Empirical exploration for a product data management (PDA) system at a major telecommunications firm

Alan D. Smith

The author

Alan D. Smith is Professor of Operations Management, Department of Marketing and Management, Robert Morris University, Pittsburgh, Pennsylvania, USA.

Keywords

Manufacturing systems, New products, Project management, Manufacturing resource planning, Data handling

Abstract

Product data management (PDM) is an essential tool that assists engineers and others manage both engineering data and the product development process. This study aims to evaluate the advantages and justify the implementation a PDM system at the broadband wireless group (BWG) of a major telecommunications firm located in Pittsburgh, PA. Examines results of previous PDM implementations and obtains primary data via a department staff survey regarding time spent searching for product or part information, product development cycle time, and information exchange or sharing. Illustrates that PDM implementations have led to significant improvement in all facets of product design, documentation, introduction, manufacturing, and support. These improvements will result in an increase in design reuse and a decrease in product development costs and the number of engineering changes.

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The manufacturing environment associated with ERP systems

Manufacturing strategy and broadband wireless group (BWG) management situation

As suggested by Bentley (1998), DeMeis (1998), and Santarini (2002), organizations' networks begin with data servers; middleware servers can query them for information and deliver it to desktop workstations. Companies that wish to transform their operating systems and associated environment should plan the following developmental steps: enhancing the Web's capability for project management; strengthen the engineering back office; introducing Java; provide for project data management; component modeling; and life-cycle integration (Bentley, 1998). Hence, "Integrated environments allow fast component design maturation" (DeMeis, 1998, p. 45). A major step towards transforming engineering and/or technical information from a departmental document into a corporate project requires storing project information in an indexed database with serve-level software that controls data access. Hence, as stated by Bentley (1998), computer files in use today seem essential, but they have some severe drawbacks. Some of these drawbacks include file management systems that cannot interpret file formats and detect internal references to external information. This situation makes it very difficult to synchronize file-based information with other corporate databases, especially as projects become larger and more complex in scope. In addition, file names and their control for connectivity are frequently erased or changed easily, but the link from other files may not be so easily changed and/or erased. "As firms move ahead, though, they can stop using files for long-term storage altogether, in favor of a commercial database" (Bentley, 1998, p. 60). Oracle, People Soft, and Microsoft currently have a number of programs on the market that act as an information technology broker for a database server.

As suggested by Lisbeth and Allwood (2002), managerial attitudes towards information and communications are extremely important to their success in the manufacturing or related environments. Lisbeth and Allwood reported on a field study of information and communication technology and its relationships to managerial strategic decision-making processes among CEOs in large organizations/enterprises. They found that processes such as integrating, sharing, accessing and accumulating knowledge are important and infrastructures are needed to facilitate this data sharing across functions and divisions. This support would, in turn, support cross-functional

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decision making. The ultimate goals of PDM systems are very compatible with eliminating as much as possible the problems associated with barriers to accessibility of information on various levels of organizations often need to be addressed.

With these concepts of increased communication and data sharing across various levels of organizations, the basic purpose of the present study is to provide the information necessary for the BWG management to evaluate the benefits and cost associated with a PDM (product data management) system implementation within a major telecommunications firm, in Pittsburgh, Pennsylvania, USA. With the ever-increasing demand to design, release, and manufacture products in shorter time frames, PDM systems have been very successful in reducing the time-to-market and the associated costs with product development. As suggested by Porter that "superior operational effectiveness can be a source of short-run competitive advantage; in the long it's nowhere near sufficient" (Surowiecki, 1999, p. 136). Based on a number of research efforts (Porter, 1985, 1991, 1996, 1998, 1999, 2001) manufacturing companies need to position themselves differently than their competitors to obtain sustainable competitive advantage; otherwise, companies just become more alike. Companies need to realize that strategy is choosing to run a different race than the competitors; otherwise, they are in the same race with everyone else where the odds stack up against them. Surowiecki (1999, p. 136) discusses the difficulty management has had with strategy, "much of what has passed for management thinking in the past decade may have been important, but it wasn't strategy-and isn't nearly as crucial as good strategy". One of the points made by Porter (1996) was that a company defying odds and running a different race is using strategy to obtain a sustainable competitive advantage. Companies that are thinking strategically and investing in human capital, an intangible strategic asset because of its imitable nature, are ultimately defying odds.

In addition, one of Porter's (2001) newly described phenomenon, clusters, is a strategic move. Clusters are regions where competitors congregate and are quickly surrounded by end product or service companies, suppliers of specialized inputs, components, machinery, financial institutions, or firm related industries (Surowiecki, 1999, p. 138). In essence, what Porter (1996, 1998, 1999, 2001) is conveying is that location and proximity to your competitions will outweigh the costs. Since new manufacturing technologies can be diffused more easily, it is easier to pick up new trends, the arrival of parts will make it easier to improve the value chain, and qualified people will gravitate to the cluster. However, there is mush debate over Porter's statement, "the arrival of the Internet will affect every industry in some way, but for 50 percent or more of the economy it's not a transformational event" (Surowiecki, 1999, p. 137). Many business practitioners probably agree that the Internet does have an impact and continue to have a significant impact on society. The author of this research effort does disagree with Porter's assessment that technology does not lead companies to have strategic advantages over others. For example, Britannia, a company who did not adapt to the changes in technology is struggling immensely, and it does not matter if they are thinking strategically or not because they are all already out of the race by not having the necessary strategic foresight to adapt to changes until after the fact (Evans and Wurster, 1997).

