QUALITY AND RELIABILITY CORNER

Strategic value of reliability and maintainability management

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Abstract

Purpose – This paper aims to examine the strategic value of reliability and maintainability management in achieving competitiveness and customer satisfaction. It looks into performance metrics for organizational performance and associates reliability and maintainability with such metrics.

Design/methodology/approach – The design strategy is based on using models for reliability and profitability assessment as well as total quality management models to illustrate how performance metrics for organizational performance can be enhanced.

Findings – It shows there is a need to associate models of profitability assessment to reliability and maintainability management. This will help top management to see the strategic value of reliability and maintainability management and, therefore, adopt necessary organizational transformations to support reliability and maintainability goals.

Research limitations/implications – It is important that the role of reliability and maintainability as important strategic variables be recognized and considered in future research that evaluates organizational performance and successes.

Practical implications – The importance of organizational cultural transformation is noted and a transformation of organizational information system to link reliability management to a central information system such as in an enterprise resource planning (ERP) framework is suggested as a process of improving system availability and reliability.

Originality/value – The aim is to have top management perceive reliability and maintainability issues as part of their strategic initiatives. While the value of total quality management in achieving organizational success is well accepted, reliability and maintainability issues are often viewed at the operational level. Yet, they are critical to achieving quality and organizational success.

Keywords Reliability management, Organizational performance, Strategic management, Profit

Paper type Conceptual paper

Introduction

Reliability and maintainability management are attracting new interest in today's corporate world. The quest to remain competitive, provide timely and accurate services, and link effectively with all the members of the supply chain is partly responsible for this interest. A company cannot adopt a rapid response strategy if its system is unavailable and unreliable. Furthermore, as many companies strive to eliminate the huge cost of inventories and remain lean in their production system, there is an increasing need to ensure that equipment are properly maintained and are highly reliable. Manufacturers and service providers are also acknowledging that they need to be their "brothers keepers" if their supply chain is to be efficient. When a company

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adopts a just-in-time philosophy of management it obviously cannot allow room for bottlenecks. Thus when a vendor in the supply chain network has an unreliable and unavailable system, the entire chain can potentially be disrupted. There is therefore a desire by all parties to ensure that work processes are not disrupted because of equipment failure. These challenges imply that a new view of reliability and maintainability must be adopted. Such views must support current corporate strategies to provide the highest quality of services to customers on a timely basis.

Increasingly, companies are viewing reliability and maintainability issues as part of the corporate quest to improve quality, achieve lean manufacturing or just-in-time, achieve six sigma, achieve customer satisfaction and remain competitive. It is no longer simply a technical issue that is left only to engineers and designers but a critical component in the entire product and service delivery process. In fact, organizational performance and survivability hinges a whole lot on the reliability and maintainability of products that a company-wide approach to achieving reliability and maintainability goals must be maintained. In this paper therefore, we shall explore ways to help organizations integrate reliability and maintainability issues into their corporate strategies and also develop strategies that will enable them to inculcate this concept in an organization-wide effort and thus achieve smooth organizational transformation and cultural change.

The aim of this paper is to offer a management view of reliability and maintainability management that could help reliability management practitioners to get needed support and funding for reliability and maintainability activities in their organizations.

Strategic value of reliability and maintainability management

Reliability and maintainability management should be viewed as part of corporate strategy. It is no longer an issue that should be left at the tactical level for consideration but one, which hinges on corporate performance and survival and must get the attention it desires. The current focus on customer satisfaction and efforts to continuously improve quality to satisfy customer is directly linked to the reliability and availability of the processes used to provide such needed services. It is therefore important to bring top management to buy into the idea that reliability and maintainability issues belong at the corporate level. In quality management, the cost of quality concept is used to highlight the importance of quality management to top management. The four types of cost of quality namely appraisal, prevention, internal and external costs are presented (Feigenbaum, 1956). It is known now that these costs are applicable to any system and one can easily breakdown reliability, availability, and maintainability costs into these four categories. Obviously, the external cost continues to be the highest cost since this impacts directly on the customer and may lead to loss of customer good will. The effect of such cost on reliability was quite apparent when Ford Motors suffered irreparable loss of customer goodwill from the massive recall of Firestone tires that were used on its popular sports utility vehicle – Explorer (Taylor, 2001). Even though at the time, it was treated as purely a quality issue but it also had to do with reliability issues. The vehicles were not dependable and had higher maintenance costs. Customers were also worried about the safety issues and possibility of preventable accidents. While the quality implications were widely publicized, a major concern that was overlooked was the perception of motorists on the reliability of

