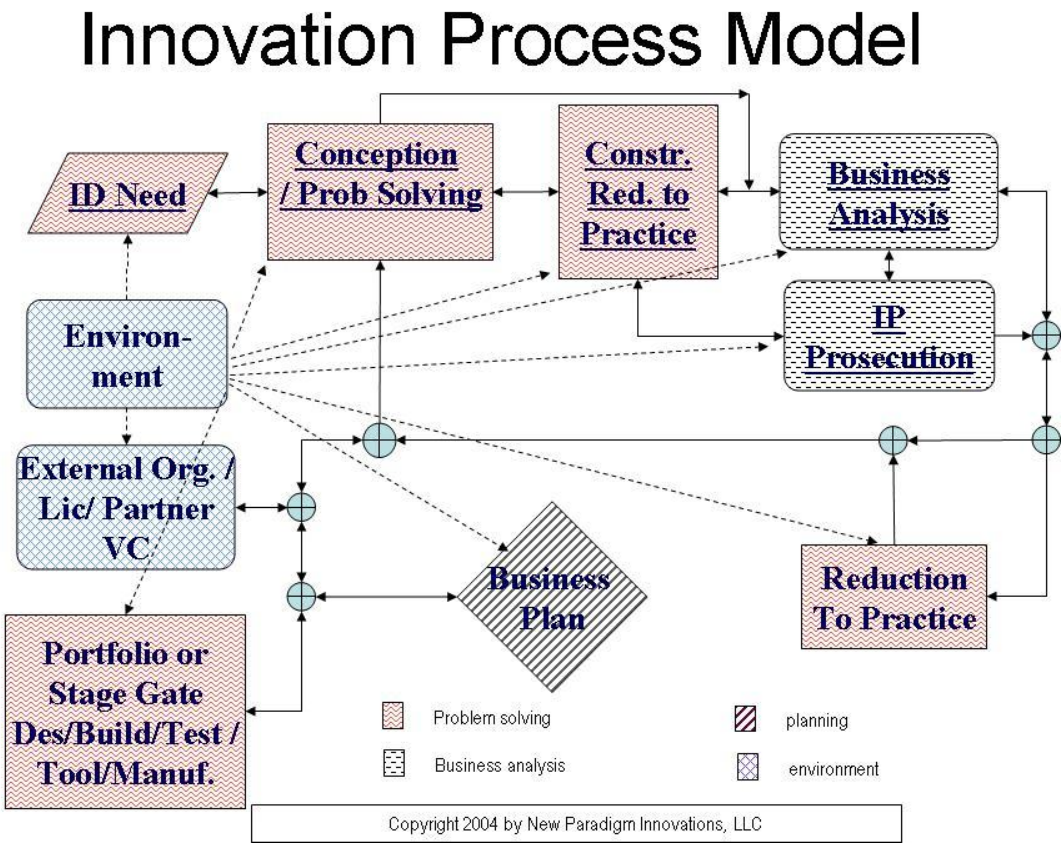
The fourth and last element is Environment. Unlike the other elements of the model, this is not part of a sequence but one that permeates the other three elements and is a motivating catalyst for those executing the IPM.

It includes the external organizations, licensees, partners, and venture capitalists with which the company collaborates. These are considered part of the Environment element within which the company works. One of these is the open innovation environment that Chesbrough refers to in his book.[20]

A justification for the model is based upon the history of how many companies began. Some started with a pioneer or inventor satisfying a need with his/her inventive solution. Other times the pioneer may try to find an application for an invention or discovery. Regardless, the solution must have some form of utility to be successful. If the originator decides to proceed he/she must decide for a physical reduction to practice, for a virtual reduction to practice via a patent, for tabling the idea in a portfolio for later strategic planning, for killing it, for reworking it, or for outside venture partnerships, manufacturing partners, or licensees. Later business planning is undertaken to guide the long term growth of the business. Finally improvement of the environment for innovation is needed to perpetuate the business by motivating new hires. Thus it is proposed that the ranking of the elements should be similar to: 1) Problem Solving/Problem Identification, 2) Business Analysis, 3) Business Planning, and 4) Environment.