Hansen *et al.* (1999) discussed how some companies use computers to disseminate knowledge to employees, while others use people to share the knowledge through a face-to-face procedure. The authors examined several different industries that use management knowledge. They focused on companies such as management consulting firms, health care providers, and computer companies and discuss how there are two different types of strategies that they use: codification and personalization. Codification refers to codifying and storing knowledge in computer databases for easy access by anyone in the organization, whereas personalization refers to person-to-person transmission of knowledge, using computers strictly as tools to communicate the knowledge, but not as the sole provider. Deciding which strategy to use depends on the business itself, the clients that are being served, and the employees that are in the firm. Not only is determining which strategy to use critical, but attempting to use both successfully or choosing the incorrect approach can be detrimental. Furthermore, the effective and successful firms excel by focusing on one of the strategies and using the other as a supporting role.

Hansen *et al.* (1999) founded that this "reuse of knowledge" ideology saves communication costs, additional work, and time creating an extraordinary advantage for specific businesses. Organizations that deal with similar problems on a regular basis would benefit from a codification strategy, since it uses existing information stored in databases to help undertake clients' needs easily and quickly. On the other hand, personalization takes a person-to-person approach where colleagues need to expand their understanding of specific issues. Hence, when organizations deal

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with highly customized solutions to unique problems, they will need to use a personalization strategy in order to be successful. In the process of developing a unique growth strategy, project teams need to tap into a worldwide network of colleagues' experiences, thus using the personalization approach in order to be successful. When information is too rich to incorporate into a written document, the personalization strategy is the best approach. However, due to the leveraging of the Internet, electronic product development activities result in superior interpretation of customer requirements. As suggested by Yang and Yu (2002), electronic product development has the feature of understanding and translating of customer -requirements to allow involved customers (ultimately the sources of articulated needs, as well as developers and/or suppliers of ideas that meet these needs), through very personalized strategy.

Thus, successful companies need to pursue one strategy predominately and use the second strategy as a supporting role. This is very similar to Porter's (1996) and his topic of trade-offs. As Porter stated and the Hansen *et al.* (1999) are suggesting, a company needs to make the choice and purposefully limit the other strategy. To further support this notion, "management consultant firms had run into serious trouble when they failed to stick with one approach" (Hansen *et al.*, 1999, p. 112). However, companies that adhere too tightly to one practice often lead to missed opportunities by management, especially when the task at hand falls outside of the normal realm of the organization's standard operations. That is why the notion of 80-20, where 80 percent of their knowledge strategy follows one strategy and 20 percent is of the other is important. In the case of BWG, information management strategy should be highly integrated into its manufacturing strategy as well for mutual benefit.

Historically, BWG has utilized a manual system to track product development activities and product documentation. This process was originally comprised of hardcopies of all documentation and a process that required tremendous amount of administrative attention. Over the years, BWG has adopted a few electronic processes, especially with the recent implementation of a management resource planning (MRPII) and enterprise resource planning (ERP) (SAP) system. However, as the marketplace demands new products more quickly, BWG was forced to continuously revisit all development processes and evaluate more efficient methods, tools, and processes. PDM is a system intended to provide the competitive edge that BWG requires in today's marketplace.

Research objectives associated with this Pittsburgh-based telecommunications firm

The purpose of this research is to evaluate the advantages and develop justification for implementing a PDM system at the BWG of this Pittsburgh-based telecommunications. Since a PDM system is a substantial investment on part of this and any organization, careful review of the realized benefits from other PDM implementations, along with a calculated return on investment, are essential to aid the decision process. Review of this research problem led to the following research objectives:

- analyze expected reduction of time-to-market for new products, including product development cycle time and product introduction time;
- develop an understanding of anticipated reduction of product development cost;
- estimate reduction of engineering changes and engineering change handling time;
- determine reduction of time related to engineering information searches and other non-value added activities; and
- establish a baseline regarding the engineering staff's perceived efficiency of current development processes and information exchange.

Based on exploratory research and the author's involvement with other firm's divisional efforts, it is proposed that a PDM system could substantially reduce product development and engineering-change cycle times, quantity of engineering changes, and the amount of time consumed by non-value added tasks. Additionally, it was proposed that these reductions would subsequently result in decreased product development costs and quantity of engineering changes. Finally, it was proposed that the current manual processes at this Pittsburgh-based telecommunications firm are contributing to development cycle inefficiencies and ineffective information exchange and sharing.

The need for PDM implementations in modern manufacturing environments

There have been multiple published reviews and case studies outlining the results of previous PDM implementations at other organizations. This research examined a variety of publications relating to PDM system performance, realized benefits, and system justification. CIMdata is an international consultancy focused on product data management and CAD/CAM technology. CIMdata was one of the earliest companies to recognize the potential of PDM technology and helps organizations identify business requirements and developing justifications for PDM solutions.

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According to CIMdata (1998), there are many compelling reasons to implement a PDM system, however, the overriding objective is to increase the profitability of the organization and to serve the business needs of all departments.