these vehicles. So, quality and reliability are intertwined and it is often difficult to draw the line (Madu, 1999). This problem also exposes the increasing risk of new management strategies such as supply chain when a manufacturer deals with different vendors that are expected to maintain quality and reliability standards that are at par with that of the manufacturer. Companies such as Dell Computers for example are known for their mass customization and rapid response strategies. These approaches offer value to customers who participate in their own product delivery but it presents challenges to manufacturers who must ensure that the supply chain is not broken. Such insurance can be gained when high reliability, availability and maintainability standards are maintained. It is apparent that a breakdown along the line may potentially delay the entire process and create unhappy customer and in addition increase production costs through sub-contracting to other vendors however, preventive strategies to ensure high quality services to customers at all times can help alleviate these problems. We shall therefore, define the goal of reliability and maintainability management (RMM) as follows: to design, operate, and improve the reliability and maintainability of a business and operations system to achieve lasting organizational effectiveness and competitiveness.

There are many ways to communicate to top management the strategic value of reliability and maintainability management. Some of these could be classified under the "Models for reliability and profitability assessment" as shown below.

Models for reliability and profitability assessment

Root cause analysis (RCA)

RCA is a common terminology in the reliability literature. It is important to understand the root causes of any problem in order to avoid future occurrences and perhaps, transfer knowledge gained in product/process design and redesign. It is important that the problems are not repeated. Root cause analysis can be likened to the Fishbone or Ishikawa diagram where the causes of any problem are grouped into four:

(1) Manpower.

(2) Method.

(3) Machine.

(4) Material.

Obviously, this classification is comprehensive and can cover problems that may be identified with a particular process reliability, availability, and maintainability. The identified causes can be quantified in terms of labor hour, energy requirement, material scraps, etc., and the potential costs estimated. Figure 1 shows an application of the cause-and-effect diagram to diagnose an unreliable system. This diagram is often referred to in honor of the developer as Ishikawa diagram. Using the four classifications as suggested in the Ishikawa diagram, we can group the causes accordingly. For example, causes as a result of Methods may include poor preventive maintenance policies, equipment replacement policies or misdiagnosed equipment failures. Manpower problems may also arise when failure rate is greater than service rate and the service facility is unable to handle the amount of request it is getting. This analysis helps top management to pinpoint the causes that lead to the unreliable system. Top management will pay attention when cost is mentioned. The potential costs may help them to pay a closer attention to reliability issues. RCA is often used in

