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Development of an Automobile Supplier Performance Information System

P. Gary Moynihan and D. Bipan Singh
Department of Industrial Engineering, The University of Alabama, Tuscaloosa, AL, U.S.A

Abstract: A software needs assessment was conducted for a major automobile manufacturer, with regard to supply chain management. An initial step toward the implementation of the resulting information systems plan was the development of a supplier performance information system. It encompasses the functional aspects of an executive information system and an output archive. The supplier performance information system includes the capability to track multiple supplier performance metrics. It combines/compares these data in various ways, as well as aggregating them into an overall program metric. The system is networked-based and was designed to utilize the company's existing hardware, software and communications assets to the fullest extent possible.

Key words: Executive information system, supplier performance, supply chain management, automobile industry

INTRODUCTION

Supply Chain Management (SCM) efforts have proven effective in reducing costs within the automobile industry. In 1989, Chrysler began its Supplier Cost-Reduction Effort (SCORE) program. This initiative was based on the solicitation of improvement proposals from first-tier suppliers. These proposals were targeted at removal of cost from the supply chain, rather than cost transference to another link in the chain (Fitzgerald, 1997). By 1997, this program had encouraged suppliers to offer 17,500 suggestions that resulted in cost savings of $2.5 billion since 1993 (Fitzgerald, 1997).

PPG Industries is a major manufacturer of paints, coatings and industrial chemicals and does a large portion of its business supplying the automotive industry. In order to maintain its preferred status with industry customers, PPG was required to reduce its costs by 5% per year, which had become a standard benchmark for automobile manufacturing suppliers (Reilly, 2000). Through its participation in Chrysler's SCORE initiative, PPG learned the long-term value of providing incentives to suppliers for continuing process improvements to reduce costs. In 1998, the company initiated the Supplier Added Value Effort ($AVE). The $AVE program principles incorporate closer coordination with suppliers; reduced total supply chain costs; improved quality, technological innovation and cycletimes and promotion of continuous improvement. By the end of the program's first year, PPG reported that 170 of its suppliers had participated in the program, with a total cost reduction of $15.7 billion (Reilly, 2000).

In this case study, the SCM objective is expanded from only cost reduction to emphasize quality improvement, as well. The production strategy of a major automobile company is to employ a lean manufacturing approach in pursuit of the dual goals of business profitability and manufacturing excellence. This strategy assumes a high reliance on purchased materials. Thus, achieving automobile manufacturing excellence depends on developing world-class suppliers. In an effort to improve and integrate its supplier base, the company initiated the formation of a set of liaison organizations, referred to as Supplier Development Groups (SDGs). Each SDG is responsible for suppliers of a specific type, e.g. interior trim components.

Six SDGs, each consisting of seven team members drawn from business functions that interface with automotive parts suppliers (e.g. Purchasing, Quality Engineering), were organized around natural groupings of suppliers (e.g. Chassis, Interior and Exterior Components). An initial group of diverse six suppliers were selected for the first year of this program. In December of that year, the SDGs and their respective Mirror Group leaders (from each vendor) were asked, in a questionnaire, to document tangible benefits that they could identify as a direct result of the program.

The top 4 benefits cited were all quality-related: reduced scrap at the supplier site; eliminated process time or people at the supplier; more stable processing time and reduced defect material tags written at the company against the supplier. For example, a 330% reduction in outer door panel defects was observed. These dropped from 5800-1100 during the program's

Corresponding Author: P. Gary Moynihan, Department of Industrial Engineering, The University of Alabama, Tuscaloosa, AL, U.S.A

first year. If sustained these defect reductions will lead to an estimated $5.4 million cost savings over the remainder of the automobile model's production lifetime.

Other benefits, such as improved material handling, communication of requirements and standardized inspection procedures, were also mentioned. However, the leaders were unable to quantify the monetary benefit of these last benefits. A benchmarking exercise indicated that these qualitative benefits were consistent with those observed by other automobile companies using similar initiatives (Batson *et al*., 2001).

The initial success of the program led to its expansion across all of the company's supplier base. The complexity and volume of the resulting data indicated a need for improved SCM software support. Interviews were conducted with the SDG Coordinating Committee, SDG Leaders and various other company personnel. This provided insight into the company environment, current methods and SDG requirements for information processing. In parallel, a literature search was conducted. Sources were reviewed for current information system practices in supply chain management, general functionality of SCM software, its relevance to the company's situation, as well as identifying pertinent commercial software in this area. Based on these results, a supplier performance information system was designed, built and tested.