An important point is that this is a simple circular discipline (albeit with some internal complexity as evidenced by the arrows) to improve the productivity in the Fuzzy Front End of the development process. Another important point is that Problem Solving as defined must have a powerful method, namely TRIZ, to attack problems to generate potentially significant solutions. Coupling Problem Solving with good business analyses and the longer time frame business planning is a winning combination[21]. The icing on the cake is to provide a supportive environment to maximize human productivity.

Figure 2. Innovation Process Model Diagram



The definitions below will further clarify how the elements act and should help prioritize activity in a Fuzzy Front End improvement plan.

1. Problem Identification, Problem Solving, and Reduction to Practice, are considered part of the Problem Solving (PS) element.

a. Problem Identification is the first part of the Problem Solving element. A problem as used here is a challenge to eliminate the gap (difference) between a desired situation and the current believed situation. This gap has obstacles which imply there is a problem in achieving the desired situation. The problem or need may be assigned or requested by customers, oneself, supervisors, etc.

Identification (ID) is therefore discovering and defining the gap between a desired situation and a current believed situation in terms that are understandable and actionable. ID may contain several layers of problems. The first layer may be management's general problem (we need to become more profitable) down to a single activity that is a well defined problem, e.g., igniting butane gas without reaching the auto-ignition temperature. This does not mean that a problem identified is the best one to pursue, is the correct definition of the situation, or is in alignment with the general problem being pursued. That decision may be made later in Business Analysis or Business Planning.

Shown in Figure 3 are some of the more popular problem identification and definition methods used by me. This is not intended to be an inclusive list of methods but only the ones I have found helpful. It is better to know a few than to be aware of many and become confused. Note that the power of the method (as determined by me) is given by a P rating, where 10 is the best rating. These methods are very popular and they can be found easily on the Internet or in libraries. As can be seen TRIZ is rated the highest for both problem identification and problem solving. This is because it contains methods to identify a more ideal solution, solve contradictions without compromise, disassemble the problem into the key problems, and identify the most beneficial and inventive solution. TRIZ is being recognized as one of the most powerful solution methods and is therefore a key to this process of innovation. [22,23] Unfortunately TRIZ is a new science and has been developed mainly in the areas of physics, chemical effects, and business. Novitskaya[24] has applied it to graphic arts but there are many other areas where it could be applied if developed. The reader is referred to my previous papers[25] with Malkin for explanation of a simplified approach to TRIZ and the Altshuller Institute[26] and the *TRIZ Journal*[27] for background and the latest information.

Figure 3. Popular Problem Indentification and Definition Methods Used.

Problem Definition Tools – "A problem well defined is half solved" anon, (in process)

Problem ID	Method	Benefit, 10=BIC
General and Maintenance	Kepner Tregoe (Prob. ID Steps)	Defined steps, P5(Power Level)
	Brainstorming/Affinity Diag	Somewhat easy, P4
	5 Whys	Easy, P3
	Customer Involv.(Focus, Problem ID, Ethnography, Kano)	Obtains customer feeling, P6
	3 Laws Marketing Physics	Good customer perspective w/o customer involvement, Fast, P3
	Fishbone Diagrams	Organizes and prompts responses P4
Technical	FMEA and Function Analysis	Organizes, prioritizes complex system and ID failures & solution approach, requires a proposed/existing system, P6
	TRIZ	ID ideal system , conflicts, subsystems, P8
	QFD	Creates compromise definition of problem (customer, marketing, eng), P5

b. Problem Solving is making meaningful progress on the gap reduction to a greater extent than previously available. The total proposed solution to a defined problem is a concept. Business Analysis would determine whether the activity should be pursued. No solution to a problem could slow the process, require additional work, table the issue, or abandon it. This further supports that this is a most critical step in the model. Problem Solving methods I have used are listed in Figure 4 below. Once again TRIZ receives the highest rating. The other methods are useful for a well defined problem and for many simpler problems they provide a fast and simple approach to a potential solution. Much has been written about these methods, especially brainstorming[28,29] which is utilized in TRIZ. However given time, it is always enlightening to apply TRIZ to the problem and see how many more solutions could have been developed.