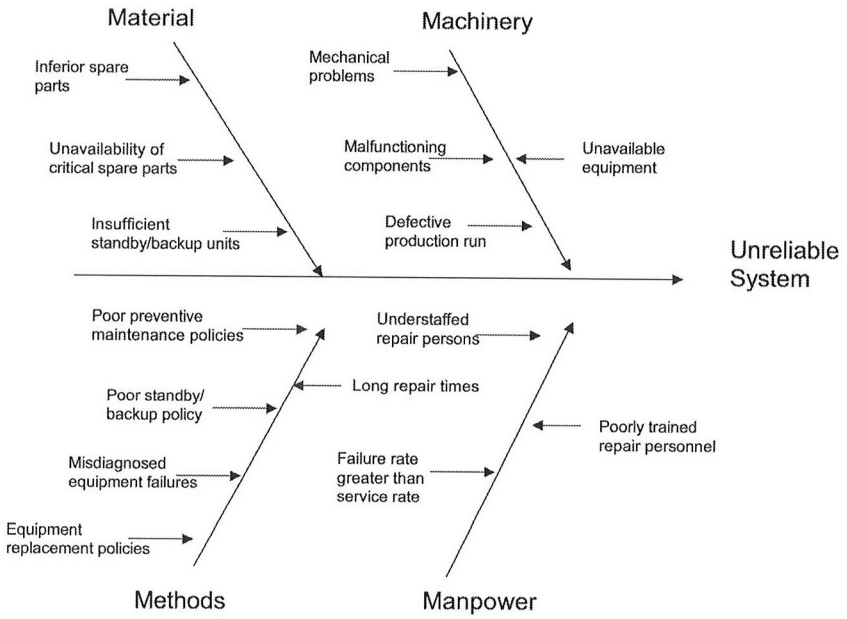

Figure 1.
Cause-and-effect diagram for unreliable system

conjunction with GAP analysis. Management normally would set monthly, quarterly or annual goals. These goals may sometimes be in terms of production rate such as how many units of items to produce per hour or per day etc. However, these goals often take for granted the state of the production process. In order to achieve the set goal, one must know the process capability and if the process falls short, why? Thus, the gap between the expected goal and the actual production is what is uncovered through GAP analysis and that can be quantified in terms of cost to show what is lost directly. This analysis is however incomplete even though it gives top management some numbers to work with. What is not covered in this is the fact that there may be lost sales. The lost sales may also include dissatisfied customers who may switch brands and move to competitors. Those customers may never be recovered. In the long run, that becomes a huge cost for the manufacturer and a potential loss of market share and market position.

Failure modes and effects analysis (FMEA)

FMEA is equally a major term in the reliability literature. Under RCA, we discussed GAP analysis to highlight the gap between the goal and actual process performance. FMEA addresses the issue of why the process is unable to achieve that goal. The aim is to identify the sources of the process problems by breaking the process into its sub-components with the intention of isolating the problem. This approach involves statistical data collection especially with relation to the frequency of sub-component failures and the cost of such failures. Like the Ishikawa diagram discussed above, FMEA also tends to relate the costs to manpower, material, method and machine problems. This has great impact on the RCA and again highlights the inability of

achieving process capability. Management will come to understand through this analysis the impact that reliability has on its ability to achieve its strategic goals.

Pareto charts

The Pareto chart has been used widely in the quality management literature and it is equally important in the reliability and maintainability literature. Specifically, the Pareto chart will help identify the "significant few" causes to the majority of the problems in any process. This is based on the concept that about 20 percent of the causes account for 80 percent of the problems obtained in any process. Simply stated, the aim is to identify the vital few causes to reliability problems. Thus, most of the reliability problems observed can be explained by a few causes. This has significant impact in managing reliability since it enables us to focus on the few causes that can potentially influence system or process reliability. This is critical information that management must have and be able to monitor and emphasize in eliminating those few causes to achieve total quality. For example, the US Department of Transportation's Research and Special Programs Administration, Office of Pipeline Safety (RSA/OPS) compiles data on pipeline accidents and their causes. Based on the data accumulated on hazardous liquid pipeline accidents from 1 January 2002-31 December 2003, we abstract Table I to show the causes and property damages. A frequency distribution and pie chart plots of these data is given as Figures 2 and 3 respectively.

These charts show that all causes are not the same. For example, materials or weld failure accounts for 40 percent of the causes and corrosion accounts for 25 percent. These two account for 65 percent of the causes that are observed. Clearly, it would

Pipeline failure causes	Property damage ($)
Excavation	8,830,722
Natural forces	2,646,447
Other outside forces	2,062,535
Materials or weld failure	28,461,998
Equipment failure	2,761,067
Corrosion	17,168,229
Operations	816,451
Other	7,037,928

Source: US Department of Transportation (2004)

