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# IMPLEMENTATION OF ENTERPRISE ASSET MANAGEMENT USING IT TOOLS: A CASE STUDY OF IB THERMAL POWER STATION

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## ABSTRACT

The paper reports the implementation of Enterprises Assets Management (EAM) System at IB Thermal Power Station. The paper covers the methodology adopted in implementing the EAM besides highlighting the structure of the organization, study and scope of Business Mapping Report. The paper highlights the Data Flow Diagram of the processes involved and describes each activity in detail and its solution in EAM. The paper also highlights the configuration and technical implantation of the solution and post implementation experiences. At the end the paper discusses the limitations and the future directions.

**Keywords:** Business Mapping report, Dataflow Diagram, ERP (Enterprise Resources Planning), MRP (Manufacturing Resources Planning), CMMS (Computer Maintenance Management Systems)

## INTRODUCTION

Any equipment, building or system (road network, real estates etc.) that requires maintenance can be defined as an asset [1]. Asset intensive industries are those where the return on assets (ROA) has a major impact on profitability. Operations and maintenance expenses in asset-intensive industries are typically above 50 % or more of their revenues. In a power plant or a telecommunications industry, any equipment breakdown can create chaos and upset profitability. Continuous,

satisfactory operations depend upon asset availability rather than on full demand. Hence capacity planning is an outcome of accurate predictions on asset availability. Companies in the utility (power, water, sewerage etc.), capital-intensive (cement, pulp and paper etc.) industries and those that need to maintain sophisticated systems (hospital services, building services, traffic networks etc.) fall under the asset-intensive category of industries. Till date, asset centric enterprises addressed these issues by integrating computerized maintenance management systems (CMMS) with individual applications for accounting [5], customer management, and so on.

However, with real time integrated information becoming a critical component of the competitive strength, this piecemeal approach to information management no longer works. Enterprise asset management (EAM) is a recent concept [4] that is currently gaining acceptance in asset centric organizations where maintenance activities have to be closely coordinated with other enterprise-wide functions like inventory and purchasing management, employee administration, and so on [1]. This is boon to managements faced with tight profit margins and a bouncy market for which profitability depends on the ability to leverage the investments in equipment and other facilities. EAM solutions focus on maintenance operations, the principal cost driver in asset centric industries. EAM solutions can support the entire enterprise operations (across locations, if necessary) on a single database and enables the integration of specialized, best-of-breed applications.

The competition in the utilities industries has never been so stronger earlier. Deregulation of policy, increased environmental consciousness, and the commoditization of products and services give rise to a new challenge of low cost, high service provider. In the electric utilities segment, new generating capacity can be built and operated at substantially lower prices than that charged by the existing players, and open transmission access gives electricity customers more choices of wholesale electric suppliers. To remain competitive, utility managers must maximize productivity by closely integrating an asset management strategy with overall enterprise functions. Emphasis on continued operation of the plant at any cost resulted in undue importance to preventive maintenance programs that inevitably resulted in over-maintenance and high maintenance repair and operations (MRO) inventory levels. Secondly, lack of proper systems for continuous monitoring of asset health can result in accelerated asset wear and tear, increased maintenance costs and under-utilization of assets. The approach of the utility industry to this problem has been to rely on computerized maintenance management system (CMMS) solutions or in-house software to address maintenance requirements [3]. While these approaches have short-term benefits, a long term solution requires a more comprehensive approach covering the entire spectrum of business practices in the enterprise. They are i) Maximizing capacity utilization at the lowest servicing assets; ii) Empowering employees by providing timely and accurate information; iii) Coordinating maintenance and operations, resource handling and increasing operational efficiency; iv) Monitoring the progress of new investments, capacity additions; v) Adhering to operational and environmental safety as per the prescribed

standards; vi) Integrate all functions and processes of the enterprise, deriving benefits across the value chain.

