World Academy of Science, Engineering and Technology
International Journal of Industrial and Manufacturing Engineering
Vol:8, No:2, 2014

Achieving Success in NPD Projects

Ankush Agrawal, Nadia Bhuiyan

***Abstract*—**The new product development (NPD) literature emphasizes the importance of introducing new products on the market for continuing business success. New products are responsible for employment, economic growth, technological progress, and high standards of living. Therefore, the study of NPD and the processes through which they emerge is important. The goal of our research is to propose a framework of critical success factors, metrics, and tools and techniques for implementing metrics for each stage of the new product development (NPD) process. An extensive literature review was undertaken to investigate decades of studies on NPD success and how it can be achieved. These studies were scanned for common factors for firms that enjoyed success of new products on the market. The paper summarizes NPD success factors, suggests metrics that should be used to measure these factors, and proposes tools and techniques to make use of these metrics. This was done for each stage of the NPD process, and brought together in a framework that the authors propose should be followed for complex NPD projects. While many studies have been conducted on critical success factors for NPD, these studies tend to be fragmented and focus on one or a few phases of the NPD process.

***Keywords*—**New product development, performance, critical success factors, framework.

I. Introduction

THIS document is a template for *Word (doc)* versions. If you are reading a paper version of this document, so you can use it to prepare your manuscript. Managing the NPD process has become a challenge for firms as it requires extensive financial and human resources and is time sensitive. The harsh realities are that the majority of new products never make it to market and those that do face a failure rate somewhere in order of 25 to 45 percent [1], [2]. For every seven new product ideas, about four enter development, one and a half are launched, and only one succeeds [3]. Despite the extensive research on how to achieve success in NPD, firms continue to deliver products that fail and therefore NPD ranks among the riskiest and most confusing tasks for most companies. As the number of dollars invested in NPD goes up, the pressure to maximize the return on those investments also goes up. It becomes worse as an estimated 46 percent of resources allocated to NPD are spent on products that are canceled or fail to yield an adequate financial return. In this paper, we propose a framework that identifies the critical success factors (CSF) for each phase in the NPD process, metrics to measure them, and the tools and techniques that can be used to evaluate each metric. Our study is based on an extensive review of the NPD literature. The paper is presented as follows. In the next section, we discuss the NPD process, followed by a discussion of critical success factors and metrics. Our framework is then described in detail, and we conclude with a discussion of our work.

A. Agrawal is with Pricewaterhouse Coopers LLP in Toronto, Canada, (e-mail: ankush.agrawal@ca.pwc.com).

N. Bhuiyan is with the Department of Mechanical and Industrial Engineering, Concordia University, Montreal, Canada, (e-mail: nadia.bhuiyan@concordia.ca).

A. New Product Development

Many researchers have tried to develop a model that captures the relevant stages of the new product process [1], [2], [4], [5]. A number of detailed NPD models have been developed over the years, the best known of which is the Booz, Allen and Hamilton model, shown if Fig. 1, also known as the BAH model, which underlies most other NPD systems that have been put forward. This widely recognized model appears to encompass all of the basic stages of models found in the literature. It is based on extensive surveys, in depth interviews, and case studies and, as such, appears to be a fairly good representation of prevailing practices in industry.

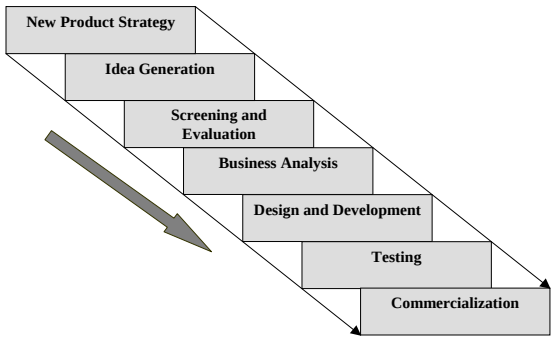

Fig. 1 Stages of New Product Development [3]

The New Product Strategy: stage links the new product process to company objectives and provides focus for idea/concept generation and guidelines for establishing screening criteria. In the Idea generation phase, searches for product ideas that meet company objectives are conducted. Screening involves an initial analysis to determine which ideas are pertinent and merit more detailed study. The Business Analysis phase further evaluates the ideas on the basis of quantitative factors, such as profits, Return-on-investment (ROI), and sales volume. In the Development, an idea on paper is transformed into a product that is demonstrable and producible. Testing conducts commercial experiments necessary to verify earlier business judgments. Finally, Commercialization launches the products.