Table I.
Cost of pipeline failure causes

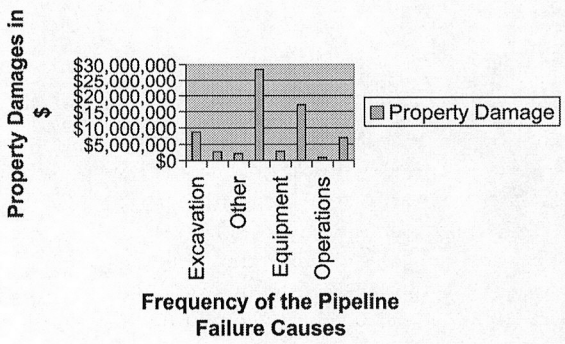

Figure 2.
Pareto chart of pipeline failure cause

make sense to spend more resources and energy to eliminate the problems of "Materials" or "Weld" failure and "Corrosion" since these will account for majority of the problems with pipeline failure. Of course the 13 percent contributed by "Excavation" and the 10 percent by "Other" should also be investigated.

Reliability, availability and maintainability (RAM)

There are several acronyms in the reliability literature. RAM is basically an engineering tool that is useful in evaluating the equipment at the different stages in the design process. It addresses operations and safety issues and aims to identify areas within the system or process where significant improvement can be achieved. Thus, it is instrumental in the design and redesigning of the system to achieve continuous improvement. The objectives of RAM are multifaceted and include identifying failure modes that should be improved on to protect the safety of the workers and the general public. It enhances system reliability, and it focuses on achieving continuous improvement through re-evaluating and proposing changes in the existing system to improve safety and reliability of the process. RAM analysis is often done using a reliability block diagram that identifies the critical functions of the equipment. Information for the blocks could be obtained through industry standards or judgment of engineering and maintenance personnel. With such information, performance metrics such as the likelihood of failure, equipment downtime, and availability can be obtained. Studies from FMEA on equipment components also provide valuable information that can be used in this process. Again, the quantitative data obtained here can be used to cost the impact of equipment failure and downtime on organizational effectiveness and performance and therefore, lack of competitiveness. Such information becomes critical to top management in assessing how well its organizational processes are able to respond to the needs of the market place. The knowledge of the role of RAM in achieving organizational mission and goals makes it more prudent for top management to buy into the idea that reliability and maintainability management must be part of the strength that the organization must develop in order to be competitive. This will therefore encourage devoting attention and needed resources to achieve this critical function.

Seven basic tools of TQM

The seven basic tools of total quality management (TQM) can also be used to understand problems associated with reliability and maintainability management and how that can impact organizational effectiveness. Already, we have discussed some of

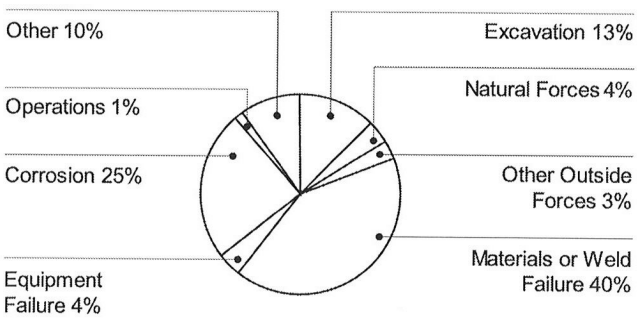

Figure 3.
Property damages in percent of cost

the tools of TQM included in this list such as the cause and effect diagrams (Ishikawa or Fishbone diagram) and Pareto charts. Also, the methods such as FMEA can use the combination of others such as histogram, check sheets, and flow charts. The other two left scatter diagrams and statistical process control can be equally applied to this problem. For example, statistical process control can be applied at the equipment design and test run stages to see if it is producing or performing according to established tolerance levels. The scatter diagrams can also be used to explore relationships. For example, one may study the relationship between the types of failure and the man-hours required to perform repair. This relationship could help to understand critical failures. Failure types could also be related to the overall resources needed to remedy such failure. This way, management can understand which failures are critical and adopt strategies to avoid or limit their occurrences. We noted above that RAM analysis is often done using block diagrams. Flow charts are basically block diagrams that use boxes and interconnected lines to describe a process. Examination of the flow process could help to identify the source of the reliability problem.