From a business performance perspective, CIMdata research has shown that PDM systems enable company flexibility and improved management. PDM makes possible a faster response to business and customer needs by providing access to electronic data of all types; the possibility to reclassify data quickly, or change programmed business rules and processes. This permits a company to respond more quickly to new opportunities and new markets. Additionally, effective management depends on rapid access to complete and accurate information. PDM ensures that all users (end users and managers) are accessing the correct information when needed and also help the company to run more proactively. Project and product information, processes, schedules, and the related statuses may easily be tracked electronically and automatically.

PDM also speeds the business cycle by reducing the time consumed on searching and retrieving data. With PDM, data arrives electronically across a network to the required people at the appropriate times. There is no need to wait for copying, mail systems, or the possibility that a document is in the possession of someone who is on vacation. PDM maintains the relationships that exist among data objects, the status of data, and the appropriate work flows. An increase in speed of the business cycle helps the company complete more work and gain more revenues in the same elapsed time. Time-to-market is of vital concern to companies that are manufacturers of rapidly changing products, such as the communications equipment developed by this Pittsburgh-based telecommunications firm. PDM systems decrease the time-to-market by enabling quicker bidding, product development, product introduction, and ultimately extending production runs (McMurtrey *et al.*, 2000). As stated by Motwani and Mohamed (2002), economic efficiencies gained through the implementation of flow type manufacturing exist because direct costs for raw materials and utilities are only incurred when finished products are sold through a pull demand arrangement. These flow characteristics are applicable to PDM systems integration techniques. Outdated linear production process, where unfinished products spent non-value steps being transported between different work stages or stations, should be minimized under proper manufacturing management systems.

Even beyond a business performance perspective, PDM also benefits the organization as a whole. To start, PDM improves corporate communications by eventually performing as a data management infrastructure for the whole company. PDM should not be compared to a network or e-mail, which only provide pathways for data to flow from point to point. PDM also manages the data flows and processes. It assists people anywhere on a network to find data and transport it to where it is needed. A PDM system may automatically translate formats if required, launch associated applications, supply the correct revisions, perform checkout functions, and record all transactions. It may significantly bring departments or other divisions closer together to work more effectively. Since the system may record all transactions, it also is efficient at supporting quality management and ISO 9002 audits. PDM is an infrastructure that manages processes, approvals, releases, and document distribution, access, and archival. This functionality ensures that an appropriate audit trail is maintained and supports regular ISO audits and other industry regulations.

Over time, a PDM system also builds corporate knowledge that is readily accessible by the employee staff. High quality data, information, and knowledge are the main resources that employees need to make quick and effective decisions. PDM provides efficient access to a valuable and extensive pool of corporate knowledge. This access also permits the true sharing data across an organization, which is required for effective concurrent engineering. It provides the data communications and process management framework for multi-discipline and multi-divisional teams needed to develop and deploy today's products.

Additionally, PDM encourages re-use of parts and designs by providing excellent visibility of designs from previous projects and the confidence that they may be re-used again with much less rechecking. To support this re-use, PDM systems provide powerful search mechanisms utilizing object attributes, properties, and relationships. Also, many systems provide full text retrieval, based on the textual content of electronic files. Another power option includes product structure navigation by following component relationships. Most systems today utilize graphical browsers, which may display the product structure allowing point-and-click searches of products and parts. PDM is also especially effective at product configuration management, including multi-level product structures for complex assemblies such as BWGs products. These structures and the associated product documentation may be integrated and communicate in real time with ERP systems via SAP applications.

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With PDM, employees may overcome wasted time, cost, and frustrations associated with manual systems and permit the addition of other value-adding activities with the same number of staff. Managers may automatically receive status updates reports, easily identify where bottlenecks are occurring or where additional resources are needed, and better coordinate geographically dispersed teams. In summary so far, below is a list of benefits and functionality that are common to PDM system implementations:

- provide a structure for all types of information used to define, design, manufacture, and support products;
- manages the product life cycle process (conception, design, prototyping, manufacturing, operation, and maintenance);
- provides data control and integrity (vaulting, approvals, and authorizations);
- concurrent engineering is truly enabled leading to additional payoffs;
- check-in and checkout provide information access;
- release management ensures data consistency;
- advanced data searching functionality;
- workflow and processes control data creation and changes;
- appropriate information is routed automatically;
- audit and historical records are automatically maintained;
- product data, documents, and bills of material are linked to product structures;
- encourages part and design re-use lowering costs;
- projects may be managed directly in conjunction with associated product information;
- improved communication for all involved in the development cycle;
- events trigger automatic notification;
- information is easily shared between users and different systems;
- data translation may occur automatically;
- viewing and mark-up provides advanced and more accurate reviews; and
- decrease in time spent on non-value added tasks.

Another excellent source of previous research information regarding PDM is from John Stark Associates. This is a management consultancy focused on improving the performance of the product development process. John Stark Assoc. has also completed substantial research regarding PDM advantages, benefits, and justifications. According to Stark, PDM systems provide a backbone for the controlled flow of engineering information throughout the product life cycle. This is important due to the complex nature of managing engineering data. CIMdata (2002) indicate that management of engineering data is complex due to:

- the large quantity of engineering data that currently exists (and daily creation of new data);
- many people using the data in different functions and often at different sites;
- the data are used by many different computer programs/tools;
- it often has several different definitions;
- it exists in many different versions;
- is has multiple relationships; and
- it has to be maintained for many years.