Maintenance of assets has evolved from a reactive or “fix it when it breaks” mode to a pro-active mode. The organizational approach towards maintenance has undergone a radical transformation – management has now realized that optimal maintenance practices are possible and contribute to overall profitability. This Case Study will explore Enterprise Asset Management System being implemented at IB Thermal Power-generating Station (IBTPS). Though the EAM application model is relatively new, it is gaining popularity in the asset-intensive and process-centric industry segments, providing proven benefits in comparison with traditional Enterprise Resource Planning (ERP) systems [6], [7], [8]. The focus on maintenance also meant the necessity to include it as a part of the total enterprise system. For an effective asset management strategy, the supporting roles of procurement, financial and resource management have to be well connected. In most utility companies however, this information is scattered over disparate systems, some just confined to the knowledge of the employees, which delays decision-making. It is sure that, in future this solution has to replace a maintenance specific application with integrated EAM.

Section 2 briefly describes the organization of IB Thermal Power Station. Section 3 highlights the about EAM and ERP System implementation. Section 4 discusses the Gap Analysis and outlines the preparation of Business Mapping Report for the Implementation. Section 5 outlines the Data Flow diagrams of the functionalities of EAM to be implemented. Section 6 outlines some of the customization procedures developed for retrofitting existing functionality in the EAM Software and successful implementation. Section 7 concludes the case study with a brief outline of post implementation experience and future area EAM to be explored.

## **Brief Description of IB Thermal Power Station**

IB Thermal Power Station is a unit of the Joint Venture of Orissa Power Generation Corporation Ltd. and AES Corporation, USA. Orissa Power Generation Corporation Limited (OPGC) was started as a wholly owned Government Company of the State of Orissa with the main objective of establishing, operating and maintaining large Thermal Power Generating Stations. As its maiden venture, the company established IB Thermal Power Station having two units of 210 MW each in the IB valley area of Jharsuguda District in the State of Orissa. The location advantage of the power plant lies in its close proximity to the coalmines as well as to the Hirakud

Reservoir. This gives the company the distinct advantage of low cost of Raw Material leading to low cost generation. The entire generation from these units is committed to Gridco – the state owned Power Transmission and Trading Company on the basis of a long-term power purchase agreement. As a part of the reform in the energy sector of the state, 49% of the equity was divested in favor of a Private investor i.e. AES Corporation, USA in early 1999. IB Thermal Power Station is having a well-organized Departmental Structure for operating and maintaining the Plant in an efficient and cost effective manner. The Departmental structure is broadly classified into Operation, Maintenance, Warehouse, Purchase, Personnel and Administration, Finance and other allied services. The different areas of the plant are Main Plant area, Ash Handling Plant (AHP) and Ash Recycling System, Coal Handling Plant (CHP), Water Treatment Plant (WTP), Cooling water system and Switchyard. Operations Department again classified into Main Plant Operation, CHP Operation, and WTP Operation and AHP Operation. The Maintenance is classified into Electrical, Mechanical, and Control and Instrumentation. These three groups of Maintenance teams handle the entire maintenance activity of all the areas. The Warehouse maintains the entire inventory for the day-to-day maintenance of the Plant. The Purchase Department takes necessary step to procure materials as per the Maintenance Department's requirement as well as makes planning along with the Warehouse to maintain the inventory of the critical items. The Personnel and Administration Department looks after the HR Activity of the Organization and the Finance Department looks after accounting, Bill Passing, Payroll Management etc. Other Service departments such as Efficiency, Contracts, Environment, Health and Safety etc. are looking into energy management, contracts management, environmental management and Safety Management respectively. There is a Maintenance Planning Department, which manages entire maintenance activity of the plant in co-ordination with all the Maintenance Department. This Department carries out various tasks such as Planning, scheduling Annual Shut downs, recording history of problems and cause of problem after closing any maintenance job, keeping the running hour of each and every equipment, Cost analysis and Cost Control of maintenance jobs, maintenance Budgeting etc.

The Information Technology Department looks after all IT needs of the Organization. IBTPS has an established Local Area Network based on Fast Ethernet Fiber-Optic Backbone and Structured Cabling System. This is to interlink various areas like Operations and Maintenance, MIS, administration, Finance, Central Store, Coal Handling Plant, Workshop, Water Treatment

Plant and Switchyard. The Network is implemented using 6 core Multimode Fiber Optic Switched Backbone and Fast Ethernet Structured cabling System in various departments providing connectivity to users. Remote users are accessing the network through dialup facility with the existing Intercom telephone lines.