B. Critical Success Factors and Metrics

Over the last two decades, several studies have examined the determinants of NPD success and identified many factors that distinguish successful products from unsuccessful ones.

Factors that are necessary and guarantee commercial success are termed as critical success factors (CSF): it is imperative to reflect on how one can benefit from each and how one can translate each into an operational aspect of the NPD process. References [6] and [7] proposed that organizations need to identify factors that are critical to the success of that organization, and they suggested that the failure to achieve goals associated with those factors would result in organizational failure. The challenge is to design a process for successful product innovation - a process whereby new product projects can move quickly and effectively from the idea stage to a successful launch and beyond.

A metric tracks performance and allows a firm to measure the impact of process improvement over time. Metrics can play an important role in helping companies to enhance their NPD efforts and are important for at least three reasons. First, metrics document the value of NPD and are used to justify investments in this fundamental, long term, and risky venture. Second, good metrics allow for the evaluation of people, objectives, programs, and projects in order to allocate resources effectively. Third, metrics affect behavior. When scientists, engineers, managers, and other NPD employees are evaluated on specific metrics, they often make decisions, take actions, and otherwise alter their behavior in order to improve the metrics. The right metrics align employees' goals with those of the corporation; wrong metrics are counterproductive and lead to narrow, short-term, risk-avoiding decisions and actions. A lack of useful metrics is undoubtedly one reason that the success rate of NPD has not improved appreciably over the past 40 years [8], [9]. If companies had reliable metrics to gauge their performance, then specific problem areas could be addressed and managers might see the same improvement in their NPD efforts that they come to expect from their quantifiable total quality management programs [10].

II. CSF's and Metrics for NPD Stages

In what follows, each stage of the NPD process and its respective CSFs, metrics, and tools and techniques for measuring progress is explained in detail.

A. New Product Strategy

CSFs: A firms' strategy should provide a clear understanding of the goals or objectives for the company's new product program, and should indicate the return-on-investment (ROI) expected such that the contribution of new products to corporate goals is well-understood. Furthermore, clearly defined arenas, i.e., specified areas of strategic focus, such as products, markets, or technologies, are needed to give direction to the firm's total new product program. The problem at this stage is not only one of developing a clear strategy but also its implementation, i.e., translating the strategy into terms that everyone understands to bring focus to day-to-day actions, and communicating the strategy with other members in the organization. Prior research suggests that companies that recognize the importance of interventional coordination and effectively sharing an NPS across departments will have more successful new products [11]. The role of new products in achieving company goals was clearly communicated to all in such firms. Thus, once a clear NPS is defined, the related confounding problem is communicating clearly the needs, requirements, resources, and plans for a new product effort - in essence, internalizing the strategy. This communication must take place in multiple forms; however, a well-documented plan and specification must serve as the foundation.

Metrics: The return-on-investment (ROI) compares the company's yearly income with the investment in the asset. While the ROI is not too challenging, management should understand how the ROI benchmarks have been calculate so that relevant comparisons can be made for the project under evaluation. A company's ROI proves to be useful in setting the new product goals. This metric will help to determine if the cost to develop a new product exceeds the resulting benefit, or if the payback affects the corporate bottom line. The aim here is to compare the return expected to be received from the project with some pre-established requirement.

Tools and techniques for NPS: The Balanced Scorecard (BSC) provides the instrument the firm needs to navigate to future competitive success [12]. BSC translates an organization's strategy into a comprehensive set of performance measures that provides the framework for a strategic measurement and management system. The scorecard measures organizational performance drivers across four perspectives which provide its framework: financial, customers, internal business processes, and learning and growth. Organizations should use the scorecard as a strategic management system, to manage their strategy over the long run and use it for the measurement focus of the scorecard to accomplish critical management processes, including communicating and linking strategic objectives and measures.

The BSC strategic objectives and measures are communicated throughout an organization via company newsletters, bulletin boards, videos, and even electronically through groupware and networked personal computers. The communication serves to signal to all employees of the critical objectives that must be accomplished if an organization's strategy is to succeed. Once all employees understand high-level objectives and measures, they can establish local objectives that support the business unit's global strategy.