Rigby (1998) discussed the usage and satisfaction levels of various management tools. Based on a research project conducted by Bain & Co. from 1993 through 1998, "77 percent of executives report that tools promise more than they deliver, and even highly rated tools varies widely in their ability to improve financial results, customer equity and competitive advantage" (Rigby, 1998, p. 62). Rigby argued these management tools are not broad solutions that may be applied to all business situations and environments. Rather, they are powerful when applied to the right problem(s). In fact, Rigby warns these management tools may be extraordinarily dangerous in the wrong hands. For instance, reengineering was an extremely popular management tool during the time of this survey and was utilized by 78 percent of businesses. However, early users of this comprehensive tool noticed severe long-term side effects, such as declining morale, loss of innovation, an erosion of trust, and weakened teamwork. These unexpected negative consequences may devastate companies' strategic assets, such as employee know-how and erode their competitive advantage. Furthermore, Rigby accurately noted, as previously hot tools cool off, other approaches rise to take their place. Consequently, managers must utilize their best business judgment when deciding to implement a new management tool, since they rarely have any historical precedents to follow. Rigby effectively utilized statistical results to show how management tools may hurt companies when implemented improperly or implemented in inappropriate business situations. Moreover, managers should not follow management tool fads based on their popularity, but on their ability to improve specific business situations (Wah, 1998; Wainwright, 1995; Wang and Seidmann, 1995; Waurzyniak, 2000; Whitaker *et al.*, 2001). However, this rise and fall in popularity of various management tools represents a continuous learning curve for businesses in search of the best

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formula for survival and growth. Consequently, the search for the best formula for success by trial and error procedures, perhaps including PDM systems implementations, will continue since a more effective method has not been discovered.

In addition, traditional organizations without PDM systems usually have processes that are sequential and the development time is the sum of the times of individual workflow steps. However, development time may be significantly reduced with PDM systems by carrying out the steps in parallel or concurrently. This will also lead to lower overall development costs, including the lost opportunity costs of projects that could not commence because of time constraints. Even after release of the product, efficient and accurate access to product data is essential. Accessing data manually may take such a long time; employees may work with out-of-date or incomplete data. PDM systems address this issue by ensuring that uses have access to the most current data allowing design engineers to rapidly proceed with new designs or permitting sales engineers to quickly respond to customer inquiries. PDM systems are designed to address all of these complexities yielding improved communications and data exchange, shorter development cycles, improved data integrity, and lower development costs.

Table I Coding schema used in the collection of primary research variables collected in the empirical section of this study

Variable name	Description	Coding schema
NVT1	Amount of time searching for data (non-value added tasks)	1 = less than 15 percent 2 = 15-35 percent 3 = more than 35 percent
ECOS	Quantity of ECOs	1 = less than 3 2 = 3-5 3 = more than 5
RUSE	Possible design reuse	1 = less than 5 percent 2 = 5-25 percent 3 = more than 25 percent
DEFF	Least efficient development cycle phase	1 = conceptual 2 = design 3 = implementation 4 = introduction
NVT2	Amount of time spent on non-value added tasks	1 = less than 15 percent 2 = 15-35 percent 3 = more than 35 percent
EXC1	Data exchange within BWG	1 = very efficiently 2 = somewhat efficiently 3 = not very efficiently 4 = undecided
EXC2	Data exchange across ADC	1 = very efficiently 2 = somewhat efficiently 3 = not very efficiently 4 = undecided
AUTO	Automated development tasks impact on cycle efficiency	5 = very positive impact 4 = somewhat positive 3 = no impact 2 = somewhat negative 1 = very negative impact

Research methodology

Research variables

This research also examined implementation results provided by a few PDM system vendors, such as Parametric Technology Corporation (PTC), MatrixOne, International Business Machines (IBM), and a few other independent sources. Below is a list of variables that were evaluated in the present study:

- non-value added time: time spent searching for engineering and/or product data;
- development cycle: time required to conceptualize, design, and release new products;
- product development cost: total cost required to conceptualize, design, release, and introduce a new product;
- eng. change cycle: time required to complete an engineering design change;
- eng. change qty: number of engineering changes per product.

Table I is the coding of primary research variables collected in the empirical section of this study.

The secondary data collected for these variables were analyzed through basic descriptive statistics in mainly the online modern manufacturing and business-related literature. Also, primary data relating to these variables were collected via an engineering survey at this Pittsburgh-based telecommunications firm. The intent of the survey was to establish an understanding of current development process inefficiencies as perceived by the design staff.

Secondary data collection

All secondary data were obtained from multiple professional organizations specializing in PDM consulting, PDM software product vendors, and various company reports regarding their individual system implementation outcomes. All secondary data were of public knowledge or through professional subscription services. Since PDM systems have been in existence for approximately a decade, there is substantial benefit and performance data readily available for review and analysis. Analysis of this secondary is illustrated through descriptive statistics in as demonstrated in Tables II and III, and also Figure 1.

