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CASE STUDY

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ABSTRACT

How can senior IS executives successfully shepherd IT initiatives through complex organizations? This paper prescribes an integrated IT investment management process incorporating four recommended activities:

- strategic planning,
- quality function deployment,
- activity analysis, and
- responsibility assignment.

The process, tools, methods, and organizational learning were drawn from two projects at Air Products and Chemicals, Inc. The integrated process for IT investment management can help senior IS executives prioritize projects and align responsibility and accountability for IT initiatives that require complementary organizational changes to activities across the entire value chain to realize full benefits.

Keywords: IT value, IT investment, responsibility gap

I. INTRODUCTION

Although IT investment is growing rapidly, the development of processes for managing such investments has not kept pace. Senior executives are concerned about whether they are making the right IT decisions and if savings will materialize [Advisory Board Company, 1997]. While forecasted IT spending increases from $665 million in 2000 to $1.4 trillion in 2005 [Barlas, 2001], Keen's 1991 comments remain more relevant today (Keen 1991):

> Senior executives are caught in a worrisome double bind: ever greater commitments to IT are being driven by competitive necessity and discouraged by escalating costs and uncertain benefits. Put another way: economically, companies cannot afford to increase capital spending on IT; competitively, they cannot afford not to do so. The economics of information capital is firmly on the top management agenda, and corporate managers are clamoring for help. (p.142)

Executives today are faced with decisions regarding a wide range of IT projects: from organization wide ERP systems to IT solutions championed by specific groups. Generally the chief information officer (CIO) is responsible for providing input to the prioritization of such projects, supporting them, and ensuring that the projects deliver value to the organization. While CIOs are often held accountable for results, they may not be responsible for the complementary operating unit organizational changes required to achieve full benefits from IT projects. This paper presents two cases of IT projects that were initiated by an internal operating group within Air Products and Chemicals, Inc. The process, tools, methods, and organizational learning that resulted led to an integrated process for IT investment management that can help CIOs align responsibility and accountability and realize value from IT investments.

Companies need an integrative process for IT investment justification and management to realize value and overcome the challenges associated with driving major IT initiatives through complex organizations. Managers often jump into new opportunities without attention to strategic alignment [Henderson and Venkatraman, 1999], sometimes with little or no quantification of the impact of these opportunities. Few organizations have a methodological approach to benefits management [Ward, 1996].

Managing IT investments is challenging because:

(1) their impact is broad, often affecting activities across the entire value chain of the enterprise;

(2) no systematic integrative processes are available to measure their impact effectively; and

(3) IT alone does not create benefits; it is the management process that uses IT to create benefits [Brynjolfsson and Hitt, 1998; Keen, 1991].

Managers who perform the analyses that justify IT investments take into account savings that will accrue once the IT solution is implemented. The three potential problems with the traditional approach to IT investment justification are:

(1) the methods often do not take into account the impact of the IT solution across the value chain;

(2) the documentation of savings does not identify the specific action steps, such as process reengineering and redeployment of people and equipment, and

(3) the managers who justify IT projects often do not have the responsibility and the authority to make the changes needed to realize savings.

The problem is a "responsibility gap" between individuals who justify projects and those responsible for taking specific actions to ensure that returns are realized. IT projects must be accompanied by complementary organizational changes to achieve payoff.

HOW CAN MANAGEMENT SUCCESSFULLY SHEPHERD IT INITIATIVES THROUGH COMPLEX ORGANIZATIONS?

The responsibility gap creates a barrier for realizing potential benefits from IT projects. Realizing benefits requires giving the responsibility of taking action steps to people with decision-making authority across the entire value chain. To achieve this goal, effective planning and execution of IT projects is needed. This paper describes two case studies that demonstrate a disciplined approach, effective communications, innovative methods, and identification of benefits across the value chain. The methods described here are scalable to IT project justification in companies of different sizes and can be migrated to other industries.

Sidebar 1

Air Products and Chemicals, Inc

This Fortune 500 company is the world's only combined gases and chemicals company. Air Products offers products and services to the global electronics and chemical processing industries. It is longstanding innovator in basic manufacturing sectors, including steel, metal, glass, and food processing. Founded in 1941 and headquartered in eastern Pennsylvania's Lehigh Valley, the company operates in 30 countries with annual revenues of $5.5 billion. The company employs 17,500 people worldwide.

Case 1 describes the two-year initiative, started in 1996, that led to the development of a product configuration tool to manage and automate sales order entry, engineering, and manufacturing design of a specific product line. The success of this initiative lured other product line owners within the company to adopt a similar approach and work process for re-engineering and managing their product lines. Lessons learned from this initiative led to the development of a formal process for achieving value from IT investment, which was applied during a second initiative that began in March 2000. This second initiative is Case 2. The scope of the second initiative involved developing a framework for a common product configuration platform capable of supporting a large number of product lines across the company. A timeline of events is provided in Appendix 1. This paper summarizes the lessons learned from

(1) the design and implementation of the product configuration tool for a single product as well as

(2) the development of a "One Company" product configuration solution supporting a wide range of product lines and applications across the company.

Value realization from IT investment requires:

(1) alignment of IT projects with business strategy,

(2) effective communication of goals and plans to all stakeholders,

(3) customer-driven initiatives,

(4) identification and measurement of IT's impact on work process activities across the value chain, and

(5) management of work process change to ensure benefits achievement, including assignment of responsibility for achieving benefits.

Based upon lessons learned through the initiatives at Air Products, we recommend four distinct activities that lead to value realization from an IT investment.

II. CASE 1: DEVELOPMENT OF PRODUCT CONFIGURATOR FOR GASGUARD^{TM}

Air Products' first major product configuration initiative focused on their highly configurable product line GASGUARD^{TM} (Sidebar 2). An outgrowth of their *mass customization* initiative for this product line (see below) was the development of a product configurator, which serves as a repository for design information and rules, identifies equipment for various offerings (options), and creates proposals, specifications, and engineering drawings that can be shared immediately with customers.

THE PRODUCT CONFIGURATOR

A salesperson uses the configurator on a laptop at a customer site to configure the product and then to electronically download the sales order, design, and manufacturing information to the home office. With the configurator, sales proposals, engineering, and manufacturing specifications are generated in one or two days compared to several weeks previously. Moreover, the configurator virtually eliminates errors in the order-entry process because the salesperson can no longer accept orders

Sidebar 2

GASGUARD

Designed to deliver high-purity specialty chemicals to the electronics industry, GASGUARD comprises a family of equipment delivery systems (Figure 1). Over 60 specialty chemicals are individually stored in pressurized cylinders and dispensed through the GASGUARD system.