The traditional approach to manufacturing planning focussed on operations within a single factory or distribution center. Materials Requirements Planning (MRP I) and Manufacturing Resource Planning (MRP II) software systems are representative of this traditional approach. The application of software for planning and controlling materials flow across the entire supply chain is relatively recent. Articles, discussing this revised approach, began to appear in the literature during the mid-1990s (Verwijmeren and Vander, 1996). This initial phase of articles is largely conceptual in nature, proposing functionality for an envisioned SCM system. This was followed by a wave of articles describing individual case studies of specific companies developing their own customized SCM systems (Harrington, 1996).

While customized approaches still appear in the literature (Lin *et al*., 2000), emphasis has transitioned to the use of commercially-available SCM software. According to reviews in the literature, this software has spread through the market and reached maturity in the past 80 years (Waltner, 2000). The interpretation of what functionality is required for supply chain management varies widely among vendors. This results in a spectrum of diverse software approaches and functionality, all labeled as SCM. As noted in Table 1, the functionality

Table 1: Representative features offered in SCM software

Order management
Order entry and processing.
Lead time management.
Delivery schedule management.
Standardized report generation.
Decision support.
Projected order scheduling.
Customer credit and pricing.
Electronic data interchange.
Vendor complaint data.
Projected cash and resource flow.
Internet-based links.
Autogenerated correspondence.
Inventory management:
Inventory control.
Demand forecasting.
Determination of volatility of demand.
Replenishment logic for reorder and safety stock.
Inventory costing.
Productivity tracking.
Production scheduling across the supply chain.
Production tracking across the supply chain.
Supplier databases.
Lot sizing.
Supplier performance rating.
Distribution process planning.
Standardized report generation.
Warehouse management:
Warehouse location.
Transportation management
Distribution routing.
Shipment planning.
Online picking/shipping.

may be categorized by order management, inventory management and warehouse management capabilities. These also may be characterized both in terms of focus as well as technique.

As noted by Hicks (1999), the fundamental approaches used by SCM software are either information-oriented or traditional logistics-oriented. The first approach stresses information as the key to supply chain improvement. It focuses on collaborative planning, sharing information and getting companies synchronized with suppliers and customers. It also focuses on synchronizing internal departments and divisions so that they can be centrally controlled and coordinated. The second approach is rooted in the more traditional supply chain paradigm. It focuses on applying high-powered numerical analysis to large data sets in order to solve extensive planning problems through analysis and optimization.

Hicks (1999) further characterizes these software systems, which map back to the previous categories. One subset, within the information-oriented approach, emphasizes organizing, executing and tracking the millions of transactions that operating a complex business entails. This subset has directly applied the concepts of ERP across the supply chain. Very large-scale software systems, such as Baan, SAP and Oracle, are representative of this type (Hicks, 1999). A second subset, within the information-oriented approach, focuses on matching the supply and demand portions of the business, instead of tracking individual transactions. It acts a bridge to the second major approach, discussed previously. Most of these software systems utilize sophisticated algorithms for demand planning, production planning and scheduling across the supply chain. Manugistics is a leader in this area (Cameron, 1999). The traditional supply chain approach is represented by very specific optimization tools. These softwares focus on very limited areas of operation, such as vehicle routing, or warehouse location (Elliot, 2000). CAPS Logistics provides software representative of this area.

Current procedure: Each SDG obtains data to support their analysis, from a variety of internal and external sources. Data obtained from the suppliers normally address production volumes and scrap quantities. Reporting content, extent and format vary considerably among suppliers. Some suppliers are unwilling to report certain values. Although, Excel spreadsheets are frequently used, suppliers also use other software or hardcopy forms to convey their information. This necessitates rekeying or some other translation step by the SDGs.

A variety of internal data sources are also utilized by the SDGs. Methods of accessing these data sources vary. As with the external supplier data, some level of translation/conversion is necessary. Data from hardcopy reports must be rekeyed into the SDG's PC, normally to a spreadsheet, before any analysis can take place. Some files are Access-based. These are converted to Excel, which is the common software of choice for SDG analysis. Specific data of interest are "cut-and-pasted" to an Excel spreadsheet. Qualifier columns may then be established to further characterize the supplier performance defect. Totals (by week, by month) are calculated and the results are usually converted to line and bar charts. These charts are later incorporated into the SDG Powerpoint presentations.