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Table II Summary statistics from comparisons of the benefit and performance information analysis

Source	Percent
Non-value added time	
Facilities Management International (1997)	20
MatrixOne (2002a)	30
CIMdata (2002)	33
CIMdata (1998)	40
MatrixOne (2002b)	40
IBM (2002)	44
MatrixOne (2002c)	50
Mean	37
Median	40
Mode	40
SD	10
Reduction of product development cycle	
John Stark Associates (1998)	20
IBM (2002)	25
John Stark Associates (2002)	25
MatrixOne (2002c)	33
CIMdata (1998)	50
MatrixOne (2002d)	80
Mean	39
Median	29
Mode	25
SD	23
Reduction of quantity of engineering changes	
IBM (2002)	20
John Stark Associates (1998)	40
John Stark Associates (2002)	40
Mean	33
Median	40
Mode	40
SD	12
Reduction of product development costs	
John Stark Associates (1998)	10
John Stark Associates (2002)	15
CIMdata (2002)	25
CIMdata (1998)	30
MatrixOne (2002d)	80
Mean	32
Median	25
Mode	N/A
SD	28
Reduction of engineering change cycle	
John Stark Associates (1998)	30
John Stark Associates (2002)	30
CIMdata (2002)	50
CIMdata (1998)	50
MatrixOne (2002b)	50
UK Department of Trade and Industry (2002)	60
Facilities Management International (1997)	80
MatrixOne (2002c)	80
Mean	54
Median	50
Mode	50
SD	19

Primary data collection

The primary data were collected via a self-administered questionnaire given to current engineering and documentation employees. This questionnaire contained questions regarding time spent searching for product or part information, product development cycle time, and information exchange or sharing. The survey consisted of a sample population of approximately 12 individuals in engineering, documentation, and engineering change management functions from the microwave and broadcast divisions of BWG. The survey instrument also contained two similar questions for similar variables as an internal validity check of the responses. Analyses of primary data obtained through this engineering survey are illustrated in Table IV and Figure 2. The variables in the survey were selected to profile the perception of the current efficiency level of development processes and tasks. Additionally, the survey was used to measure the amount of time consumed by non-value added activities by the engineering staff and how effectively information is exchanged within the organization.

It is hypothesized that the percent of time the engineering staff spends on searching for data is directly dependent on how efficiently engineering data is exchanged or shared within the organization. Therefore, in this survey, the dependent variable is NVT2, non-value added time, and the independent variable is EXC1, data exchange. NVT1 could also be used as a dependent variable; however, in this survey it will only be used as an internal validity check for NVT2.

It is also hypothesized that the percent of past designs that could be reused if associated design information was easily located (RUSE) is directly dependent on automating routine and systematic development tasks to increase cycle efficiency, data exchange, and change management (AUTO). Therefore, in this survey, the dependent variable is RUSE, design reuse, and the independent variable is AUTO, task automation. The statistical analyses of these hypotheses are illustrated in next section.

Statistical results and discussion

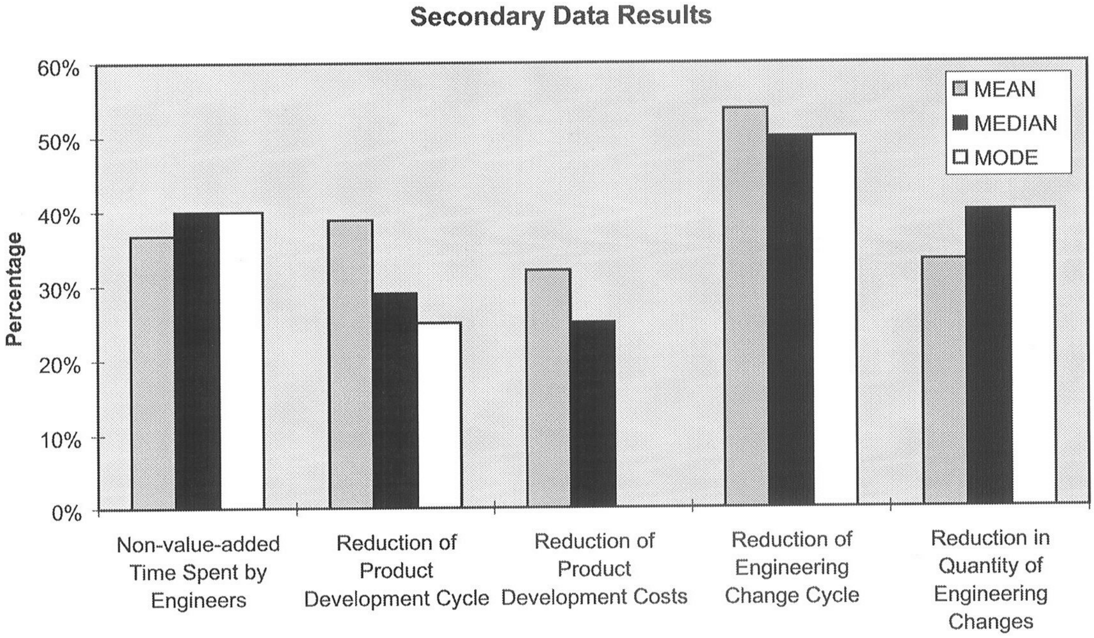
Observations concerning secondary research

From the tables, it may be observed that according to previous PDM implementations and other research in this field, these systems have a substantial positive impact on improving development efficiencies and reducing development costs. Table III and Figure 1 summarize the results obtained from the secondary research. As evident from an inspection

Table III Preliminary results concerning important variables from the secondary research effort on engineering parameters included in the present study

	Non-value-added time spent by engineers (percent)	Reduction of product development cycle (percent)	Reduction of product development costs (percent)	Reduction of engineering change cycle (percent)	Reduction in quantity of engineering changes (percent)
Mean	37	39	32	54	33
Median	40	29	25	50	40
Mode	40	25	N/A	50	40
SD	10	23	28	19	12

Figure 1 Graphical representation of the preliminary results concerning important variables from secondary research efforts



of Table III and Figure 1, the following highlights may be observed:

(1) On average, before PDM implementations: 37 percent of engineer's time is spent performing non-value added tasks, such as searching for design data, product information, drawings, etc.
(2) On average, after PDM implementations:
    - Organizations realized a 39 percent reduction of the time to complete the product development cycle and 32 percent reduction in the associated development costs.
    - Organizations realized a 54 percent reduction of the time to complete the engineering change cycle and a 33 percent reduction in the quantity of engineering changes.