The Maintenance Department carryout maintenance jobs after getting request from the Operation Department. These are either breakdown or defects in any system. The Maintenance Department carries out Preventive maintenance jobs as planned by the maintenance Planning Department. Maintenance People schedule the manpower, Spares and Consumable for the maintenance job. They submit their inventory requirement to the Warehouse. Warehouse issues the material to the requester if it is available in the store, else gives its request to the purchase Department to initiate procurement action. It is also possible for the Maintenance Department to give their request for procurement directly to the Purchase Department. Warehouse always tries to keep optimum Inventory by suitable analysis and planning. Purchase department procures the required material and forwards the Purchase Order after receipt of the material by Warehouse to the Finance Department for bill passing. Finance Department finally books the costing to the cost center of the respective Maintenance job.

The company had been using diverse software for diverse functions supplied by different vendors, the software specifications and workflows were disparate. Manual Procedures were followed in various maintenance activities and planning. There was no system for Inventory Tracking. For an effective asset management strategy IBTPS decided to implement EAM system and procured the RAMCO e-Application [9]. Initially only three main modules (Maintenance, Purchase and Inventory) are implemented [10]. The Ramco e-Application is a complete Enterprise Asset Management (EAM) for utilities. It is an integrated client-server based EAM solution that integrates core maintenance functionality with other enterprise wide functions covering Inventory, Purchasing etc. The Implementation of the EAM was carried out through the following steps.

1. Training of the Project Team: The first step is to give a broad level training to the Project Team on the base functionality of the product being implemented.
2. Study of Scope and Business Mapping Report: A thorough business process analysis and requirement study was carried out with interactive involvement of the maintenance engineers; pre-analysis was done on business model, workflow, procedures and

requirements. Mapping of the ERP with desired functionality and identification of the gaps was carried out. Deliberation on the criticality of the 'unique processes resulting the gaps and discussion whether these gaps can be minimized through the use of the alternate processes provided in the absent functionality of the ERP. Deliverable at this stage is the Business Mapping Report, which outlines the process requirements in detail, and how they are met in the ERP with screen shots. Documenting the gaps and the approach to catering to the gaps from systems perspective. The BMR should also identify the 'Reporting / MIS requirements'. The BMR then becomes the 'Bible' of the implementation.

3. Configuration and Implementation: This was the technical stage where necessary customization and system setting were done as per the BMR. Then the final solution was installed and master data (Item codes, Account Codes, Chart of account, Equipment Codes, task Codes etc.) were uploaded after proper codification for final implementation.

## **BRIEF REVIEW OF ENTERPRISE ASSET MANAGEMENT**

Enterprise Asset Management (EAM) is the new concept for asset centric organizations where maintenance activities have to be closely integrated with enterprise-wide functions like logistics, financial, and human resources management. It is mainly for the companies whose work is based on the Management of the Assets. This means, organizations that insists for obtaining the highest plant availability indices, through Maintenance Plans, which ensures an efficient and effective operation. This software is a byproduct of the CMMS (Computer Maintenance Management Systems), whose basic components are: Maintenance Plan and Inventory Management. Secondly, Enterprise Resource Planning (ERP) is ideal for manufacturing organizations, which is on based on their finite and rough capacity planning on the sales forecasting and market conditions. The three basic components are: Bill of Materials, Item Master and Master Production Schedule.

During the last ten years, major vendors of stand-alone EAM or CMMS packages have reengineered their product suites around the Web and enhancing their global capabilities. Additionally, they have been adding capabilities such as e-commerce, fleet management, facility and property management often by partnering

with specialized players to be more competitive in various niches. They are targeting large existing customers in process industries such as petrochemical and oil refiners as well as mining and metals processing and hybrid sectors for their value-added services. However, the major challenge of these vendors is to win increased acceptance among discrete manufacturers that have not readily purchased this increasingly proven productivity tool in the past, and which has been ERP vendors' fertile area.

Importantly, EAM solutions are distinct from ERP (enterprise resource planning) solutions, which is a derivative of manufacturing resource planning (MRP) and was developed to cater to the needs of discrete processing industries (e.g., automobiles). Subsequently ERP applications grew to accommodate the needs of process manufacturing industries (e.g., oil refineries, food and beverages) by adding functionality specific to these industries. However, ERP solutions focus on the revenue earning end products of an enterprise. While they are well suited to handle planning, manufacturing and customer management, they are of limited use when it comes to handling asset management activities where the maintenance related activities are central to operations.