Figure 1. GASGUARD System at a Semiconductor Facility

Air Products had been supplying GASGUARD to the electronics market since the early 1980s. Driven by demanding electronics customers, over the years the product design evolved into a family of highly customized systems. In 1995 the GASGUARD design team decided to implement mass customization techniques to deliver product variety rapidly while maintaining cost-competitiveness.

with options that cannot be manufactured.

The product configurator resulted in major cost reduction, speed to market, and improved product quality. In less than a year, the GASGUARD unit cost was reduced by 28% and the average lead time was reduced from 14 weeks to less than 6 weeks. Other details about cost savings were discovered through a post-implementation activity analysis exercise described later in this section.

The objective of the mass customization redesign of GASGUARD was to achieve flexibility of product options/features so that the product could be easily configured. Modular design concepts were applied so that subsystems and components were easily interchangeable and configurable. The basic concept of mass customization is shown in Figure 2. While there are several options for connecting points 1 and 2 (AB, AC, DC, or E), by maintaining fixed dimensions for E, any combination can easily be substituted. A product configurator generates the specifications and design drawings for any of the options depending upon customer preferences specified during order entry.

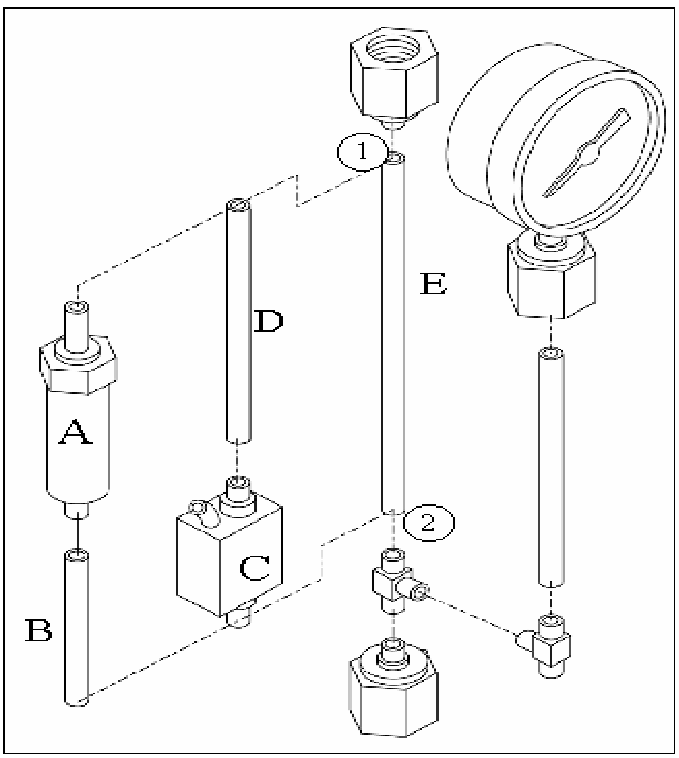

Figure 2. Flexible Modular Design for Mass Customization

THE DEVELOPMENT PROCESS

The cross-functional development team of 10 included individuals from the company's engineering, commercial, operations, and manufacturing organizations. A management steering team also provided guidance to the core team. The overall 18-month development program involved the following tasks:

Vision Statement: The team issued a simple vision statement with stretch goals that were realistic, measurable, and attainable. The Vision Statement is summarized in Table 1.

Table 1. GASGUARD's Vision Statement

• Depart from custom-designed to a standard functional product.
• Product design based on customers' basic functional requirements.
• Improve speed-to-market; achieve target leadtime.
• Cost-competitiveness; achieve a target unit cost position.
• Improve quality; achieve a target quality goal (nonconformance reporting).
• Maintain Air Products' industry leadership position (market share).

Mass Customization Product Design Framework. The members of the development team defined a framework for mass customization that involved modularizing subassemblies and classifying them as:

- "required subassemblies" (components to meet customer basic functional needs),
- "optional subassemblies" (frequently requested features and enhancements beyond basic functional needs), or
- engineered to order (infrequent needs).

The classification was based on the relative costs and design lead times of these assemblies (Figure 3), given the development team's perceptions of the importance of particular options to customers. These classifications were revised as the process unfolded.

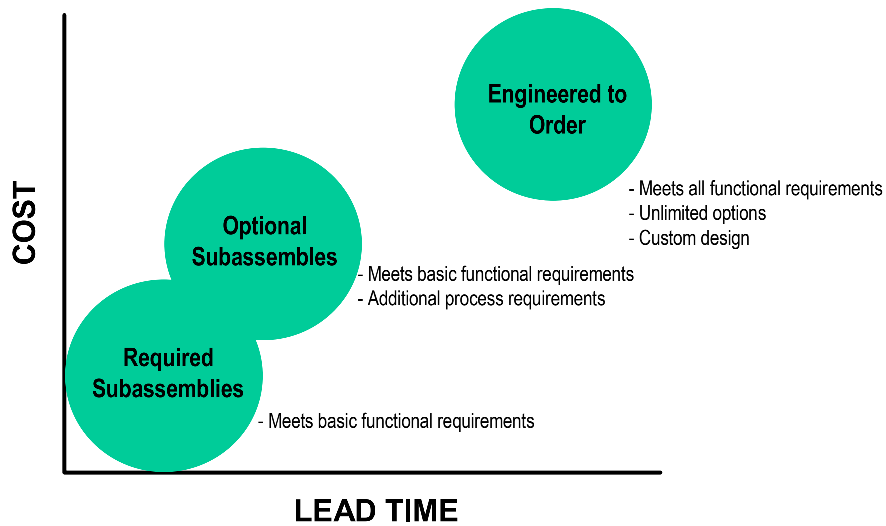

Figure 3. Modularization for Mass Customization Product Design

Detailed Design of Product Configurator. The detailed design process focused on the development of rules that defined unique products that were then incorporated into a knowledge-based product configurator. The configurator allows customers to select options from a pre-defined combination of product portfolios [Strom and Axworthy, 2000]. The configurator uses the rules prescribing acceptable combinations of parts to generate equipment specifications, CAD drawings, manufacturing instructions, bills of material, sales proposals and costs for acceptable alternative configurations. Early configurators such as that built by Digital Equipment Corporation for configuring minicomputers were custom developed and could not be maintained at a reasonable cost [Kalakota and Robinson, 2001]. Today, vendors such as Trilogy, Calico, and Catalyst offer configuration software solutions.