These results basically support the following propositions:

- A PDM system will significantly reduce product development and engineering change cycle times, quantity of engineering changes, and the amount of time consumed by non-value added tasks.
- These reductions will subsequently result in decreased product development costs and quantity of engineering changes.

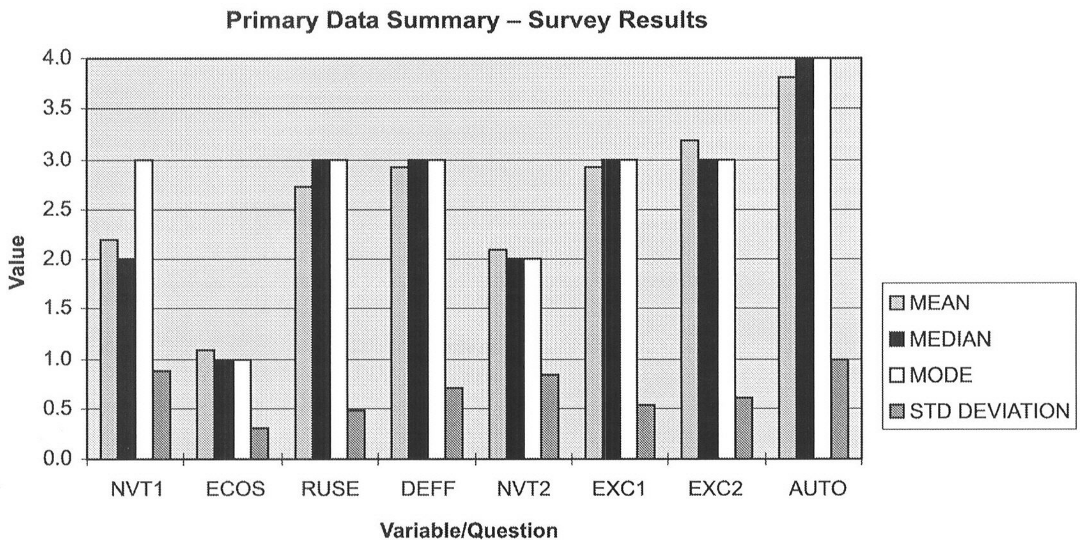
Table IV Basic descriptive statistics of responses for each of the questions from the engineering survey

	Variable							
	NVT1	ECOS	RUSE	DEFF	NVT2	EXC1	EXC2	AUTO
Mean	2.2	1.1	2.7	2.9	2.1	2.9	3.2	3.8
Median	2.0	1.0	3.0	3.0	2.0	3.0	3.0	4.0
Mode	3.0	1.0	3.0	3.0	2.0	3.0	3.0	4.0
SD	0.9	0.3	0.5	0.7	0.8	0.5	0.6	1.0

Observations concerning primary research

The following empirical results were found in an examination of the survey section of this study. As illustrated in Table IV and Figure 2, a series of summary statistics demonstrate some of the purposes of the engineering survey. Table IV and Figure 2 present basic descriptive statistics of

Figure 2 Graphical representation of basic descriptive statistics of responses for each of the questions from the engineering survey



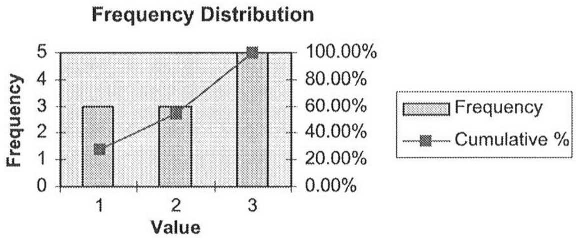
Note: Explanations of variable labels and coding schema may be found in Table 1

1. What percent of your time per week do you spend searching for data (component information, product data, drawings, etc.)?

Code Values for **NVT1**

A.	Less than 15%	(1)
B.	15-35%	(2)
C.	More than 35%	(3)

Value	Frequency	Cumulative %
1	3	27.27%
2	3	54.55%
3	5	100.00%

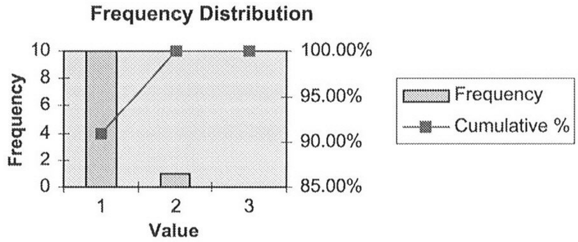


2. How many ECOs per week do you personally create, review, and/or approve?

Code Values for **ECOs**

A.	Less than 3	(1)
B.	3-5	(2)
C.	More than 5	(3)

Value	Frequency	Cumulative %
1	10	90.91%
2	1	100.00%
3	0	100.00%



3. What percent of your past designs do you feel could be reused (in whole or part) if associated design information was easily located and retrievable?