B. Idea Generation

The main purpose of this stage is to create a number of different ideas from which the firm can select the most feasible and promising one(s). A greater likelihood of achieving success depends in part on the number of ideas generated. Brainstorming, morphological, analysis and gap analysis are most commonly employed methods for generating ideas [1]. Customers can be an especially good place to start searching for new product ideas.

CSFs: Customer focused idea generation is a CSF for this stage as per studies done by many researchers that show that a thorough understanding of customer's needs and wants is vital for new product success [1], [13]. Successful businesses and

teams that drive winning new products have a dedication towards the voice of the customer. A strong customer involvement is necessary right from the idea generation stage. According to a review of causes of NPD success and failure, internally generated ideas had lower success rates then externally generated ideas [14]. A relatively high rate of success is achieved for project ideas that originated from marketing and customers as compared to ideas originating from R&D, suppliers, and management.

Metrics: Metrics to track idea generation and enrichment include: number of ideas generated from the customer, number of ideas retrieved and enhanced from an idea portfolio, number of ideas generated over a period of time, and the value of ideas in idea bank. Among all of these metrics, the number of ideas generated from the customer is the most associated with the CSF of the idea generation stage. Firms must devote more resources to customer based idea generation activities, such as focus groups with customers; detailed, one-on-one interviews with customers; customer site visits, especially by technical people; the active solicitation of ideas from customers by the sales force; and the development of a relationship with lead users [11].

Tools and techniques for Idea Generation: Understanding customer and market needs is a consistent theme for successful product development in studies by [11], [15]. There are many creativity and brainstorming techniques for enriching the idea stream. Effective methods for enriching the customer based idea stream utilize lead user methodology and ethnographic approaches. The lead user methodology is based on customer input and usually collects information on new product needs from a random or typical set of customers. An ethnographic approach is a descriptive, qualitative market research methodology for studying the customer in relation to his or her environment. Researchers spend time in the field observing customers and their environment to acquire a deep understanding of customer's lifestyles or cultures as a basis for better understanding their needs and problems.

C. Screening and Business Analysis

While the screening and business analysis are proposed as two different stages in the BAH model, we consider the two stages as one for simplicity of the proposed framework.

CSFs: Up-front homework is a CSF for the screening and business analysis stage as too many new product projects move from the idea stage right into development with little or no early preparation [16]. The results of this approach are usually disastrous. Up-front homework includes activities such as financial analysis, undertaking thorough market and competitive analyses, research on the customer needs and wants, concept testing, and technical and operations feasibility assessments. Solid pre-development work drives up new product success rates significantly and is strongly correlated to financial performance.

Metrics: Financial or economic models treat project evaluation much like a conventional investment decision. The expected commercial value (ECV), net present value (NPV), internal rate of return (IRR), and the profitability index (PI), are metrics that are proposed as being most useful for measuring the success of the screening and business analysis stage. These metrics should be used to rate, rank order, and ultimately select projects. All metrics have their own advantages and disadvantages. For example, the NPV method ignores probabilities and risk; it assumes that financial projections are accurate and financial goals are important. The ECV depends on extensive financial and other quantitative data.

Tools and techniques for Screening and Business Analysis: The financial methods of evaluation for the proposed metrics and how they measure the financial performance of each project are explained below. The Expected Commercial Value (ECV) method seeks to maximize the value or commercial worth of the project, subject to certain budget constraints, and introduces the notion of risks and probabilities. The ECV method determines the value or commercial worth of each project to the corporation. The ECV measures the value of the project in terms of its expected financial returns from the perspective of the company's overall commercial strategic objectives. In order to arrive at a prioritized list of projects, the ECV of each project is determined projects are rank ordered accordingly. The net present value (NPV) criterion for evaluating proposed capital investments involves summing the present values of cash outflows required to support an investment with the present value of the cash inflows resulting from operations of the project. The inflows and outflows are discounted to present value using the firm's required rate of return for the project. Only those projects that have a positive or zero NPV meet the criterion for acceptance. The internal rate of return (IRR) is that rate which exactly equates the present value of the expected after-tax cash inflows with the present value of the after-tax cash outflows. Once the IRR of a project has been determined, it is a simple matter to compare it with the required rate of return to decide whether or not the project is acceptable. Projects are ranked according to the IRRs: the project with the highest IRR is ranked first and so on. The profitability index (PI) is the ratio of the present value of the after-tax cash inflows to the outflows. A ratio of one or greater indicates that the project in question has an expected yield equal to or greater than the discount rate. The profitability index is a measure of a project's profitability per dollar of investment. As a result, it is used to rank projects of varying costs and expected economic lives in order of their profitability.