Air Products initially selected one of these commercially available rule-based product configuration tools. Incorporating design rules into the tool required an in-depth understanding of the product design. The number of rules was ultimately too large for the initial configuration tool to handle, so it was eventually replaced with another robust tool. Key applications were integrated with rule-logic to generate order entry, quotation, pricing, engineering drawings, manufacturing instructions, routings, etc. (Figure 4).

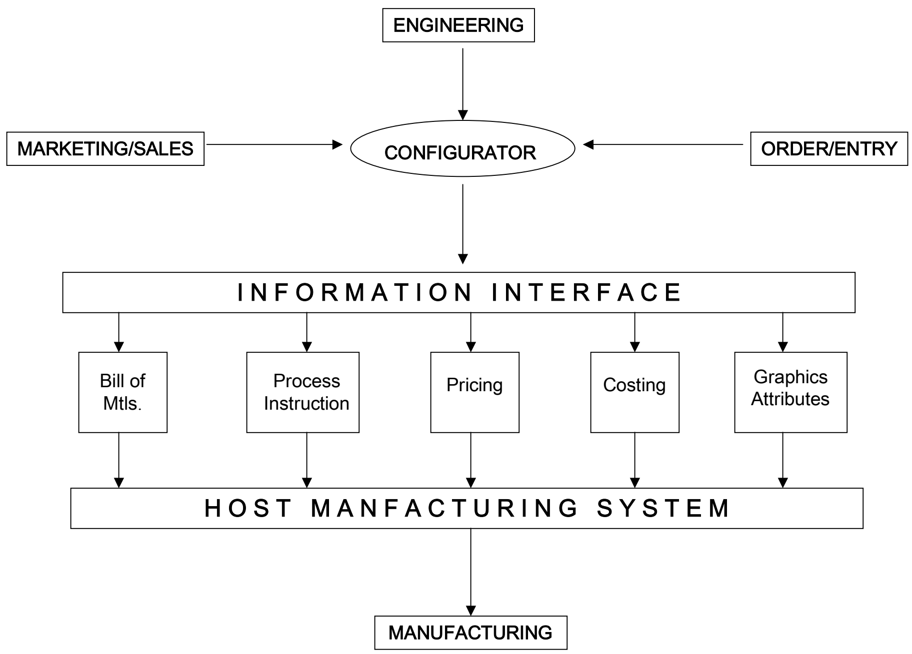

Figure 4. Product Configurator Output

Change Management. Extensive communication and training were necessary at all levels of the organization because the configurator changed the work processes for engineering, sales, and order entry departments. For example, the engineering organization shifted from a "project centric" to a "product centric" work process as shown in Figure 5. Instead of copying designs from recent projects and then modifying them, all designs were based on a common "master." Design changes were all routed through a cross-functional review team. While this methodology led to a reduction in unnecessary custom offerings and more control over design changes, it required designers to revise their work processes because the design approach changed fundamentally. In addition, it was particularly important to solicit input from field personnel before a formal rollout of the configuration tool across the organization. Sales and marketing personnel had to be trained to use the tool to develop configurations with customers.

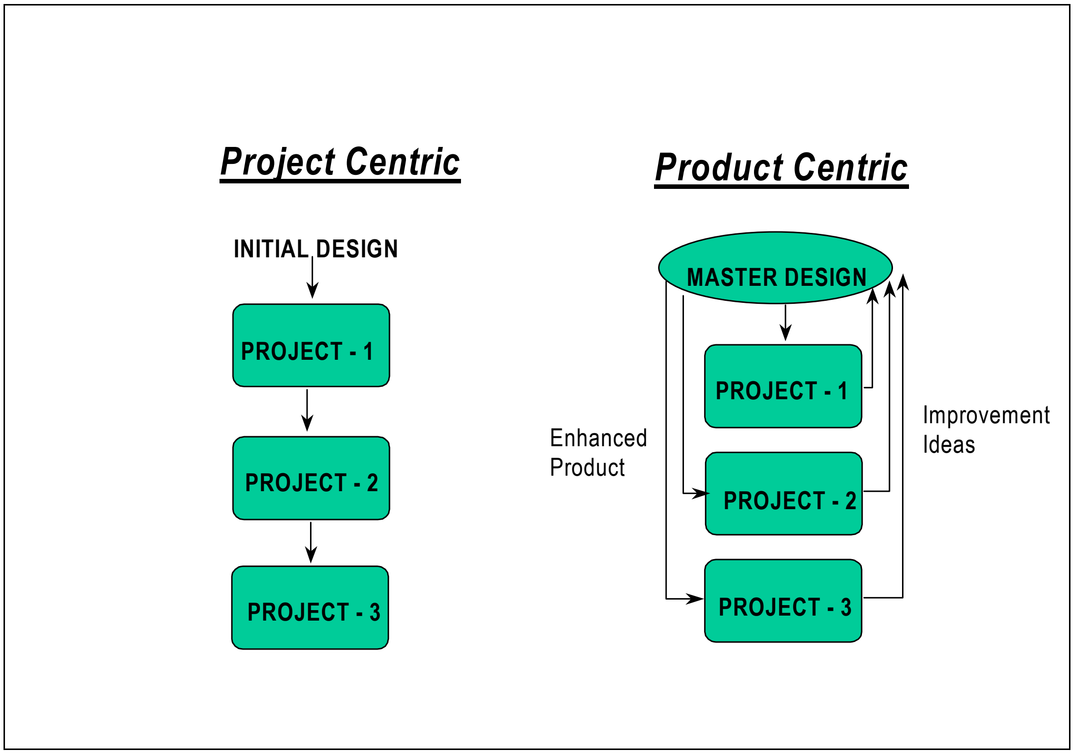

Figure 5. Project to Product Centric Work Process

Outcome. The project was highly successful and Air Products learned a great deal about the IT investment process. Not only was the value of mass customization demonstrated, but also the importance of a disciplined integrative process for investment planning and management was established, particularly if the concept was to be extended to a common platform for product standardization.

The project demonstrated the importance of clear communication at the onset of the vision and project plan throughout the organization. Roles and responsibilities were clearly defined. A core team (the development team) was established with well-defined objectives and milestones. A management steering team was also formed to provide guidance and direction to the core team.

While the core team was quite successful in reengineering the product using flexible and modular concepts of mass customization that subsequently led to product configuration, the trial and error approach resulted in several iterative cycles. For example, the original third-party product configuration tool was replaced once it was realized that the number of design and configuration rules exceeded the original estimate by 50%.