These Powerpoint presentation files are sent by each individual team to the SDG website administrator for archiving on the company intranet. This website is programmed in Lotus Notes and exists on the company server. Once converted, the Lotus Notes file becomes another selectable link on the company intranet website.

Assessment of current situation: Responses from the SDGs indicate the perception that the current process is cumbersome to obtain data and time-consuming to analyze it. Accuracy of the data is also a concern (due to different interpretations of its meaning). SDG stated preference would be for a single data source to automatically generate scorecard and chart output. SDGs lack a consistent approach beyond the basic procedural guidelines. Interpretations of these guidelines vary, along with the tools that are utilized.

Certain short-term solutions are currently underway, which address these requirements for improved efficiency, to a limited degree. The electronic productivity aids, provided as part of a previous project task deliverable, represent a first iteration of this solution. They provide a suite of standardized software tools from which the SDG may input data directly to one of a series of templates, in order to generate the required chart output. The templates provide a standardized format for the analysis and reporting of an individual supplier's performance. The software was programmed in Excel, in order to interface with the existing hardware and software assets (i.e. Microsoft Windows environment executing on networked IBM-compatible microcomputers) at the company. Excel also provided the active processing functionality necessary, both to support the user requirements and to adapt existing reporting features. Major modules of the software include templates for status, standard charts (e.g. for generating line, bar, pie, radar, fishbone and Pareto charts) and reporting formats consistent with VDA 6.3 (the German automotive standard).

Emphasis in the existing approach solely emphasizes the analysis of quality problems. The current simple analysis methods appear adequate for this purpose. However, there appears to be a need for consistent standards and thresholds. Output of the SDG analysis tends to be fragmented. Each SDG conducts their own analysis, presents their results and sends copies of this presentation for archiving on the company intranet. Although, the website appears to be an effective means of disseminating the information, it is a passive repository. Another facility is needed which would conduct analyses across the multiple SDG teams, as well as across multiple months of data.

Information system plan: As mentioned previously, the electronic productivity aids are considered to be a first iteration in a comprehensive systems solution, as well as an initial module from which a more extensive information system may be developed to better support the needs of the SDGs and company management. This expanded system consists of the productivity aids, a consolidated input database, an output archive, an Executive Information System (EIS) and linkage to the existing SDG intranet website (Fig. 1). The largest deficiency of the current approach is the inability to conduct analyses across multiple suppliers, across multiple months.

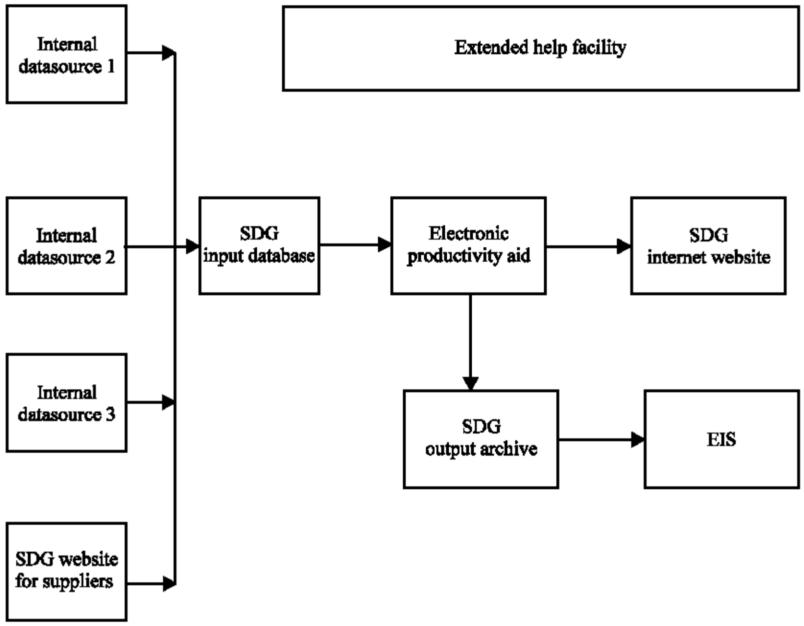

Fig. 1: Information system plan

According to this information system plan, the first step in developing a more extensive SDG information system is to construct a new data archive. Multiple supplier directories would comprise the new archive and would be used to support further analyses. The current SDG intranet webpage could not be used as the archive, in this case, due to the constraints of the Lotus Notes software.