c. IP Prosecution is one of the quickest ways for a Reduction to Practice. Creating a patent is sometimes referred to as Constructive Reduction to practice. It is the quickest way to legally document the solution. The term originates from patent law where creating a patent or provisional patent is considered a reduction to practice even though a physical prototype was not constructed. In this fast paced world, having a legal document to establish an invention date is important. The discussion is expanded to include an invention disclosure which is also a legal document for the establishment of a priority date of the invention in the cases where the patent becomes a subject to infringement proceedings. The only other quick way to establish an invention date is to have each page of a lab notebook signed and witnessed. Even with a physical prototype, the inventor must legally document the device to establish an invention date. Without these, the US Patent Office uses the date they receive the patent application as the date of invention.

d. Reduction to Practice is creating a physical prototype. This takes time but is one of the best ways to insure the inventor has captured the method to solve the problem. Submitting a provisional or utility patent application based on the prototype will reflect a working embodiment within the scope of the patent. If the scope of the final solution is outside of the original patent submission, the inventor will have to abandon the original patent and resubmit the new application. This gets expensive.

e. Portfolio Development is adding the problem solution concept to an internal inventory for future use. There are also other alternatives in this box such as conducting verification testing, and most importantly, it is the jumping off interface to the development stage of a stage gate development process.

Figure 4. Problem Solving Methods Used

Problem Solving Tools- (in process)

Problem Soln	Method	Benefit, 10=BIC
General and Maintenance	General Scientific Method* (most general approach & contained in many other methods)	Generally accepted approach, P4 (Power Level)
	Kepner Tregoe (Prob Soln Steps)	Defined steps, P5
	Brainstorming Solutions	Somewhat easy, P4
	5 Whys	Easy, solution becomes obvious, P3
	Fishbone Diagrams	Organizes and prompts solutions, P3
Technical	FMEA/Function Analysis	ID failures & solutions, P5
	TRIZ	ID ideal system , conflicts, subsystems, P8
	QFD	Creates compromise definition of problem (customer, marketing, eng), P4

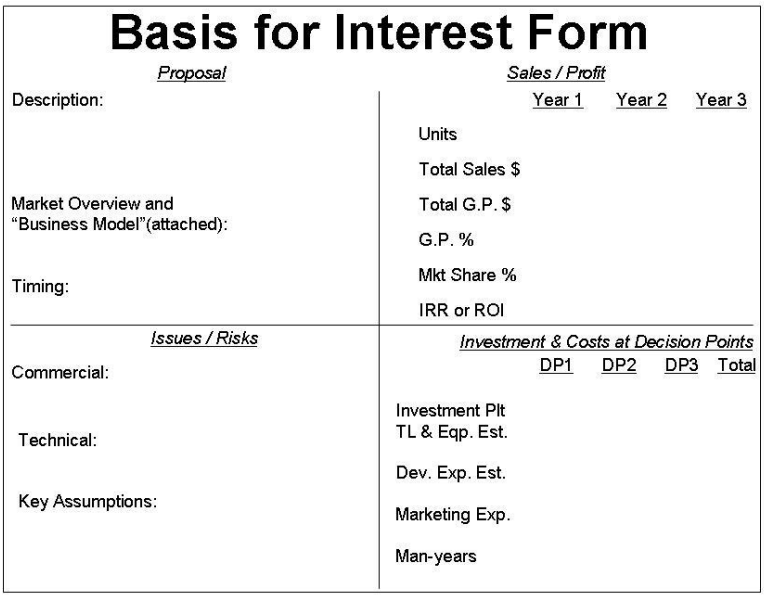
2. Business Analysis (BA): Means analyzing the problem solution/concept as documented by the Opportunity Identification form (OI), Basis for Interest form (BFI), Invention Disclosures, or other documents that may support business analysis for potential innovation. Business Analysis determines the degree that the activity should be pursued. These documents measure the commercial benefit. The BA is dependent on the quality of data it receives or as the saying goes "garbage in garbage out." Thus it is advisable to have more of a solution than only an idea. In order not to exclude the submission of good ideas from anyone, a route from Problem Identification to BA is shown. It also allows the submission of unintended discoveries, e.g., Nylon, Scotch Guard, etc. that were laboratory accidents found to have applications.

   Shown in Figure 5 is the OI form. It can document an idea or partial solution, even before a solution is proffered. If the idea receives a favorable rating from the BA team further information or refinement will be requested from the originator or a more appropriate person (many times someone from the Fuzzy Front End), be relegated to a portfolio for later consideration, or be declared dead on arrival.