### **Essential requirements of an EAM solution**

Maintenance personnel in most industries face common problems such as: work management, adherence to regulatory / safety procedures and guidelines, work crew allocation and utilization, budgeting and staffing constraints, and above all, a highly reactive and disorganized work environment. It is estimated that one third of the productive time in maintenance departments is spent searching for manuals, drawings and documents, obtaining work permits, as well as coordinating with accounting, purchasing and inventory for spare parts management. In an industry where asset unavailability has a big impact on profitability, any disruption of schedules will mean diverting senior management attention and intervention to speed up such fire-fighting activities. In this situation an EAM system can offer maximum benefits by combining the power of technology, information integration and workflow capabilities to increase the productivity of the maintenance organization. In addition, EAM systems also transcend traditional work order based preventive/predictive maintenance practices to incorporate in-process asset health tracking mechanisms to record equipment condition and recommend pro-active action to maintenance personnel. An effective maintenance environment is based upon an exhaustive equipment database, online work crew and material planning, electronic document management besides

tracking costs comprehensively to have a complete picture of the assets.

In asset-intensive industries, improperly administered and inherently unsafe maintenance practices have led to many disasters, over 70% of which are attributable to human factors. Loss prevention is an important component in utilities, fleet as well as process industries where safety practices are a high priority area since it has operational, environmental, social and legal repercussions. For instance, in a power generation company where EAM was implemented, the need was to isolate equipment for safety purposes, before maintenance activities could be carried out. The Clearance Permit system of Ramco EAM ensured that the operations and safety personnel were notified (through workflow) of any maintenance request, as soon as one is raised. The operations personnel would then carry out the standard isolation procedures like de-pressurizing the container or electrical disconnection. The safety personnel would confirm the availability of adequate ventilation, readiness of fire-control measures etc. Care has to be taken that the clearance activities on equipment do not in any way affect other equipment. Once confirmations are received from both the departments (communication through workflow), the maintenance activities are carried out. On-line Standard operating guidelines and attachments of AutoCAD files guide the worker in executing his tasks without danger. On completion of activities, the equipment is returned for operations.

Since the knowledge base of an EAM system is built using input from many sources, EAM systems are typically configured for widespread deployment. EAM systems are designed for collecting information from various functional departments through transaction input from desktops, bar coding devices, Internet browsers, and handheld monitors in order to accomplish enterprise-wide information availability. An EAM system should ideally be equipped to provide the following practices:

**Work management:** This process interprets and acts upon information from process control systems, creating a pro-active approach to maintenance activities; integrate production and asset-care related work management information with the supporting enterprise activities such as accounting and financials, materials and purchasing etc.; and interface with bar code devices, hand-held computers for data acquisition. The benefits of this process are: i) Single reference database and all information will be available on-line; ii) Improved speed and accuracy of field data collection; iii) Point-of-performance corrective actions and v) Reduce time spent on fire-fighting and administration

**Inventory and Purchasing:** This provides for various stock planning methodologies taking into account the various lead times and opportunity costs, communicate electronically with customers and suppliers and gives on-line visibility of stock across locations. The advantages of this process are shortened lead times, reduced inventory costs, improved customer, vendor relationships and higher serviceability

**Regulatory compliance and Knowledge management:** This process aids building in (process) checks for employee and equipment safety, stores records electronically on safety and regulatory compliance (cost of shutting down in asset intensive industries is prohibitive and unrecoverable) and creates a congenial working environment that encourages employees to share information, innovate on best practices which can be easily implemented through the system

**Financials and Human resources management:** This process tracks material consumption, labor, downtime, energy and other costs for all activities and aids in benchmarking of processes, ability to capitalize costs for depreciation purposes and for asset retirement, replacement decisions, maintain on-line resource database of employees, contractors, their availability, skills and so on.; administration support for payroll, grievances handling, career planning etc.; information on time, to the right person

Maintenance departments have to contend with a staggering inflow of unstructured information, usually across disparate systems such as on engineering drawings, budget data from financial systems, vendor and purchase details, breakdown information, safety procedures etc. Besides, considerable knowledge is locked up in the minds of employees. EAM captures this vast database of information across functions and integrate it on a single platform to enable all transactions to be based on this information. Intranet and extranet supported EAM systems provide a new dimension to information sharing and access to employees, customers and suppliers. For instance, a maintenance employee can access the intranet to locate similar problems encountered in a sister plant, improving the speed and quality of response. Online enquiries and quotations speed up purchase order placement and follow-up. An EAM solution, by virtue of bringing all departments and even companies together, ensures that productivity gains or cost savings realized through better business practices in one location get replicated everywhere else.