The purpose of the new archive is to provide a single data source to support the Executive Information System (EIS). An EIS is a software system designed to support the informational needs of senior management. It is characterized by Watson *et al*. (1991) and Watson and Frolick (1993):

- An easy to use and maintainable graphical user interface.
- Integrated capabilities for data access, analysis and control.
- Analysis and report generation across multiple data sources.
- On-request drill down capability.

This last capability allows the pointing and clicking on a specific data field for which the user desires an additional level of detail. As a result, the components of that data field are then displayed. EIS systems frequently have a top-level menu featuring stoplight statuses. Red, yellow and green lights are indicated based on comparison to preset thresholds. Clicking on any of these stoplights allows drill down to the desired level of reporting, in order to indicate the source of any problems.

Several EIS software shells are commercially available, which allow customization to individual company needs. This customization may not include all of the templates required by the company, however. Alternatively, the EIS could be coded directly using a programming language. In this way, the functionality of the electronic productivity aids could be assimilated directly into the EIS. While this approach would streamline the extended SMG information system, it would also entail more time and labor.

The next step, as described in the information system plan, involves simplifying the source of input for SDG analysis. It was recommended that the internal data sources provide a periodic standardized data update to a common SDG input database. Another source of SDG data is the supplier. It was recommended that a new internet website be established to provide a common framework for obtaining this data. The website would be secured to allow input by authorized representatives of the supplier companies. The data would then be time/date stamped and stored in the SDG input database under the appropriate directory. It was noted that the existing SDG intranet webpage cannot be easily modified for this purpose. The entire company intranet is currently secured against outside access. Its reliance on Lotus Notes software makes it incompatible with the analysis software used by the SDGs. It was further noted that this new website would only facilitate vendor input in a consistent format. It would not solve the problem of specific vendor reluctance to share data with the company. The existing SDG intranet webpage appears otherwise adequate for its role in disseminating information.

The establishment of a help facility was also described in the information system plan. It should be accessible across the individual modules identified for this extended SDG information system. The help facility would provide a set of written procedures and instructions for using the system. It would provide definitions of terms, as well as recommendations for standard thresholds.

DEVELOPMENT APPROACH

Review of the information systems plan indicated that the requested functionality of a requested supplier performance information system mapped to that of the combined EIS/output archive. The scope of this design thus addresses these combined modules as the basis for the supplier performance information system, within the context of the more extensive integrated system.

A Commercial Off-the-Shelf (COTS) product was recommended for developing the supplier performance information system. A COTS product is not an EIS per se, but rather a set of software tools with which to construct an EIS. They generally include the capability for constructing standard executive information features, such as picture menus, icons, hotspots, key performance indicators and drill-down. Utilization of a COTS diminishes EIS development cost due to the availability of such product-specific data manipulation tools. The literature review indicated that subsequent maintenance costs for a COTS-based system would be substantially less than in-house development.

The COTS products were reviewed for their applicability as a software platform for this system. This review was accomplished via internet search, as well as review of software magazines and journals. This led to identifying twelve products whose capabilities potentially matched the project requirements. The softwares were then evaluated based on eight criteria (i.e. user friendliness, drill-down capability, charting facilities, reporting facilities, integration with Excel, customization capabilities, operating environment and security capabilities). Analysis resulted in recommendations for a make/buy decision (i.e. whether to code all system functionality directly from a programming language, or to purchase and utilize the prepackaged capabilities of a COTS product). The company has a set of unique reporting requirements, however. Although, several EIS software shells allow customization to individual company needs, this customization did not include all of the templates requested. The evaluation results revealed that the commercially-available software could not be fully customized to meet the company's needs.

Alternatively, the EIS can be coded directly using a programming language or other application software. In this way, the functionality of the electronic productivity aids could be assimilated directly into the EIS. It was determined that the system would be programmed in Excel and Visual Basic application software. These softwares are capable of supporting the requested functionality, as well as linking to the SDG productivity aid software.