Figure 5. Opportunity Identification form

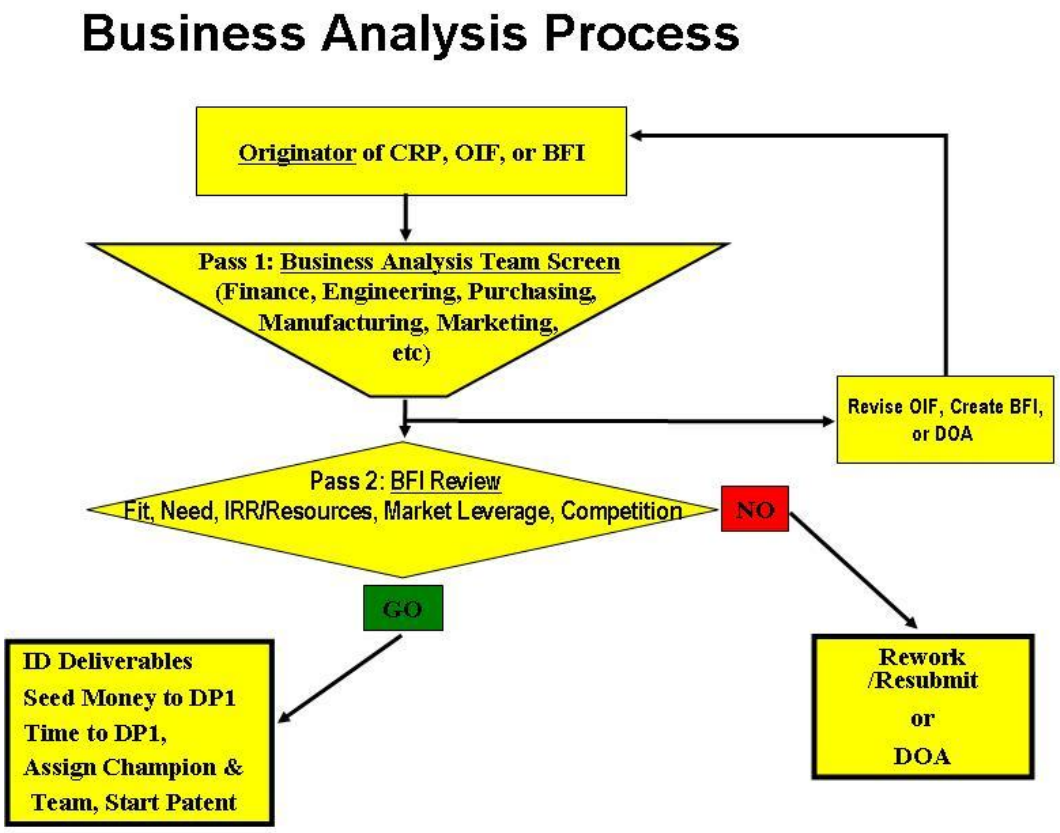
When more information is requested, the Basis for Interest form is developed and represents the next level of analysis by the Business Analysis team. The BFI form contributes rough estimates of data that are very important for the next disposition of the concept such as market overview with business model definition, commercial and technical risk assessments, duration for development, sales estimates, profit potential, market share impact, profit as a percent of business, rate of return (or the more exact internal rate of return), investments in tooling, plant, and equipment, development and marketing expenses, and, man years of development effort vs time. Next to Problem Solving (PS) this is arguably the next most immediate priority. Most companies start with a PS and a BA that hit the bull's eye. Later other factors such as long term planning and environment are utilized to enhance the enterprise longevity.

Figure 6. Basis for Interest form



The overall process for the BA element is summarized in Figure 7. It shows at least two reviews of the data. The first primarily involves the OI form and other documentation that is available. This initial screening will determine if the idea is pursued in the short term. The second screening requires the BFI form and other documentation that explain it. This screening will determine if the concept receives resources for further research, goes to development immediately, is relegated to a portfolio for longer term consideration, is considered for outside development or commercialization, or is discarded as DOA.