Some work process changes became evident only after implementation. Product development tools such as QFD and ABC were applied after system implementation and during the process of continuous improvement. The application of these tools at the early planning stages could have been even more beneficial. Some benefits were not even recognized upfront and therefore did not materialize until much later. For example, the modular mass customized design approach, enabled by the product configurator, had a profound impact on spare parts inventory, which was significantly reduced through consolidation of common parts. The good news of inventory reduction surfaced a year after implementation. It was only after performing an activity analysis that a 50% reduction of field location spares was reported as a potential savings opportunity for the company.

Post-Implementation. The activity analysis that led to the discovery of additional savings was a post-implementation exercise aimed at assessing the full impact of the project. The *storyboarding* ^{TM} methodology was used to perform activity analysis and capture the enterprise-wide impact of the changes [Turney 2001]. The method followed included the following steps:

1. Development of an organizational map. A cross-functional core team was used to identify the parts of the organization's value chain that were impacted by the IT project.
2. Activity analysis. A facilitator worked with the core team to identify specific activities that were affected. These activities ranged from material handling and inventory control to modifications made by technical service personnel in the field.
3. Quantification of benefits. The facilitator worked with the controller of the business unit and other key managers to gather data across the enterprise to develop estimates for the dollar value of savings that had been realized across the enterprise.

Sidebar 3

Storyboarding

Storyboarding is a simple process requiring input from knowledgeable individuals directly engaged in the work process. Typical duration of a storyboard session can vary depending on the magnitude and complexity of the work process and the required level of details penetrated. A storyboard session can range from a single ½ day session to several sessions. Most of the storyboard sessions at Air Products were accomplished in less than three sessions.

The results indicated that the savings from this project amounted to nearly $2 million. One conclusion was that additional savings would have been documented and realized sooner if the activity analysis had been performed before implementation and responsibility for cost reduction had been assigned to managers and groups across the value chain. Cost savings and performance enhancements could have been targeted earlier so that action plans and resources could have been assigned against each value proposition. It is safe to state that if these tools were applied early in the project, a number of key benefits, such as inventory reduction, could have been achieved in half the time.

Key lessons can be summarized as follows:

- Clear communication is critical to project direction.
- A core team and steering committees add value to the implementation process.
- Benefits may appear later and in unanticipated parts of the value chain.
- Early activity analysis helps bridge the responsibility gap.

III. CASE 2: "ONE COMPANY" CONFIGURATION FRAMEWORK

The rapid success of the GASGUARD product configurator attracted several product managers within the company toward a configuration-based business model.

Migrating the GASGUARD product configurator into other product applications was difficult because the configurator was specific to the GASGUARD product design and the associated work processes. It became quite evident that before a configurator design was executed, a fundamental analysis of the product design and the supporting work processes was essential. A few organizations within Air Products dealt with this challenge while others pursued a "quick fix." In less than two years, since the formal rollout of the GASGUARD configurator in 1998, more than a dozen product configurators evolved within the company, creating new work processes and subject matter/tool experts. Within a short time, resources and total funding needs for sustaining multiple product configurators approached the initial first-time development cost. This situation initiated the concept of a "one company" product configuration framework.

Air Products' diverse product portfolio was a challenge for the vision of a common configuration platform. The company builds everything from custom multimillion-dollar plants to small commodity products that may cost under $5,000. The variations and sheer numbers of configuration rules increase considerably as additional products and supporting work process rules are added to the configurator database.

To manage the development of a common platform, Air Products adopted a *stage-gate development process*, which divides development into sets of prescribed and concurrent activities involving cross-functional teams. The adoption of this design method suggested the need for developing a specific process and sequence for defining required capabilities of the configurator and identifying specific work processes affected so that responsibility could be assigned to ensure achievement of benefits. Our integrative process framework for planning an IT project, which evolved from lessons learned in Case 1 and was applied in Case 2, is summarized in Figure 6. This integrated process planning framework for realizing value is based on the application of three product development tools:

(1) strategic planning document, which, together with the vision statement helps define goals, establish the cross-functional team, and communicate priorities to all stakeholders of the project.

(2) quality function deployment, which prioritizes opportunities and capabilities by

determining the alignment with strategic priorities and the requirements of stakeholders. and

(3) activity analysis of the new work process against the old work process which helps identify gaps and activities that would be affected across the organization.

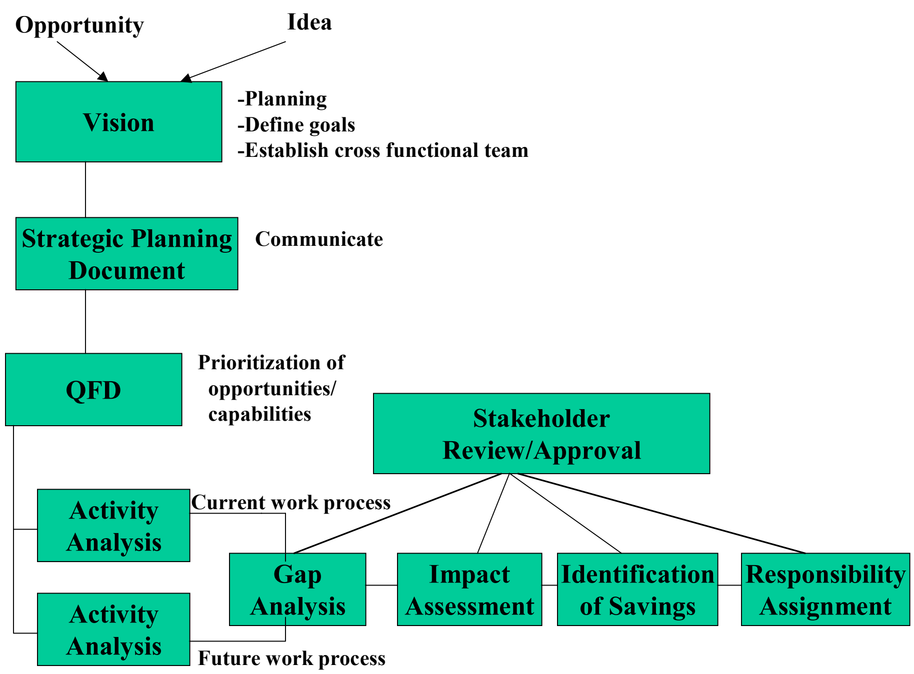

Figure 6. Integrated Process Framework

This framework enables assessment of the organization-wide impact of the project as well as identification of savings. It sets the stage for identifying managers who will be assigned the responsibility for eliminating activities and redeploying resources to realize the projected savings. The process is conducted in consultation with stakeholders so that their concerns are attended to and any overlooked implications of future work processes become visible.