SYSTEM DESIGN

The largest deficiency of the current approach is the inability to conduct analyses across multiple suppliers, across multiple months. The first step in developing the supplier performance information system was to construct a new data archive. The common archive contains the monthly Excel analyses, conducted by the individual SDGs, via the productivity aid software. Each Excel file is identified with a standard naming convention, based on the date of analysis, the type of productivity aid template used (e.g. Pareto analysis) and the name of the specific supplier. Since, Excel supports analyses across multiple files, the new archive can be used to support further analyses by aggregating the data to the overall program level.

The supplier performance information system supports the concept of data-tiering, or "drill-down", in the subordinate applications. This concept allows users at various levels of the company SDG's to see data details relevant to their position and viewing responsibility. Users at lower levels can view data details specific to their individual supplier (e.g. outer door panel defects), while users at higher levels can view summaries across multiple suppliers. All levels are able to track SDG data across multiple months. Drill-down capability exists for visibility to further levels of detail. Multi-level security for data access was established.

Input specifications: The productivity aid software provides the medium for input to the common database archive. These input files, recorded in the common data archive, in turn are used by the system to generate the desired output. Input files are categorized based on: Supplier Development Group, specific supplier, report category and report name.

The archive storage structure is based on these categories. To further clarify the storage system in the data archive, consider this example. Each SDG has its folder with a specific name, e.g. Exterior Trim. This folder has subfolders for all the suppliers handled by this Supplier Development Group (Exterior Trim). Each supplier then has four subfolders pertaining to four different categories of reports, e.g. Status Reports. These reports have been further classified into subreports, which are part of these overall categories. The productivity aid output is stored on its specific location, in the archive, based on the date input. Based on the nature of the supplier performance information required by the company, the archived data is divided into two different categories: Productivity aid output and performance output.

Processing specifications: The main screen of the supplier performance information system is designed to feature spot light statuses. Red, yellow and green lights are indicated based on the threshold values provided by company management. The system automatically compares the current position with respect to the threshold values and reflects the determined status against a specific area for a particular customer. Management has the option to change the threshold values, access to which is restricted by password. Sometimes a specific target number (in addition to the % value) will be required to support the subsequent threshold and comparison logic. The Category Number, noted below, refers to the RYG Threshold Logic to be used. In each case, the Actual Number is compared to the Target. The default target number is 10, while the default percentage is 5%. The threshold logic used is indicated in Table 2.

In order to conduct a comparison for a single supplier, for a single month, the system merely compares the Actual to the Target and applies the RYG threshold logic noted above. Consideration of a single supplier, for multiple months, requires the calculation of an Average Target and an Average Actual (both calculated based on the range of months indicated by the user). These average values are then compared using the RYG threshold logic. Consideration of multiple suppliers for a single month, as well as multiple suppliers for multiple months, are handled analogously.

The Category III criteria are used for Pie and Pareto charts, where the conventional RYG logic does not apply. The color used for the status block, in this case, is white. Category III values are not used in calculating averages for the comparison logic. These charts require additional logic. The “Type” field, in these reports, must be identical in order to compare the following ranges:

- Single supplier for multiple months.
- Multiple suppliers for a single month.
- Multiple suppliers for multiple months.

Table 2: RYG logic

	Status	Criteria
Category I		
	Green	If Actual is <= Target Value
	Yellow	If Target Value < Actual <= Target Value +5%
	Red	If (Target +5%) < Actual
Category II		
	Green	If Actual is >= Target Value
	Yellow	If Target Value > Actual >= Target Value -5%
	Red	If (Target -5%) > Actual
Category III		
	RYG criteria do not apply	

If the “Type” fields are not identical throughout the ranges being analyzed, then the error message, “Comparison is not possible due to differing data content.”, is displayed. Assuming that the “Type” fields are identical across the ranges being compared, the system will calculate averages and apply the RYG threshold and comparison logic discussed previously. In addition, the Pareto Chart logic will use a calculated Average Value for each Type, then will combine these to calculate a cumulative total.

Depending upon the status indicated by this logic, the user can drill-down to lower levels of detail. Coding to add these features was done in Visual Basic for Applications software. The entire code was saved as macros in Excel. The system is capable of providing the comparative status among different suppliers and across different months. For the security of data access, password protection is provided to access the drill-down feature.