Figure 7. Business Analysis Review Process

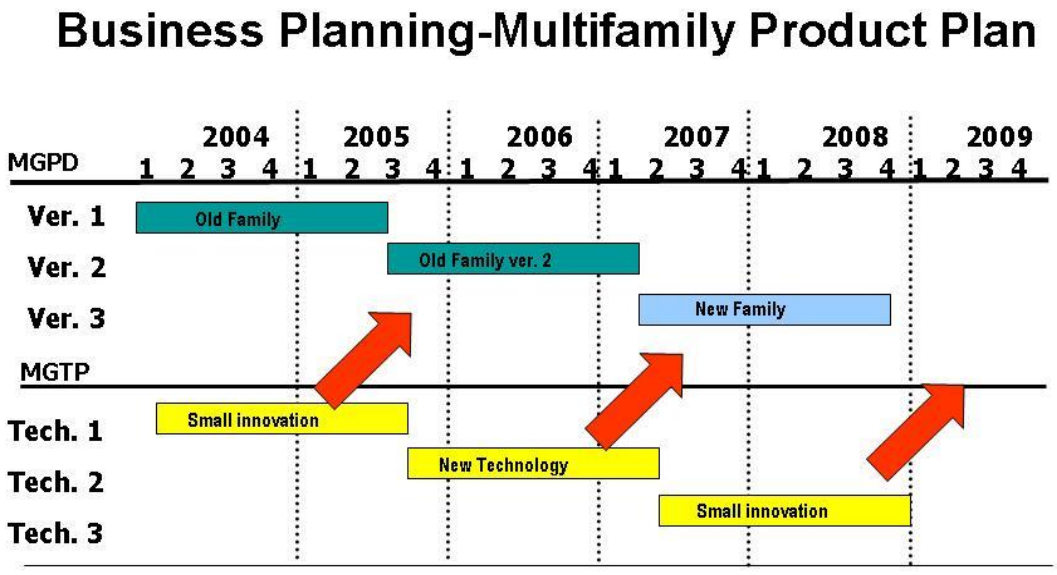


3. Business Planning (BP) for Innovation: The next element of the IPM is BP. BP is the planning of future business and innovation actions, so as to maintain the business's continued viability and growth. These actions relate to the business mission, business models, products or services planned in support of the mission and models, and goals (e.g. become a 1 billion dollar business in 2020). It is a very integrative interdisciplinary activity. The following steps are not intended to be a primer on developing business plans but instead to show how the invention and innovation activities relate to the plan. A typical business plan has many of the following activities:

   a. Review vision, goals, and objectives as seen by upper management
   b. Review state of the business (including performance to old business plan), growth, and profitability
   c. Review consumer and customer trends, demographics, must haves, needs, and wants that have been collected from ethnographic studies, market studies, and other research.
   d. Review the competition, company market share position, channels of distribution, and business models for the channels (value proposition, target audiences, value chain, costs/margins, how paid, position in value chain, and competitive strategy)
   e. Review product lines
   f. Review Fuzzy Front End activities that are in process and a review of portfolio technology that may be germane.
   g. Analyze the company strengths, weaknesses, opportunities, and threats.
   h. Brainstorming and documenting of a new business plan that includes a Multifamily Product Development Plan with linkage to a Multifamily Technology Plan and strategic initiatives that will be investigated in the future. A family is defined as a particular design business concept that is a configuration that would last for several years before a new and better family is introduced. This is similar to car platforms that change after a few years of minor changes. Each industry has its own cycle time. The cycle time is partly dependent on goals, competition, available innovation, and ability to amortize the investment before a new platform is introduced.

   Developing the MFPP utilizes concepts that are underway in the Fuzzy Front End or major development, archived in the portfolio of concepts, or generated in the meeting. Part of the outcome of this activity could look like Figure 8 where the Multifamily Product Plan is supported by a Multifamily Technology Plan that feeds and enables it. Another part of the outcome is an actionable plan for the different organizations (including the Fuzzy Front End) which can include working with outside partners and universities, licensing, research, venture capital, spin offs, special task forces and projects,etc. If a continuous flow of innovation is not available from the organization, it can create a crippling effect on the business growth and viability. This is why the productivity of the Fuzzy Front End is so important.

Figure 8. Business Planning



4. Environment (EN): The Environment is defined to mean the physical surroundings for workers (especially in the Fuzzy Front End), the organizational structure, benefit policies, the human interactions (motivation, vision, leadership, trust, friendship, etc.) that a person experiences while conducting innovation related activities.