STRATEGIC PLANNING DOCUMENT

The importance of a strategic planning document at the beginning of key development initiatives is well recognized at Air Products. A document template captured key strategies and was used to create a systematic plan for accomplishing necessary tasks. The planning document listed critical information including purpose, scope, team members, core objectives, gap statements, given conditions, communication strategies, and measures. Table 2 shows the gap statement of the “one company” configurator framework initiative.

Table 2. Gap Analysis for “One Company” Product Configuration Solution

From	To
Multiple product configuration approaches	Single product configuration approach
Multiple product configurator platforms	Fewer product configurator platforms
Technical expert making routine decisions	Product configurator making routine decisions
Change management process independent of configurator (lagging work process)	Enhanced change management process directly linked with configurator
Product documentation and deliverables manually managed (e.g., drawings, specs)	Product data/documentation managed electronically through configurator
Lack of discipline in making changes to product design; easy to make unnecessary, low value-added changes	Highly disciplined approach through configurator; changes planned and managed through a formal work process
Primarily document based knowledge management	Primarily data-based knowledge management
Large number of non-configurable system designs managed as independent discrete files (inflexible)	Fewer configurable system designs; highly flexible in managing options/features
Poorly defined business rules for offering options/features	Well-defined business rules for offering options/features
Slow process for options selection, estimating, and bidding	Highly responsive in retrieving product data associated with options/features
Low reuse of preengineered systems and product designs	High product reuse due to ease of retrieving product data
Inconsistent product information and knowledge across functions and organizations	Consistent product information transfer through configurator (single database) across functions and organizations

The strategic planning document, which is currently a standard template at Air Products, provided direction and a common language for the core team. This document served as the basis for communications, common understanding, and commitment between the development team and the stakeholders. It was also a medium for negotiating scope between the development team and the stakeholders.

QUALITY FUNCTIONAL DEPLOYMENT

Quality Function Deployment (QFD) is a visual planning tool that belongs to the TQM (Total Quality Management) technique. QFD involves understanding the needs of the users and then translating them into a set of design requirements. By using QFD, the development team is motivated to focus on its users and translate their requirements into final product specifications. The basic steps to the QFD process are:

1. Prioritize and rank the relative importance of customer attributes (horizontal view).
2. Apply *Organizational Features & Capabilities* (vertical view) against the customer attributes and rank the relative impact of each feature and capability.

While QFD originated in Japan in 1966 [Haag et al., 1996], it was not until the early 1980s that a few American companies adopted this technique. Today its application is widespread in product development and planning in companies such as Ford, Chrysler, Procter & Gamble, GE, Boeing, and Intel. QFD can also be used effectively as a planning and prioritization tool for identifying requirements for IT development [Haag et al., 1996].

Air Products applied the QFD technique across a broad range of products to identify customer requirements and the relative impact of product configuration capability against those requirements. A “Go” or “No Go” decision was made based on QFD results. QFD was performed for various market segments sorted by external and internal customers, all of which were used in prioritization and making design decisions. Figure 7 is an example of a simple QFD worksheet that lists typical customer attributes and the relative impact of internal capabilities, including product configuration.

Following the approval of the strategic planning document, the cross-functional development team developed an extensive list of customer attributes. For typical products the list ranged anywhere from 50 to 150 attributes. These attributes were then clustered into a number of major categories as represented by the left column of the example worksheet in Figure 7. The team used a standard QFD template to identify the relative importance of the various categories.

Quality Function Deployment Matrix

Product : XYZ
Date:
Core Team:

Product / Organization Features & Capabilities

Customer Attributes	ENGINEERING WORK PROCESS (I / C)	PRODUCT CONFIGURATION (I / C)	PROCUREMENT (I / C)	NEW SALES CHANNELS (I / C)	START UP SUPPORT (I / C)	NEW TECHNOLOGY (I / C)	(a) Customer Need	(b) Our Current Rating	(c) Competitor Rating	(d) Goal	(e) Improve Ratio =(d)/(b)	(f) Sales Point	(g) Raw Weight =(a)*(e)*(f)	(h) Normalized Raw Weight =(g)/Σ(g)
MARKET ANALYSIS & BUSINESS PLAN	3 / 36	1 / 12	1 / 12	3 / 36	0 / 0	0 / 0	5	2	2	4	2.00	1.2	12.00	33.3%
LOW COST OFFERING	3 / 30	3 / 30	3 / 30	3 / 30	1 / 10	3 / 30	4	3	3	5	1.67	1.5	10.00	27.8%
FLEXIBLE OFFERING	3 / 19	3 / 19	3 / 19	3 / 19	0 / 0	1 / 6	4	3	3	4	1.33	1.2	6.40	17.8%
EH&S EXCELLENCE	1 / 6.3	3 / 19	0 / 0	0 / 0	3 / 19	1 / 6	5	4	3	5	1.25	1	6.25	17.4%
SPEED	1 / 5	5 / 27	1 / 5	3 / 16	1 / 5	1 / 5	4	3	3	4	1.33	1	5.33	14.8%
QUALITY	1 / 4	3 / 12	1 / 4	1 / 4	3 / 12	1 / 4	4	4	3	4	1.00	1	4.00	11.1%
RELIABILITY & OPERABILITY	1 / 4	3 / 12	1 / 4	1 / 4	3 / 12	1 / 4	4	4	3	4	1.00	1	4.00	11.1%
Contribution	**69**	**119**	**63**	**73**	**58**	**56**	1-5, with 5 being highest need	1-5, with 5 being best performance	1-5, with 5 being best performance	1-5, with 5 being best performance			**35.98**	

Sales Point – If we met our goal, would sales increase? (Use 1, 1.2 or 1.5, with 1 being no, 1.5 significantly)
I = Impact (0 = no impact, 1 = possible impact, 3 = moderate impact, 5 = high impact)
C = Correlation = Impact * Raw Weight

Figure 7. Example of a QFD Worksheet

QFD is a qualitative approach in identifying gaps and improvement opportunities in the work process. It also provides a common direction and focus for the cross-functional development team. Its application can be quite versatile. In Figure 7, a product was evaluated and the relative impacts of various capabilities were analyzed. QFD was similarly applied in the analysis of work process at various levels of detail. While maintaining the fixed customer attributes (left column), each capability (top row) was individually expanded into its elements and evaluated against each other for impact. This exercise provided detailed data of the product and associated work processes, useful in making trade-off decisions. It helped prioritize development efforts.