Return on investment (ROI)

Many profitability analyses seem to focus on direct economic benefits since they are easier to explain to, and appreciated by managers. It is easier to show management the returns from reliability and maintainability programs over a projected timeline. There is tendency to focus on the short-term especially with the increasing focus of investors on financial returns. Managers are therefore under pressure to deliver to investors. So there is a need to not just show how failure to achieve reliability and maintainability may affect organizational effectiveness but also to show using known financial measures such as ROI when the expected returns may be realized. However, there is a caveat to this. Often times, the focus on these short-term returns may miss the entire picture. There are intangible benefits that may not be captured directly. For example, the impact of poor reliability systems on customer perception and the subsequent effect on competitiveness may not be easily captured. Some of the impacts that reliability improvement may have may be indirect and not directly captured in a financial metric.

Developing company-wide reliability and maintainability management

Once management accepts the fact that reliability and maintainability management contribute to organizational competitiveness, there is a need to develop action plans and support framework to support its role within the organization. To achieve this, the mindset of the organization must change. There will need to be an organizational cultural change both in attitude and perception of this critical function. In fact, the needed change will be akin to the changes adopted to introduce total quality management. So therefore, companies that already have total quality management programs are better positioned to benefit from company-wide reliability and maintainability management.

In this section, we shall identify some of the key issues that will be needed to develop company-wide reliability and maintainability management:

(1) *Use of teams.* The use of teams is encouraged in effectively resolving reliability and maintainability issues. This again borrows from the gains that were made in TQM through the use of team. The use of teams here acknowledges the fact that reliability and maintainability knowledge does not reside with one function

or group of practitioners or engineers but reside throughout the organization. So, a cross-functional team should be formed that should also include members of the supply chain. For example, some of the reliability issues are obtained through customer complaints, warranty reports, litigations, etc. The sales department obtains its field surveys through direct association with customers. Such information can be shared and discussed with all members of the value chain to effectively improve the system. Members of the team must be empowered and top management should be part of such a team to give it clout in the organization but also to communicate the significance of reliability and maintainability in the organization's corporate strategy. The presence of top management will enable the team to get the needed funding and resources to react actively and timely in solving critical system problems.

(2) *Continuous improvement.* Reliability management is an ongoing process and not a project. In the past there is tendency to view the work of reliability as having ended at the design stage. It should be viewed as an ongoing process that will need to be continuously improved on. Today's companies are required to take product stewardship (Dillion and Baram, 1991; Roy and Whelan, 1992). It is to their best interest to ensure that the product or process is at its best level at all times. So, just as in TQM, there should be no end when it comes to reliability and maintainability improvements.

(3) *Top management commitment.* Top management involvement and commitment is key to ensuring that adequate attention is devoted to reliability and maintainability management. The importance of this cannot be overstated. Top management is key in devoting needed resources and encouraging other functional units within the organization to support company-wide initiatives. The commitment of top management should be common knowledge to everyone within the organization and its extended environment such as its value or supply chain. This way, all the connected parties will view reliability and maintainability as core part of organizational strategy.

(4) *Supply chain participation.* It is important to note that companies today cannot be as effective without a good supply chain. Many companies today adopt strategies to minimize inventory, focus on increasing value to customers at minimum cost, and also on rapid response to the needs of the marketplace. However, these strategies are built on the premise of exceeding the needs and wants of the customer. Manufacturers must share information with members of their supply chain in order to better serve the customer. Timely information sharing helps to identify the sources of reliability problems such as manpower, machine, material, and methods, and help to react actively to remedy the situation. The causes of the problem may reside outside the manufacturer but with one of the members of the value chain. That does not exempt the manufacturer from responsibility since a cradle-to-grave approach of its process or product must be taken.

(5) *Avoid finger pointing and blame game.* When the manufacturer creates a team to deal with reliability and maintainability issues, it must appreciate that the aim is to identify potential causes of problems and to solve them as expediently as

possible. This way, it can continue to satisfy its customers by always offering them processes or products that have high reliability. To effectively achieve this, it must avoid finger pointing or blame game. Such actions will kill the morale of the team participants who may start fighting to protect their functions or groups. The goal should be how to resolve problems without demonizing a team member.