   The Environment permeates all elements of the IPM. The Environment acts as a catalyst or amplifier in the operation of the model. A better environment improves innovation productivity. Some stress is helpful and too much stress is harmful for innovation productivity. Even under the most stressful situations, some innovation can occur. In *Jump Start Your Business Brain*, Hall[30] shows a formula relating innovation productivity to stress and stimuli. Factors that are considered useful in Environment are:

   a. Leadership
      1. Classic attributes: technical, human, conceptual skills[31]
      2. Standouts attributes
         1. Vision-conceptual-technical
         2. Charisma-human
         3. Conviction-human
         4. Alacrity-human
         5. Insight-technical
   b. Fresh view/Optimistic/No old bad images/Prejudices
   c. Chaos to a degree
   d. Skunk Works
   e. Consultants/Collaborative/University research
   f. Knowledge Management (maintaining a portfolio of solutions or concepts)
   g. Spin Offs
   h. Physical comfort/Pleasant surrounding
   i. Satellite organization
   j. Diversity
   k. Delegation
   l. Opportunistic
   m. Time for invention and investigation

The factors listed are ones that I have seen to be effective.

Attempts at Measurement of Innovation Process Model Effectiveness

Attempts to correlate the four key elements of the IPM to company success through an innovation audit have been difficult. It may have been naïve to think that companies would want to reveal their weaknesses and executive's inadequacies or to reveal competitive advantages. Correlation is also difficult since this is a holistic model where all parts must work reasonably well, and failing on one or more parts may not produce company success even though some elements are present. Also it rare to find a company using all four elements as prescribed. It is understandable why many of the books on business management use the case study method.

Validation of model from other sources has been more successful. Books have spent extensive time on the subject and therefore validation through the literature is being attempted. As referenced in this paper management books such as *Good to Great*[32] complement the IPM. A web site, "1000ventures"[33], founded by Kotelnikov appears to support a system for innovation. A blue ribbon panel was commissioned by the Secretary of Commerce in 2007[34] to measure innovation and it confirmed the difficulty in measuring innovation. My concern with their approach is that they tend to measure results vs. identification of the key drivers, methods and tools as prescribed in this paper.

Summary and Conclusion

The Innovation Process Model can provide a simple structured process for the Fuzzy Front End of the Development process that can improve the productivity and flow of innovation concepts. There are four main elements of the Innovation Process Model: Problem Solving, Business Analysis, Business Planning, and Environment. Prescriptive methods are provided that facilitate implementation of each of these elements.

One key tool of the model is the TRIZ methodology for solving problems. This will improve innovation productivity when combined with the rest of the model.

IPM is a holistic model that must be executed in total to be effective. It has been developed based on many years of personal industrial experience, research, and study of the literature. For it to be effective all elements must be executed.

IPM is a work in progress and it is not presented as a finished product. Validation work to measure its effectiveness and further research to develop the model must be conducted. The author welcomes collaborators who would be interested in validation and development of the model. To paraphrase The Advisory Commission on Innovation commented much needs to be done.[35]

ENDNOTES

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[21] This is valid, if one considers the disciplines, but in a holistic way, that *Good to Great*, *Blue Ocean Strategy*, *Open Innovation*, and my experiences have collectively shown to work. The Innovation Model Process explicitly captures these disciplines in a prescriptive way for successful innovation. Admittedly this is work in progress and I expect to elucidate more on the details in the future.
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Professor Coates teaches courses on innovation, energy power and industrial controls at Kent State University's College of Technology. Previously he was Vice President of Engineering at the Speed Queen Division of Raytheon, Director of Corporate Primary Development and Director of Dishwasher Engineering at the Frigidaire Company of AB Electrolux, Director of Research for the Hoover Company of the Maytag Corporation and Manager of Whirlpool Automatic Washers at the Whirlpool Corporation. He received a Ph.D. and MSME for Purdue University and a BSME from the State University of New York at Buffalo. He also received the Distinguished Engineering Alumnus and Outstanding Mechanical Engineer awards from Purdue University. He holds 21 patents, eight pending, and has authored eight papers. He is member of the American Society of Quality and the National Society of Professional Engineers.