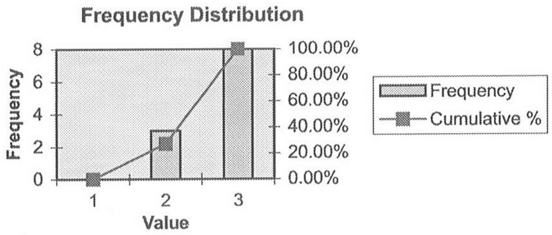
Code Values for **RUSE**

A.	Less than 5%	(1)
B.	5-25%	(2)
C.	More than 25%	(3)

(continued)

Figure 2

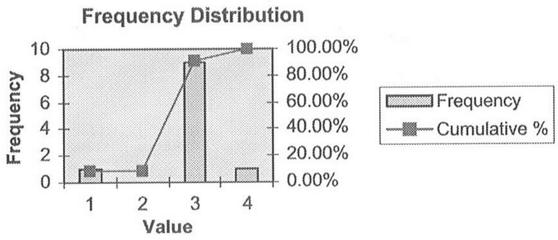
Value	Frequency	Cumulative %
1	0	.00%
2	3	27.27%
3	8	100.00%



4. What part of our development cycle do you find the least efficient?

		Code Values for DEFF
A.	Conceptual/Specification	(1)
B.	R&D/Design	(2)
C.	Documentation/Implementation	(3)
D.	Product Introduction/Validation	(4)

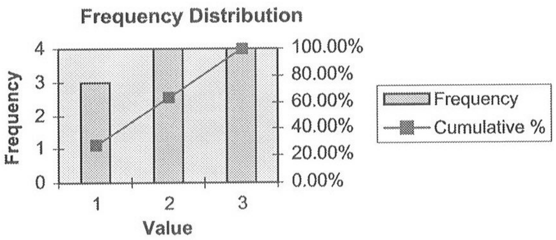
Value	Frequency	Cumulative %
1	1	9.09%
2	0	9.09%
3	9	90.91%
4	1	100.00%



5. What percent of your time per week do you spend performing non-value added tasks (such as searching for parts, drawings, etc.)?

		Code Values for NVT2
A.	Less than 15%	(1)
B.	15-35%	(2)
C.	More than 35%	(3)

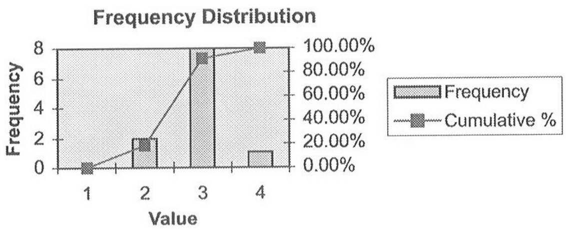
Value	Frequency	Cumulative %
1	3	27.27%
2	4	63.64%
3	4	100.00%



6. How efficiently do you feel engineering data (such as design and product data schema) are exchanged within BWG?

		Code Values for EXC1
A.	Very efficiently	(1)
B.	Somewhat efficiently	(2)
C.	Not very efficiently	(3)
D.	Undecided	(4)

Value	Frequency	Cumulative %
1	0	.00%
2	2	18.18%
3	8	90.91%
4	1	100.00%



(continued)

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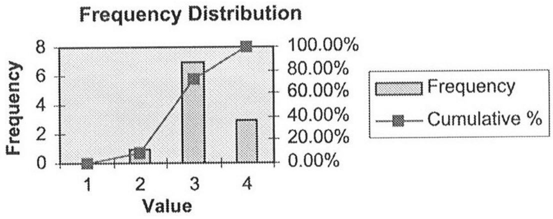
Figure 2

7. How efficiently do you feel engineering data (design data, product data, etc.) are exchanged across ADC?

		Code Values for **EXC2**
A.	Very efficiently	(1)
B.	Somewhat efficiently	(2)
C.	Not very efficiently	(3)
D.	Undecided	(4)

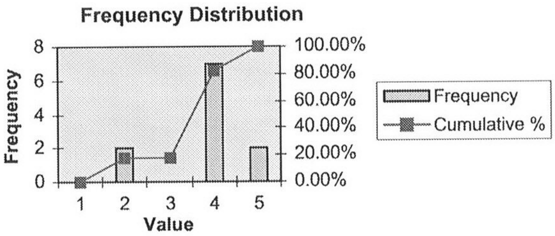
Value	Frequency	Cumulative %
1	0	.00%
2	1	9.09%
3	7	72.73%
4	3	100.00%



8. If routine and systematic development tasks were automated, what impact do you feel this would have on cycle efficiency, data exchange, and change management?

		Code Values for **AUTO**
A.	Very positive impact	(5)
B.	Somewhat positive impact	(4)
C.	No impact	(3)
D.	Somewhat negative impact	(2)
E.	Very negative impact	(1)

Value	Frequency	Cumulative %
1	0	.00%
2	2	18.18%
3	0	18.18%
4	7	81.82%
5	2	100.00%



responses for each of the questions from the survey in a snapshot format.