In general, most product configurators offer an extensive list of capabilities such as enabling sales order entry, knowledge management and collaboration, design specification, and change management. The QFD exercise identified that not all products require every configurator capability. Factors such as product magnitude and complexity, order frequency, and market turbulence were key drivers in the selection of configurator capability and automation. Through QFD, configurator capabilities were ranked based on their impact on meeting customer requirements.

ACTIVITY ANALYSIS

ABC is a method of measuring the cost and performance of activities and cost objects [Turney, 1993]. ABC assigns cost to activities based on their use of resources and assigns cost to cost objects based on their use of activities. The ABC data can be used effectively for cost driver analysis, activity analysis, and performance analysis. By using the principles of ABC, the true value of any development initiative can be evaluated accurately. QFD, described above, provides a general direction in terms of gaps and improvement opportunities in the work process. ABC can supplement QFD results by identifying the relative benefits and impact across the entire value chain and focus the analysis on the area of maximum reward. ABC paints a clear picture of the future work process and serves as the basis for establishing post-success measures. While QFD helps prioritize IT investment projects, ABC serves as the basis for estimating the value of these investments, complementing QFD for project justification, and enabling management of these investments to ensure that benefits are achieved.

By applying "*storyboarding*[TM]*,*" a technique within ABC, key dimensions of the work process performance data, including activities, resources, costs, cost drivers, and performance data, were collected.

ABC analysis can help guide appropriate project selection. The *storyboarding* process helped identify the activities impacted by the introduction of a product configurator. In this case, along with work process consolidation, it actually introduced ideas for new work processes that could enable flexibility in product configuration. Air Products initially focused on introducing a product configuration tool for an entire facility. However, after the *storyboarding* process, it was recognized that there would be greater benefits if designs were modularized into individual subsystems so that mass customization and product configuration could be implemented at the subsystem level.

ABC analysis identifies specific activities that can be improved with the introduction of the new system. Figure 8 shows the impact of product configuration on the activities involved in the development of control system software used in large capital plants. Resource requirements for each activity were compared for a traditional custom design project with a mass customized product-based project having similar scope. The product-based approach provided more flexibility through the application of modular design. Design solutions were preengineered and easily configured with a product configurator. As shown in Figure 8, the custom design consumed approximately three times the labor or "touch time" to deliver a software solution compared to a work process using the product configurator.

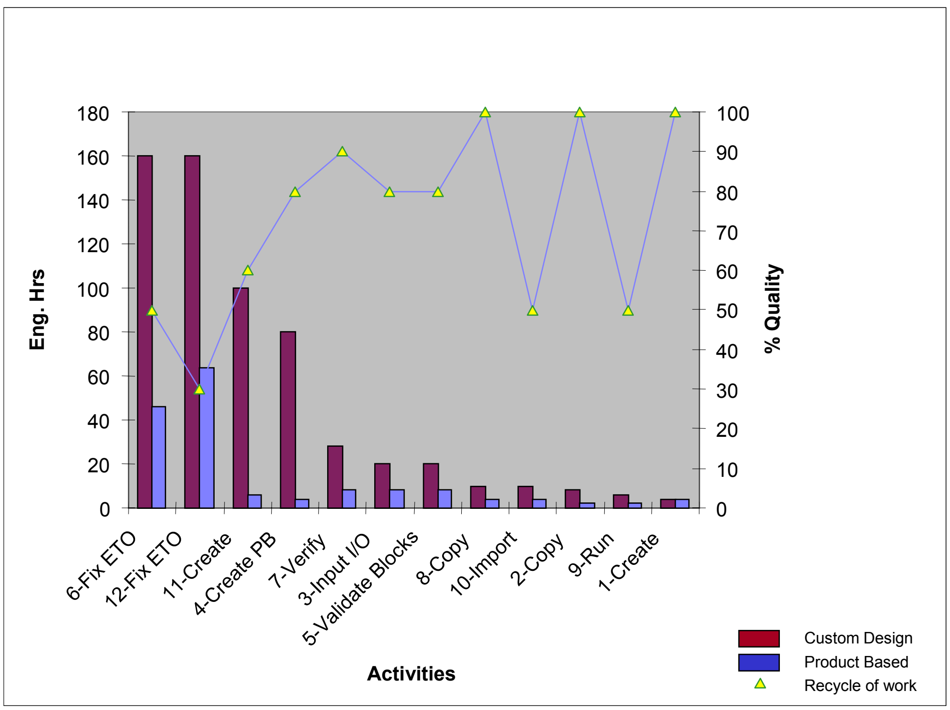

Figure 8. ABC Analysis of a Work Process With and Without Configuration Capability

Figure 8 also shows specific activities that would be affected by the introduction of the product configurator. This analysis provides valuable data for continuous improvement of the work processes. It also clearly identifies activities that must be consolidated or changed to achieve the full benefit from the investment in product configuration. This information was used to assign responsibility clearly with appropriate milestones, performance measures, and scorecards.

The performance data collected through the *storyboarding* exercise indicated cost drivers and the related gaps and improvement opportunities within work processes as shown by the line representing quality in Figure 8. A lower quality number for a particular work activity signifies a higher recycle of work. For example, 100% quality (activities 8, 2, 1) would indicate zero recycle, i.e., tasks are completed the first time. Activities 6, 11, and 12 in this example show the biggest gaps and maximum opportunity for improvement. Although activities 9 and 10 identified a 50% quality improvement opportunity, the overall process impact from such improvements would be marginal based on the relative resource (engineering hours) demands of the current work process. The *storyboard* exercise provided a multidimensional performance view of the work process so that design decisions could be aligned with work process efficiency. It served as the basis for prioritizing activities that were likely candidates for automation and configuration.

Implementation and rollout of the “one company” initiative is still in the early stages at Air Products. However, the anticipated results are quite impressive. The estimated direct cost savings ranged from 20 to 30%. These figures did not take into account the softer (indirect) savings such as those realized from inventory reduction. According to one manager, including the indirect savings would raise the cost reduction to almost 40% in some cases. As shown in Table 3 in Section IV, results for Case 2 can vary by product lines based on the maturity of the product and the responsibility assigned by the product owners.