User/system interaction: Once the user enters the system, the opening screen is displayed. This is followed by password control. The supplier performance information system provides three basic types of outputs. These include: Spotlight statuses, periodic reports and analysis across multiple suppliers and multiple months. The supplier performance information system top level menu is referred to as the Company-wide Supplier Selection Matrix (CSSM). The matrix categorizes data access based on the options available from the productivity aids software. Each analysis category is segregated across the individual suppliers. The CSSM provides a “hotspot” button at the intersection of the reporting categories and the supplier identifiers, indicating the RYG status. The user activates the button by moving the mouse cursor to the desired intersection and clicking.

After making a selection from the CSSM matrix, the user is presented with either a subordinate matrix or a dialog box, which contains other options. The user will then make the desired selection utilizing either the mouse or the cursor control keys. From this screen the user can view different reports for the supplier for different months. A similar screen appears for each of the suppliers and is used to pull different status reports from the common database. After clicking on the button (for a particular report), the next screen will request the month for which the user wants to see that report.

Once the selection is made, the appropriate subsystem module is executed. Utilizing a graphical user interface, the user is provided requested information from the server database in the form of graphs, tables and charts, consistent with the format of the productivity aid software. The user is then able to drill-down to the desired level of detail using either the mouse, navigational buttons, or icons. The third type of output that the supplier performance information system provides is an analysis across different suppliers and different months. This analysis can be carried out only for specific reports (based on performance data in the archive).

From the main screen, the "Multiple Suppliers" option allows the user to compare the reports across different suppliers. The system is capable of analyzing the above-mentioned reports across multiple months. Using the drill-down button, the user can view different options (i.e. reports) that can be compared. For example, the user can choose to see the comparative line charts for the cockpit display suppliers, upon clicking the appropriate button. The comparative line chart screen then will appear. Similarly, a comparative bar chart may be generated.

The Standard Score Card, provided in the productivity aid software, shows an SDG assessment with red, yellow, green and blank colors placed against 23 different assessment criteria, e.g. management responsibility, quality system, corrective and preventive actions. These assessment criteria are common to the automobile industry (Batson *et al*., 2001). With the supplier performance information system, management can also view the SDG assessment across different months or for different suppliers for a specific month.

VERIFICATION AND VALIDATION

Verification is the process of determining how well the system performs with respect to its intended role in actual practice. Conventional software verification techniques were used to evaluate the integrity of the supplier performance information system, utilizing a library of predetermined test cases. Each of the subordinate programs and functions were verified individually. Modules were evaluated individually by similarly running a series of tests. The complete system was then verified to insure that the integrated modules behaved as expected.

Validation determines if the system completely and accurately addresses the problem domain and that it achieves acceptable levels of performance. A variety of literature sources were reviewed for common procedures for establishing content validity (Kroenk and Hodch, 1994). Face validation (essentially having a domain expert evaluate the system at "face value") is a common approach. A face validation of the system was conducted with the research project client to obtain customer feedback In parallel, the productivity aid software, output archive and the supplier performance information system were implemented on the workstations of four SDG team leaders. This field validation was accompanied by reviewing the completed system and associated documentation with the SDGs. The following month was allocated as a beta test period. During this period, the SDGs applied actual supplier performance data to the system and evaluated the results.

Based on subsequent user recommendation and feedback from the face validation and beta test, some programming was reformulated and restructured. Customer emphasis was on improving the capabilities for modifying the list of suppliers used by the system. Efforts have been made to simplify this process, within the constraints of the Excel-based structure. Pareto analysis processing, within the productivity aid software, was also improved.

CONCLUSION AND KEY BENEFITS

The University research team conducted a software needs assessment regarding supplier management at a major automobile manufacturing plant. A phased plan for SCM software support was formulated, ranging from the initial development of simple electronic templates to serve as productivity aids, to a full-scale integrated information system. The keystone of this architecture is the supplier performance information system. The general functionality and structure of this system is consistent with that of an EIS and is thus applicable to many industries. The nature and content of the specific output displays and reports are configured for the automotive industry, in general and the company's unique requirements, in particular.

The objective of the supplier performance information system is to provide company management with accurate and timely data that will improve supplier management efficiency. Additionally, the system will reduce time spent analyzing data and the uncertainty associated with the decision-making process. The supplier performance information system includes the capability to track multiple supplier performance metrics. It has the capability to aggregate data, obtained from individual SDGs, to provide insight into overall program status. It also combines/compares these data in various ways, as well as aggregating them into an overall SDG program metric. The system is networked-based and was designed to utilize the company's existing hardware, software and communications assets to the fullest extent possible.

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