**Comparison of CMMS and EAM:** CMMS deals strictly within the confines of the work order and preventive maintenance activity. Specific functions include the following: i) Scheduling preventive maintenance based on triggers (such as hours of operation) or timed events (for example, every three months); ii) Ensuring probability-based availability repair and spare parts; iii) Serial number tracking and tracing; iv) Suggesting and originating the purchase of needed repair parts; v) Warranty tracking; vi) Ensuring availability of manpower resources with required skills and training; vii) Maintaining an asset registry and repair parts database (i.e. nomenclature, hierarchy structure, where used, support descriptions, etc.); viii) Tracking costs of maintaining individual pieces of equipment; ix) Differentiation and appropriate management of fixed, mobile, and continuous assets; x) Recording unexpected events for further analysis.

Where as, EAM enables optimized planning, shortens response times and better knowledge management, by comprehensively integrating the maintenance function with the key enterprise areas such as inventory, Purchasing, Financial and Human resources management. This will result increased asset availability, better resource utilization, reduced maintenance and inventory costs and tighter control on financial transactions. EAM is based on the client server architecture and developed on Microsoft Windows NT platform using SQL Server database and development tools like Visual C++ and supports both distributed and centralized computing. The built in Software tools enables the user to define custom menus and MIS reports without any additional programming. The various features of EAM are listed below.

**Maintenance management:** This process includes i) Unscheduled breakdowns minimized through planned maintenance; ii) Interface with real-time data acquisition systems; iii) Clearance Permits for safe and secure maintenance operation; iv) Decreased mean-time-to-repair through optimal utilization of resources; v) Rule based preventive maintenance schedules and condition based monitoring; vi) Equipment history analysis for preventive / corrective action; vii) Plan and monitor shutdown activities; viii) Maintenance budgets compare expenses against plan; ix) Automatic routing work requests and work orders.

**Spares and Inventory Management:** This includes i) Lower costs through enterprise wide visibility of inventory; ii) Reserve and allocate critical items / spares for future use; iii) Reduce inventory stocks through optimum inventory holding; iv) Tracking inventory stocks

through online stock-status check; v) Improve materials management by analysis of consumption pattern.

**Purchase and Contracts Management:** This includes i) Reduce tendering and order time through vendor database detailing products and terms for each vendor; ii) Trigger automatic purchase requests and Purchase orders based on inventory planning parameters; iii) Track vendor performance through vendor analysis and rating; iv) Reduce procurement lead-time through electronic ordering and tracking of purchase orders.

**Maintenance and Financials:** This includes i) Costing of maintenance expenditure; ii) Managing assets including acquiring, capitalization of maintenance costs, depreciation and retirement.

**Materials and Financials:** This includes i) On-line stock status and valuation; ii) Multiple valuation methods (standard cost, weighted average, LIFO, FIFO)

**Maintenance and Materials:** This includes i) Automatic reservation of spares; ii) Automatic generation of purchase request on stock non-availability; iii) On-line check for stock status and future stock availability

**Maintenance and Human Resources:** This includes i) Employee availability; ii) Employee skill sets and rate profiles; iii) Training Records

## BUSINESS MAPPING REPORT

Preparation of Business Mapping Report (BMR) after scoping study is the most critical and important phase of implementation. The entire implementation is based on the final BMR document, which is prepared by detailed analysis and understanding of the business requirements through exhaustive discussions with the functional users, mapping of the EAM/ERP with the desired functionality, identification of gaps, deliberation on the criticality of the 'unique processes' resulting in the gaps and discussing whether these gaps can be minimized through the use of the alternate processes provided in the absence functionality of the EAM/ERP. Deliverable at this stage is the Business Mapping Report, which outlines the process requirements in detail, and how they are met in the ERP with screen shots. The BMR should also identify the 'Reporting / MIS Requirements'.