Case 2 illustrates the organizational learning that resulted from Case 1. The lessons from Case 2 may be summarized as follows:

- Strategic planning is critical to establishing priorities and setting up effective communications.
- Cross-functional teams provide accountability for changes that impact the entire value chain.
- Activity analysis provides insights into impact of project across the value chain.

- Innovative methods such as QFD help prioritize development and implementation.
- Assigning responsibility is critical to realizing value.

IV. COMPARISON OF INITIATIVES

This paper described two successful IT initiatives at Air Products. The initiatives had different objectives, work process alignment goals, implementation strategy, and overall results. Table 3 summarizes the two initiatives.

Table 3. Comparison of IT Initiatives at Air Products

	GASGUARD™ PRODUCT CONFIGURATOR (Case 1)	"ONE COMPANY" CONFIGURATION FRAMEWORK (Case 2)
Goal	Quick return on investment	Improve competitiveness
Configurator Application	Specific product	All products and applications
Level of urgency	High	Moderate
Impact of initiative	Limited to a specific business area	Benefits realized company-wide
Use of best practice	Limited; established best practice basis for the company	Extensive
Investment process	Reactive	Proactive
Approach	Trial and error	Disciplined
Strategic document	Internal vision statement	Widely distributed
Use of QFD	Limited to continuous improvement stage	Applied before investment
Application of activity analysis	After implementation to determine additional benefits	Before implementation to assign responsibility for benefits achievement
Results	Visible; easily measured	Vary by product lines based on responsibility assigned by product owners

While Case 1 was highly successful in demonstrating the benefits of product configuration for a single product line, it was recognized that a more ambitious project involving a "one company" configuration framework (Case 2) required a much more disciplined process and framework for investment prioritization, justification, and management. Due to urgent business needs, the GASGUARD implementation strategy was reactive.

The subsequent initiative, "one company" configuration framework, was proactive in the sense that it was aligned with company IT strategy for a common IT platform. The formal strategic plan communicated throughout the organization at the beginning of the "one company" configuration project was much more effective in establishing a common language for the effort compared to the informal internal (departmental) vision statement that initiated the GASGUARD™ project. As tools such as QFD and ABC were applied during continuous improvement of the GASGUARD configurator, it became clear that their application at the front end of a project would be highly beneficial. From the two case studies it was apparent that a formal QFD at the beginning of an IT initiative results in fewer repetitious efforts. Without QFD, the trial and error approach used in Case 1 (Section II) resulted in several different modular design and product configuration engines. The ABC analysis shows all cost and performance data of a product and associated work process. When ABC was applied during the later stages of this first project, additional benefits were recognized. The importance of using tools such as QFD and ABC early in the planning process was quite evident.

V. RECOMMENDED APPROACH

This section presents the broad set of recommended activities that we prescribe for value realization from IT projects based upon the lessons learned from these two cases. These activities were considered central to the two IT projects implemented at Air Products and Chemicals, Inc. While Cases 1 and 2 (Sections II and III) contain specific lessons, these recommendations are considered universal.

STRATEGIC PLANNING DOCUMENT

A strategic planning document, widely distributed at the onset of an IT initiative, captures and clearly communicates the IT vision and the project plan to all stakeholders. It includes:

- the purpose and scope of the initiative,
- core objectives,
- team members' roles and responsibilities,
- a gap statement clearly comparing the organization before and after IT implementation,
- conditions (resources, budget),
- communication strategy (to leadership, stakeholders, core team), and
- measures (scorecards) to evaluate the success of the initiative after implementation.

The planning document ensures alignment with business strategy, helps build consensus, and provides direction for the development team.

QUALITY FUNCTIONAL DEPLOYMENT (QFD)

Often referred to as "Voice of the Customer." QFD is a quality management tool that systematically translates subjective customer wants and needs into objective design specifications and features. It sorts through a large number of user attributes/requirements and prioritizes them in accordance with company strategy, available resources, and capabilities. QFD may be used by companies to ensure that IT projects are driven by customer's functional requirements and organizational capabilities are identified and aligned with customer requirements [Haag et al., 1996].

ACTIVITY ANALYSIS

The principles of Activity-Based Costing (ABC) provide a foundation for quantifying the true value of an IT investment. ABC-based value realization motivates development teams to drive faster implementation. The systematic approach of ABC establishes a real-time link between the cost-benefits vision of an IT investment and the work process activities that will be affected, enabling focused management of IT projects. ABC also serves as the basis for post-success measures [Carlson and Young, 1993, Turney, 1993].

RESPONSIBILITY ASSIGNMENT

Specific activities that will be affected by the introduction of information technology are identified through the activity analysis. This analysis enables responsibility assignment to ensure that the projected benefits are realized. In IT projects that impact activities across the value chain, there can be a "responsibility gap" between those who justify the project and those who must ensure that benefits are achieved.

VI. THE ADVANTAGES OF AN INTEGRATED PROCESS FRAMEWORK

Based upon our review of the literature, the process framework presented in Section V integrates ideas from research on strategic alignment of IT and business strategy [Henderson and Venkatraman, 1999], cost management methods [Greenwood and Reeve, 1992; Turney, 1993], reengineering studies [Shank and Govindarajan, 1992], quality management and activity-based concepts [Moravec and Yoemans, 1992], and product design. It focuses on the process of assessing and achieving proposed benefits rather than just measuring benefits. It focuses on activities across the value chain critical to effective cost management [Turney, 1993], recognizing the need to manage resources to realize cost/quality/time improvements by using knowledge of specific activities that must be targeted.

Most benefits resulting from IT implementation occur only when decision makers use the information appropriately to induce changes in work activities. IT alone does not create benefits; it is the management process that uses IT to create benefits [Brynjolfsson and Hitt, 1998 Keen, 1991]. Activity-based management (ABM) [Turney, 1993] prescribes that non-value-added activities which form parts of a process be combined or eliminated. It is only when resources are taken out of the system or put to value-adding use that cost savings can be realized. If resources are not redeployed from one function or business to another, cost savings and other benefits remain elusive. When the impact of IT initiatives on work processes is not evaluated before implementation, these activities may not be changed in a timely manner. Resources that IT may replace may not be removed or redeployed, thereby understating the payoff.

Successful results are the joint responsibility of many different managers spanning organizational boundaries, complicating the assignment of responsibility for ensuring that all benefits are achieved. If specific responsibility for achieving proposed benefits is not assigned to individuals with authority to reorganize and restructure to exploit these investments, the projected benefits will not occur. These factors all contribute to potentially widening the responsibility gap between the justification of IT investment and the realization of its benefits.