D. Development

Once the results of the business case of the new product conform to company objectives, the new product team can move on to the development stage, which is made up of activities that range from prototype development to volume ramp up and test marketing. The interaction between the program and project manager is no longer one of selling or buying the concept, but rather one of bringing the product to market on time, within budget, and to the required specifications.

CSFs: Reducing development time is a vital competitive weapon and yields competitive advantage; it means that there is less likelihood that the market or competitive situation has changed by time the product reaches the market and it means a quicker realization of profits [2], [11], [13]. Companies that develop products quickly gain many advantages over their competitors: premium prices, valuable market information, leadership reputation with consumers, lower development costs, and accelerated learning [2]. Most importantly, fast development minimizes the impact of a changing environment. The challenge here is to shorten development time so as to minimize the chances that the development target has changed. Seeking customer feedback is a vital activity throughout development stage, both to ensure that the product design is right and also to speed development toward a correctly defined target. Customer feedback is perhaps the most certain way of seeking continual and honest customer input during the development phase. Seeking customer input should become an integral part of the design team to speed up and make development stage successful.

Metrics: Development time is defined as the duration from the start to completion of the development stage, i.e., the length of time to develop a new product after passing business case stage to initial market sales. Cross-functional teams are essential for timely development, improving design quality, and lowering development costs. A cross-functional team is defined as a team consisting of representatives from the various functions involved in product development, usually including members from marketing, R&D, and operations (and perhaps others, such as purchasing, as needed). Related is the degree to which team members are committed, or dedicated, to the project. Since project team members' time commitments are typically spread across a number of projects at any one time because departmental managers are vying for team members' time, team members are often on and off development projects. This creates a discontinuity and increases development time. It is in this stage that it is crucial to have a team with dedicated team members. Activities need to be undertaken concurrently (rather than sequentially), thus more activities are undertaken in an elapsed period of time. The purpose is to achieve product designs that reflect customer wants as well as manufacturing capabilities and to do so in the shortest possible time. Finally, the degree of design effort on real customer needs is a qualitative in-process metric which ensures as much as possible that the final design meets customer requirements. This requires seeking customer input and feedback throughout the entire development stage and thus the customer becomes an integral part of the design team to overcome technical problems that arise and that necessitate product design changes during the development stage.

Tools and techniques for Development: The literature review has shown that there exist a number of tools and techniques to reduce development times that are consistent with sound management practice. Dynamic time to market is a tool which can be useful in predicting the end date of the said project as well as in tracking the progress of a project. It works in the following way: when a schedule prediction is made, the prediction date is plotted against the date the prediction was made. By assessing dynamic time to market, the team members will get an early warning of potential late delivery and appropriate action can usually be taken by the team to maintain schedule integrity. Thus projects are kept on schedule to achieve timely product development. The degree of team cohesiveness gauges the growth of the team as a working group and it is a function of length of time that a team has worked together in a past or present project [17]. Overlapping means doing various activities in parallel rather than doing them sequentially. By overlapping activities, the cycle time, i.e. the total time taken to complete the product development from concept until the product reaches market, can be greatly reduced. In general, the higher the number of overlapped activities, the higher the degree of concurrency and the shorter is the development time.

E. Testing

The purpose of this stage is to provide final and total validation of the entire project: the commercial viability of the product, its production, and its marketing. Design and testing go hand in hand, with testing being conducted throughout the development stage. Information obtained during testing is used in developing the product. This phase is extremely important in that it may dramatically decrease the chances of failure in launch, since it has the capacity of revealing flaws that could cause market failure [18]. Studies show that a test phase that is customer oriented is the critical factor - whether it is done and how well it is executed - is significantly correlated with the new product success [11], [19]. Different types of testing, i.e. concept testing, prototype/development testing, and test marketing, should be conducted in this stage. It should be noted, however, that testing should not be solely restricted to this stage; it must be conducted throughout the NPD process.