**BMR of Plant Maintenance:** The Plant Maintenance System consists of one component module i.e. Maintenance Operations, coded by MO. The Role of Maintenance Management is to ensure maximum

availability and reliability of equipment for production. With proper use of Preventive and Predictive maintenance and through proper Maintenance Planning, unexpected equipment breakdown and hence production losses can be

minimized. The different Processes of Maintenance Operation are listed in Table 1.

Table 1: Maintenance Operations Process/Component

Sl. No.	Process	Name
1.	MO-01	Preventive Maintenance
2.	MO-02	Inspection / Condition Monitoring
3.	MO-03	Work Order Processing
4.	MO-04	Maintenance Planning
5.	MO-DN	Master Definition

**MO-01 Preventive Maintenance:** The main objective of Preventive maintenance is to reduce the probability of equipment failure and to keep the performance of the system at its desired level. In preventive Maintenance, plans/schedules are made for equipments to carry out standard maintenance activities like lubrication tasks, replacement of worn out parts, oil change etc. These tasks

are then attached to the equipments with task requirements like spare parts, resource requirements etc. When the maintenance period is opened the system generates the PM work orders for the equipment at the scheduled date and time. The different activities and the detail of each activity are listed in Table 2a and Table 2b.

Table 2a: MO-01 — Preventive Maintenance

Activity ID and Activity Name	Requirements	Solution in EAM	Solution Type
MO-01-01 Attaching Tasks / Procedures with the Equipment	Most of the Equipments have Preventive Maintenance Schedules. Each Schedule has a list of Tasks that progressively builds up with higher Schedules.	Attach all the Tasks or Procedures that are carried out during Preventive Maintenance of each equipment in the Preventive Maintenance Schedules screen.	Direct
MO-01-02 Assigning Tasks Requirements (Parts, Resources)	Many of the Tasks during Preventive Maintenance Schedules require change of some parts or lubricants. Each Task also requires various resources, like Human Resources, to carry it out.	Assign the expected requirements of the Tasks (both in terms of parts and resources) in the Task requirement sub screen of the Preventive Maintenance Schedules screen.	Direct
MO-01-03 Scheduling Preventive Maintenance Tasks / Procedures	Preventive Maintenance schedules carried out from daily to yearly intervals (Fixed Date, Fixed Interval). Preventive Maintenance of some Equipment is also done based on run hours (Usage based Schedule).	The actual scheduling (based on Date or Usage) of each Task or Procedure attached to an Equipment can be done by clicking the SU button on the Preventive Maintenance Schedules screen in the corresponding Maintenance module.	Direct
MO-01-04 Opening next Maintenance Period	At present, there is no concept of Maintenance Periods.	The fiscal years is defined as Maintenance Years, split into 53 weekly Periods.	Process Change Succeeding Activity: MO-03-07

Table 2b: MO-01 — Preventive Maintenance

Activity ID and Activity Name	Requirements	Solution in EAM	Solution Type
MO-01-05 Closing of previous Maintenance Period	At present, there is no concept of Maintenance Periods.	The earliest open Period can be closed as and when all the Work Orders scheduled in that Period have been closed or rescheduled to some future Period.	Process Change Preceding Activity: MO-03-11

**MO-02 Inspection / Condition Monitoring:** Apart from the schedule based Preventive Maintenance there is another type of Preventive maintenance known as condition based maintenance, in which the decision to replace or to carry out any other maintenance activity is done according to the outcome of the inspection result of the equipment. This is used where replacement costs are high. In this process inspection tasks with various parameters are defined and then attached to critical equipments. Then schedules are made for inspecting these

equipments and also predictive triggers are specified which describe the condition in terms of the threshold values of their attribute and range parameters, along with the action to be taken. Whenever the value of a range parameter is updated based on an inspection checklist, a work request or work order would be generated if it satisfies the predictive trigger conditions. The different activities with their detail description are listed in Table 3a and Table 3b.