(6) *Justifying reliability management.* Although we have discussed some of the reliability and profitability assessment methods, it is also important to understand the potential impacts of reliability management on organizational performance metrics such as productivity, quality, availability, and costs. Productivity for example is a major index of organizational effectiveness. A process that is highly unreliable and unavailable will obviously lead to declining productivity. Likewise, an unreliable process will not be able to produce high quality products. All these will mean that there will be higher product rejects, scraps, warranty requirements, and rework all at a high cost to the manufacturer, low productivity, and loss of customer goodwill. This message needs to be conveyed to other members of the organization so they would see the need of supporting company-wide efforts to improve process or equipment reliability and maintainability.

(7) *Enterprise reliability data management (ERDM).* There is a need to present a single view of reliability data on a timely basis. This will help to ensure that everyone is looking at the same information and solving exactly the same problem. The ERDM should benefit from the growing focus on enterprise resource planning (ERP) where a central data warehouse is maintained rather than keeping islands of information in different functional areas. Members of the supply chain should be hooked to the central database and should be able to use data mining techniques to derive critical reliability data on a timely basis.

(8) *Customer satisfaction.* Quality cannot be achieved in the absence of system reliability. Thus, reliability is also a measure of customer satisfaction. Reliability is one of the dimensions of quality that Garvin (1988) identified. Mechanical systems that have high failure rate and long service times obviously create a lot of dissatisfied customer. Reliability must therefore be a key component of any quality design. It is actually difficult to treat reliability and quality as different subjects since they both feed on each other. Thus, the perception that reliability is also a measure of customer satisfaction should help to focus attention in maintenance and reliability.

(9) *Changing customer needs.* Reliability is time and event dependent. The needs of the customer changes and so should reliability measures. For example, during the periods of crude oil scarcity or increasing price of gasoline, customers tend to shift to fuel-efficient vehicles. This forces manufacturers to design and produce fuel economy cars that will satisfy the changing needs of the customer. Also, competing products that are offered may influence customers' needs. It is imperative that environmental scanning is done to understand what competitors are doing and changes in customer needs in order to be the best in class in achieving reliability.

(10) *Organizational survival.* Reliability is key to organizational survival. As we have already mentioned, reliability and quality are intertwined. Organizations today cannot survive without a focus on them. These are the major measures of customer satisfaction. An unsatisfied customer will not be a loyal and patronizing customer and the loss of market share will ultimately affect organizational survival.

These ten items are key in achieving company-wide reliability management. Although there is a need for reliability changes to be result-oriented in the sense that there must exist metrics to pinpoint reliability impacts on organizational performance however, we should be careful not to be overly focused on the short-term. Top management involvement will help to look into the strategic value that reliability management provides in terms of creating a new vision and its impacts on the different segments of the organization.

Company-wide reliability information system

Information management is key to effective reliability and maintainability management. Information is needed to identify the key components of a system, the modes of failure, and to analyze causes of system failure. Since there are many stages in product and process development and many participants in the supply chain, it is important to have a central information system that is linked to all participants. Members of the supply chain should have a single view of system reliability and be able to react accordingly to address the problem. As more and more companies are implementing ERP system, information can be obtained through the ERP system.

Reliability information system (RIS) is embedded in the data warehouse for an ERP system. Customer complaints are fed back to the system and should be accessible to all value chain providers. That information becomes critical in process design and redesign and helps the organization to achieve continuous improvement. The value chain members are also able to recognize the major causes of problems at every touch point. These causes become the major concern of all and remedies are sought to address them.

A system integrator is introduced in this framework since the customer interface with the ERP system through other modules such as customer relationship management (CRM) software. Although this front office application (CRM) is not shown in the diagram however, customer information is obtained through this source and transferred through the system integrator to the back office operation offered by ERP. The manufacturer is therefore able to obtain direct information from its customers through the customer's lifecycle and is able to manage that information to effectively serve the customer.