IT sometimes runs the risk of emphasizing a new tool or technology without fully exploring its application in the organization. The second initiative at Air Products began with a focus on the product configurator tool, but it was recognized that the bulk of the upfront work needed to be dedicated towards understanding the current and future work process. If the practical work process is envisioned and then communicated to gain project impetus, the IT tool challenge becomes simple and linear. When work process changes are recognized early in the process, responsibility for achieving benefits is clear.

The approach to IT investment taken at Air Products focuses on activities that must change. It not only ensures that responsibility is assigned but also identifies specific activities that will be changed. The approach highlights the following procedures that can be used to ensure successful investments in IT:

- Identifying enterprise-wide impacts.
- Setting well-articulated and quantifiable goals.
- Identifying and assigning responsibility for action steps related to specific process activities.
- Ensuring that such action steps are aligned with strategic intent.
- Conducting comprehensive evaluations (audits) to measure progress.
- Redeploying labor and equipment resources to take costs out of the system.

The strategic planning document establishes and communicates the goals. The use of QFD ensures that plans are consistent with providing customer value. ABC accounting helps identify enterprise wide impacts as well as identify and assign responsibility for realizing value. It provides the basis for continuous improvement and redeployment. Although these tools are relatively new at Air Products, their benefits are gaining wide publicity within the company. Today the company's formal stage-gate product development work process recognizes the application of these tools as standard deliverables so that they are applied during new initiatives at the front-end planning stages. The overall performance of product development, through the use of these tools, is also measured quarterly and scorecards are widely communicated across the company.

VII. CONCLUSIONS

The two cases described in the paper contain important implications for senior IS executives.

- CIOs can and should play a proactive role in IT project prioritization and take steps to bridge the responsibility gap so that the projected results are realized.
- They can use tools like QFD to ensure strategic alignment and use activity analysis to identify elements of the work process that need to be changed.
- CIOs can then work with a steering committee to assign responsibility to managers for making process changes and taking costs out of the system.
- Finally, CIOs can help design a process that will not only assign enterprise wide responsibility but also track progress and provide reports to management.

This expanded role requires that CIOs gain knowledge of business processes in their corporation and be an active partner with management for realizing value from IT projects.

A disciplined approach to the planning and management of IT investments can help organizations realize value from information technology investments that require reengineering work processes across the value chain. Changes introduced with information technology, such as the mass customization effort at Air Products, demand that organizations be creative, adaptive, and responsive to change. Many IT investments require changes to activities across the entire value chain of an organization. Cross-functional networks can work together with joint responsibility for value realization. The urgency of the effort should be clearly communicated so that organizations can react quickly. IT efforts should focus on customer value. A fundamental understanding and alignment of the information technology and organizational work processes are necessary. It is recommended that an organization foster continuous improvement through ongoing realignment of its product, services, and capabilities. Effective management of the investment can foster value realization.

Our paper introduced an integrated "process framework" that others can use to evaluate and achieve full benefits from IT investments. We demonstrated the importance of identifying, collecting, and evaluating appropriate information relevant to the IT investment's impact on external customers, internal stakeholders, and work processes. We introduced techniques to evaluate customer requirements. Organizational factors related to the IT investment were considered, with processes to identify gaps, success measures, and opportunities for benefits that cross functional boundaries. Cross-functional teams help to close the responsibility gap.

Most large organizations today must establish priorities among competing IT projects. Our framework highlights the importance of a strategic view and the discipline and structure essential for spearheading a successful IT initiative. Effective planning and successful completion of the IT initiative is often insufficient to ensure implementation success. A clear alignment of IT tools with the practical aspects of the work processes is essential. Ownership of the IT tool should be delegated to appropriate line managers so that work process changes are captured proactively and IT capability gaps are minimized.

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APPENDIX. TIMELINE OF EVENTS

Decision to implement mass customization for Gasguard	1/1995
Case 1 vision statement	3/1995
Product design framework for case 1	6/1995 -6/1996
Detailed design of Gasguard configurator	3/1996-12/1996
Replacement of third party configuration tool	6/1998
Formal rollout of Gasguard configurator	1/1999
Application of QFD and ABC in Case 1	11/1999
Development of more than one dozen product configurators	1997-2001
Second initiative begins	3/2000
Application of QFD in Case 2	5/2001
Application of ABC in Case 2	7/2001
Completion of Case 2	11/2001

GLOSSARY OF TERMS

Activity analysis: analysis of key activities that form parts of a process or value chain. It includes estimation of cost, quality and cycle time parameters and may be used to estimate the impact of elimination or reduction of activities resulting from improvement initiatives and/or information technology investments.

ABC (Activity Based Costing): a methodology that measures the cost and performance of activities, resources, and cost objects. Resources are assigned to activities, then activities are assigned to cost objects based on their use. ABC recognizes the causal relationships of cost drivers to activities [Norm and Turney, 1991].

ABM (Activity Based Management): a discipline that focuses on the management of activities as the route to improving value received by the customer and the profit achieved by providing this value. This discipline includes cost driver analysis, activity analysis, and performance measurement. ABM draws on ABC as its major source of information [Norm and Turney, 1991].

Cost drivers: any factors that cause a change in the cost of an activity. For example, the quality of parts received by an activity (e.g., the percent that are defective) is a determining factor in the work required by that activity because the quality of the parts received affects the resources required to perform the activity [Norm and Turney, 1991].

Mass customization: ability to mass produce customized products.

Product centric: a reactive approach to meeting customer needs in which engineering and detailed design functions are performed after a customer order is placed.

Product configurator: a system that generates complex product options according to pre-determined rules.

Project centric: a proactive approach to meeting customer and market needs in which engineering and conceptual design functions are performed prior to receiving customer orders.

QFD (quality function deployment): a visual decision-making tool that identifies and prioritizes customer needs to help develop a common understanding of the voice of the customer and a consensus on the final engineering specifications of the product that has the commitment of the entire development team.

Stage-gate development: a disciplined approach to product development that divides the process into sets of prescribed and concurrent activities involving cross-functional teams.

Scorecards: create, validate and use financial and non-financial outcome measures drawn from different parts of the value chain to evaluate performance or outcomes of investments and other decisions.

Storyboarding: a methodology to obtain a department's activity information which migrated to ABC from quality management although its roots go back further to Leonardo DaVinci, Walt Disney, and others [Turney, 1993), p. 246].

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