CSFs: Product functionality is critical for the testing stage as the aim here is to see whether a product with the attributes called for has been produced. It must be proven that claimed attributes exist and the causes for missing attributes must be found. Customer acceptance is critical for this stage to gauge whether the product is acceptable to the customer, to measure the customer’s level of interest, liking, preferences, and intent to purchase, and to determine those benefits, attributes, and features of the product to which the customer responds. In short, the customer reaction must be sufficiently positive so as to establish purchase intent.

Metrics: The performance of a product is how well the product achieves the functionality desired. Product performance is usually measured in such ways as testing physical features, perceptual features, functional modes, and perceived benefits. Validation and user testing techniques are used to gather data on product performance. These primary research techniques generate quantitative results. At this stage in the NPD process, these are the types of research results necessary to make final critical decisions and reduce the risk of possible failed launches. Customer-perceived value is

measured to determine whether the customer is willing to purchase the tested product or not and to gauge whether the product is acceptable to the customer.

Important metrics for this stage are: perceived relative performance, customer satisfaction (Like/Dislike), and the preference score to determine the nature of the competitive situation. These are qualitative metrics, but are very important nonetheless to record the basic likes/dislikes of the customer early before the product gets launched into the market. Based on the qualitative data, managers can take action to make changes in the product.

Tools and techniques for Testing: Validation tests normally aim to evaluate actual functionality and performance, as is expected in the production version and so activities should be performed in full. It is probable that the validation test is the first opportunity to evaluate all of the component elements of the product together, although elements may have been tested individually already. Thus, the product should be as near to representing the final item as possible, including packaging, documentation and production processes. Data from a validation test is likely to be quantitative, based on measurement of performance. Normally, this is carried out against some benchmark of expected performance or criteria set before. Usability issues may be scored in terms of speed, accuracy or rate of use, but should always be quantified. Issues such as desirability may be measured in terms of preference or user ranking. Data should also be formally recorded, with any failures to comply with expected performance logged and appropriate corrective action determined. User and field testing is performed by real users or customers, and in some cases, this testing must precede product shipment. This is not to be confused with marketing customer testing, where certain strategies regarding sale and marketing of the product are explored. Test protocols are produced by the company and can range from rigorous to non-existent. In the first case, the developer closely monitors and follows up the beta test with in-house staff or contracted staff from a specialty testing company. In the second case the developer may simply contact the customer by phone or has an group or individual contact to ask for opinions on the product. The test results attempt to confirm that the user feels the same toward the prototype as toward the verbal concept discussed earlier in the NPD stage. The results of the testing either confirm that the product meets its requirement or show the areas where the product is deficient, and is therefore a critical stage to be considered in the development process.

III. Framework of CSFs, Metrics and Tools and Techniques for NPD

The CSFs, metrics, tools and techniques proposed for successful NPD discussed in the previous section are all summarized in the framework proposed in Table I.

TABLE I
Critical Success Factors and Metrics for Stages of NPD Process

Stage	Critical Success Factor	Metrics	Tools and Technique
New Product Strategy	Clear Strategy	Return on Investment	Financial Analysis
	Well Communicated Strategy	Degree of Communication	Balanced-Scorecard as a Communication Tool
Idea Generation	Customer Focused Idea Generation	Number of Customer Focused Ideas Generated	Lead User Methodology Ethnographic Approach
Screening and Business Case	Up-Front Homework	Expected Commercial Value (ECV) Net Present Value (NPV) Internal Rate of Return (IRR) Productivity Index (PI)	Financial Method of evaluation
Development	Speed	Development time	Dynamic Time to Market
		Degree of functional integration	Team Cohesiveness
		Degree of team commitment	
	Customer feedback	Concurrency of activities	Degree of Parallelism
		Degree of design effort on real customer priorities	
Testing	Product Functionality	Product Performance	Validation Testing
	Customer Acceptance	Customer-Perceived Value	User and Field Testing

For each stage of the NPD process, the factors that are essential, metrics which can be used to measure the performance of those factors, and tools and techniques to implement the metrics are all detailed in the framework. As a preliminary proposed framework, we believe that any complex NPD project that follows this framework will have an increased chance at success.