Furthermore, interpreting the results presented above and the frequency distributions, the following is observed from the BWG engineering staff survey:

- Of the engineering staff surveyed, 54 percent spend up to 35 percent of their time per week searching for engineering data. The remaining 46 percent of the respondents spend greater than 35 percent.
- Of the engineers, 27 percent feel that up to 25 percent of personal past designs could be reused (in whole or part) if associated design information was easily located and retrievable. The remaining 73 percent of the respondents feel greater than 25 percent of their designs could be reused.
- Of the engineers, 91 percent feel that the documentation/implementation phase of the development cycle is the least efficient.
- Of the engineers, 72 percent feel that engineering data (design data, product data, etc.) is exchanged not very efficiently within BWG.
- If routine and systematic development tasks were automated, 82 percent of the engineers feel that this would have a somewhat positive to very positive impact on cycle efficiency, data exchange, and change management

Also, in reviewing the analysis of the primary data, several other observations may be made. First, there is a moderate correlation between the amount of time spent on non-value added tasks (NVT2) and how well information is exchanged within the organization at BWG (EXC1). The correlation coefficient was calculated for these two variables. This calculation results in an $r = 0.4664$ ($p = 0.148$) illustrating that there is a moderate positive correlation between variables NVT2 and EXC1. The coefficient of determination $r^2 = 0.22$, indicating that 22 percent of the

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variance in amount of time spent on non-value added tasks (NVT2) may be explained by the variance in how well information is exchanged within the organization at BWG (EXC1). However, this does not indicate significance in the correlation. This phenomenon is presumed to be deeply rooted in the small sample population that resulted in introducing greater error variance. This limitation is described in further detail.

Secondly, there is significant correlation between variables NVT1 and NVT2 indicating strong internal validity of the responses since these questions were intentionally written in a similar fashion. This calculation results in an $r = 0.8010$ ($p = 0.003$) illustrating that there is a strong positive correlation between variables NVT2 and EXC1. The coefficient of determination $r^2 = 0.64 = 64$ percent indicating that the responses to the questions for variables NVT1 and NVT2 are considerably similar. This situation does indicate significance in the correlation. Finally, the other significant correlation indicated by the analysis is between the percent of past designs that the engineering staff feel could be reused if associated design information was easily located (RUSE) and automating routine and systematic development tasks to increase cycle efficiency, data exchange, and change management (AUTO). The correlation coefficient was calculated for these two variables resulted in an $r = 0.7534$ ($p = 0.007$) illustrating that there is a strong positive correlation between variables AUTO and RUSE. The coefficient of determination $r^2 = 0.56$, indicating that 56 percent of the variance in the percent of past designs that the engineering staff feel could be reused (RUSE) may be explained by the variance in automating routine and systematic development tasks to increase cycle efficiency, data exchange, and change management (AUTO).

Research limitations

A few inherent limitations of this research include: all secondary research is based either on opinions or data collected from third party research, of which some may be purely objective; the primary data collected via the staff survey only included individuals in design engineering roles. The results could vary if all employees within the organization were included in the sample population. However, it is assumed that the engineering staff would be most significantly impacted by a PDM system implementation, even though benefit would extend throughout the organization.

Conclusions and recommendations

Project data-management systems are extremely important, but fairly complicated and are currently in competitions with other less expensive, Web-enabled communication technologies (such as those available at Framework Technologies Corp. located Burlington, MA, USA) that integrates e-mail with project-communications management and can handle large CAD file transfers and viewing in real time. However, as designs become more complex and potential collaboration become more global in nature, engineers and project managers alike are more pressured to improve product data management systems as they become more critical to new and existing product development and manufacturing issues. Management must approach project and information issues with a total systems-integration approach. As noted by Reddy and Reddy (2002), the shear of the concept of the organizational life cycle highlights the types of organizational rigidities typical in large and mature firms, which includes the following:

- a multitude of diverse and globally dispersed systems that need to remain operational while new systems are being implemented, thus diverting staff attention from development to maintenance;
- formalized, but possibly outdated business processes are embedded into existing information systems;
- ownership relationships exist regarding business processes and related information technology systems; and
- achieving cross-functional consensus for systems projects during times of tight budgets.

Reddy and Reddy (2002) recommended that as companies move through these stages of growth and maturity, they should adopt a more systematic approach to systems development. Management of PDAs requires a similar systems-wide thinking approach if they are to succeed. In particular, based on the results of the present research, it is concluded that a majority of the engineers surveyed:

- spend a significant amount of time per week searching for engineering data;
- feel that a large percentage of their past designs could be reused if associated design information was easily located and retrievable;
- perceive that the documentation/implementation phase of the development cycle is the least efficient;
- sense that engineering data are not exchanged efficiently within BWG; and

- that automating routine design tasks would have a positive impact on cycle efficiency, data exchange, and change management.

Also, as illustrated in the research, past implementations have had exhibited significant improvements in all facets of product design, introduction, manufacturing, and support. Following a successful implementation of a PDM system at this Pittsburgh-based telecommunications firm, product development, engineering change cycle times, quantity of engineering changes, and the amount of time consumed by non-value added tasks would all be reduced significantly. These reductions will subsequently result in decreased product development costs and quantity of engineering changes.

Therefore, based on this research and analysis, a recommendation to proceed with a PDM system implementation at this Pittsburgh-based telecommunications firm is conferred. A PDM system would provide the competitive edge that BWG requires in today's marketplace enabling faster time-to-market, product configuration management, and product data integrity.

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