The use of a common data warehouse for RIS offers coordinated and integrated information system that should contain both customer transactions and interactions with the organization through all the different service delivery contacts. This helps to identify the customers concerns, needs and wants. Customer complaints are recorded and are available as historical data and can be explored or analyzed to identify major complaints. This makes it easier for example to develop a Pareto chart and identify the major causes of unreliable system and to properly channel resources to address them. Therefore, the integrated nature of data warehouse and the single view that is

presented to all value chain partners by ERP can help in improving the reliability of the system and delivering high quality services to the customer.

Figure 4 also shows an advanced reliability planner and optimizer. The goal of this is to update reliability information and search for the best strategies to improve product and process reliability. These are communicated to reliability planners and designers in the form of decision support. Information on reliability management flows not just from customers but also within the organization and from its extended partners such as the members of the supply chain. All these parties have a common interest in achieving customer satisfaction and must ensure their own internal efficiency and the reliability of the products and processes that are offered either for internal use or to the customer.

Conclusion

The main aim of this paper is to highlight the importance of reliability and maintainability management in achieving organizational competitiveness. It focuses on introducing reliability issues as an integral part of the strategic function. However, it argues that reliability and maintainability issues must be sold to top management by focusing on effects on the bottom line. There is tendency to perceive reliability management as a technical issue that requires the attention of the technical staff and is therefore not treated as a strategic issue. Through the reliability and profitability assessment models presented here, top management will come to understand that reliability management has direct impact on organizational effectiveness and survival. The paper also proposes a company-wide reliability and maintainability management and identifies strategic issues that must be addressed to achieve success. Such strategic issues require the participation of top management and all the value chain partners to adequately address the causes of reliability problems in order to better serve the customer. An Ishikawa diagram and a Pareto chart are used to demonstrate how unreliable systems can be analyzed and failure causes adequately addressed.

Further, it is recommended that an enterprise reliability data management (ERDM) be adopted and integrated within the ERP system that many companies are currently

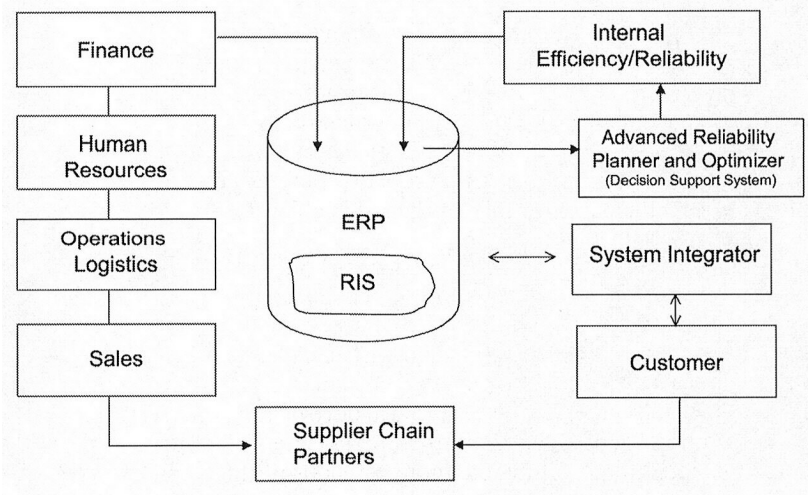

Figure 4.
Reliability information system (RIS) embedded in ERP system

adopting. This way, a single view of information is provided to all value chain members and since knowledge on reliability management reside with different parties including customers, knowledge and learning can be effectively dispersed through the enterprise. This approach also offers expediency in treating customer complaints, eliminates the duplication of activities, and benefits from knowledge sharing. All value chain partners come to understand their critical role in ensuring that a highly reliable and dependable product or process is offered to the customer.

Finally, this paper offers a management view of reliability and maintainability management. It is intended to help reliability practitioners to take systemic view of the reliability function and to understand the need of marketing this important function to top management by highlighting reliability management link to key organizational performance metrics such as productivity, profitability, and quality.

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