IV. Discussion and Conclusions

New product success still remains the critical challenge for companies. Many companies are aware of the major role new products must play in their future and quest for prosperity. The framework we developed proposes that to achieve success, NPD firms should have a clear and well communicated new product strategy. These firms should have well defined new product arenas along with long term trust, with clear goals. Successful businesses and teams of NPD have a dedication towards the voice of the customer. It is critical that firm should gather as many ideas as possible and a large number of these should come from customers so that the firm can be in a position to design and develop winning new products. Up-front homework prior to the initiation of product design and development is found to be a key factor in a firm's success. The quality of execution of the predevelopment steps - initial

screening, preliminary market and technical studies and business analysis - is closely tied to the products financial performance. Firms should try to shorten the development time so as to minimize the chances that the development and customer needs have changed when the product comes into the market. It is important to verify and validate product performance requirements and design specifications along with customer's acceptance before launching the product into the market via validation and user field testing. This paper explored and analyzed the new product process and attempted to identify ways in which firms can improve their performance when developing new products, mainly through the study of factors that are critical to success. These factors were identified through an extensive study of the practices and performance of successful firms presented in the NPD literature. The CSFs which have been described in the literature are generally defined for the overall development process, rather than specifically addressing each stage. To overcome this problem, this paper sought out CSFs for each stage of the process. Presumably, no other study to date has developed such a framework, which can be crucial for NPD success.

REFERENCES

[1] Crawford, C. (1987, 1997), New product management. (2nd ed& 5th ed.). Illinois: Richard D. Irwin.
[2] Cooper, R. (2001), Winning at new products: accelerating the process from idea to launch. (3rd ed.). Perseus Publishing, Massachusetts.
[3] Booz, Allen, Hamilton (1982), New product management for the 1980's. New York: Booz, Allen & Hamilton, Inc.
[4] Ulrich, K.T. and Eppinger, S.D. (2012). Product Design and Development, McGraw-Hill.
[5] Wind, Y. (1982), Product policy: Concepts, methods, and strategy. Reading, Mass: Addison-Wesley.
[6] Daniel, R. (1961), Management data crisis, Harvard Business Review, Sept-Oct, pp. 111-112
[7] Rockart, J. (1979), Chief executives define their own data needs, Harvard Business Review, 57:2 238-241
[8] Crawford, C. (1979), New product failure rate- facts and fallacies, Research Management, 9-13.
[9] Crawford, C. (1992), The hidden costs of accelerated product development, Journal of Product Innovation Management, 9:3 188-199
[10] Lynn, G., and Reilly, R. (2000), Measuring team performance, Industrial Research Institute Inc., March-April 48-56
[11] Cooper, R. (1999), From experience: the invisible success factors in product innovation, Journal of Product Innovation Management, 16 115-1333
[12] Kaplan, R., and D. Norton, (1996), The Balanced Scorecard, Harvard Business School Press, Boston, Massachusetts.
[13] Cooper, R. (1993), Winning at new products: accelerating the process from idea to launch. (1st ed.). Perseus Publishing, Massachusetts.
[14] Souder, W. (1987), Managing new products innovations. D.C. Health and Company, MA.
[15] Song, M., and Parry, M. (1996), What separates Japanese new product winners from losers, Journal of Product Innovation Management, 13 422-439
[16] Rosenau, M., Griffin, A., Castellion, G., and Anschuetz, N. (1996), The PDMA Handbook of New Product development. John Wiley and Sons, Inc.
[17] Balakrishnan, A. (1997), Concurrent engineering: Models and metrics. (Master dissertation, McGill University, Canada)
[18] Urban, C., & Hauser, J. (1993), Design and marketing of new products. New Jersey: Prentice-Hall.
[19] Cooper, R. (1998), Product leadership: Creativity and launching superior new products. Perseus Books, Reading, Massachusetts.

Ankush Agrawal completed his Master if Applied Science degree at Department of Mechanical and Industrial Engineering at Concordia University in Montreal, Canada. He is currently a Manager of Advisory Services at PricewaterhouseCoopers LLP in Toronto, Canada.

Nadia Bhuiyan is an Associate Professor in the Department of Mechanical and Industrial Engineering at Concordia University in Montreal, Canada. She. was an Assistant Professor at the Queen's School of Business and a lecturer at McGill University in Management Science. She is the Associate Director of the Concordia Institute of Aerospace and Design Innovation (CIADI).She has published in journals such as Management Science, European Journal of Operational Research, Research-Technology Management, International Journal of Project Management, and has published a book and a book chapter. Her research interests are in operations management, particularly in product design and development processes and lean, with a focus on emerging tools and techniques to improve process performance.

Dr. Bhuiyan is a Senior Member of the Institute of Industrial Engineers.