Table 3a: MO-02 Inspection / Condition Monitoring

Activity ID and Activity Name	Requirements	Solution in EAM	Solution Type
MO-02-01 Attaching Inspection Tasks to Equipment	Most Equipment undergoes regular Inspection Schedules.	Attach all the Inspection tasks and the Corresponding parameters that are recorded during inspection of each Equipment in the parameter Inspection schedules screen.	Direct
MO-02-02 Creation of Predictive Triggers	Maintenance work of some equipment is carried out based on Parameters like vibration, bearing temperature, etc. Defined only when Predictive Work Orders are required to be generated.	Define the Triggers for each Parameter of an Equipment in the Predictive Maintenance Triggers screen.	Direct
MO-02-03 Scheduling Inspection Tasks	Inspection Tasks for different Equipment are scheduled on a daily or weekly basis.	The actual scheduling of each Inspection Task attached to an Equipment can be done through the Parameter Inspection Schedules screen.	Direct
MO-02-04 Opening next Maintenance Period	At present, there is no concept of Maintenance Periods.	Define the fiscal years as Maintenance Years, split into 53 weekly Periods. Automatic Creation of Inspection Work Order (Inspection Checklist). Maximum Number of Periods that can be at open status is controlled through System Parameter.	Process Change



Table 3b: MO-02 Inspection / Condition Monitoring

Activity ID and Activity Name	Requirements	Solution in EAM	Solution Type
MO-02-05 Updation of Inspection Parameters	Corrective Maintenance carried out in case any of the Parameters monitored during the inspection warrant so.	The Parameters in the Inspection Checklists have to be updated in the Parameter Inspection Checklist screen. Automatic Creation of PREDICTIVE Maintenance Work Order if the value of the Parameter goes beyond the specified range. Predictive maintenance activity has to be executed and closed before updating the parameter value	Direct
MO-02-06 Closing of Inspection Checklist	No such practice as of now.	After all the Parameters have been updated, the Inspection Checklists have to be closed to ensure posting into Equipment History. Status of Inspection Checklist becomes closed. Automatic Posting of Inspection Parameter details into Equipment History.	Process Change
MO-02-07 Closing of previous Maintenance Periods	At present, there is no concept of Maintenance Periods.	The earliest open Period can be closed as and when all the Inspection Checklists scheduled in that Period have been closed. List of Work Orders that are not closed would be displayed in the Period Closing screen except Inspection Work Orders. Closing of all work orders before closing Maintenance Periods Is mandatory. The number of Inspection work orders that remain open would be displayed.	Process Change

**MO-03 Work Order Processing:** The most important process in maintenance management is the work order cycle. Work orders are created by (i) authorizing maintenance request, (ii) directly, (iii) from Preventive maintenance schedules, (iv) maintenance Planning. The work order Planning phase is same for all types of work order, in which the maintenance planner schedules the work order by assigning different tasks and task requirements (spare parts and resource) to it. At the end of

this process the work order is ready for release. The work order execution process is the last in work order cycle. At this stage the work order is actually in progress. When the work is completed, the actual details of duration of tasks, resource deployed, parts consumed are entered. Once all tasks are completed and actual are entered, the Work order is closed. On closing the work order the system updates the Equipment History. The different activities are listed in Table 4a and Table 4b.

Table 4a: MO-03 Work Order Processing

Activity ID and Activity Name	Requirements	Solution in EAM	Solution Type
MO-03-01 Maintenance Request Creation	No formal written Maintenance Request is being used in most cases at present, because the User department and the Maintenance department are the same. In case any communication regarding Maintenance requirement has to be made to another department, a written intimation is sent.	Creation of Maintenance Requests is not mandatory. Work Orders may be directly created as discussed in Activity ID MO-03-03. For System based Maintenance Requests, the User will enter the details of problems faced in the Work Request screen in the Maintenance module.	Process Change
MO-03-02 Authorization of Work Request	No such concept at present.	After the Process Change as discussed in Activity ID MO-03-01 above, the Maintenance user will approve the Work Request(s) for Equipment in his location in the Work Request Approval screen.	Process Change
MO-03-03 Work Order Creation	On receipt of information about any Maintenance requirement, the Engineer generates a Job Order. WO can also be generated without request. More than one work order can be generated for single request.	After the Process Change as discussed in Activity ID MO-03-01 above, the Maintenance user can generate Work Orders by approval of Work Request(s) in the Work Request Approval screen. He may also directly create Work Orders in the Work Order screen in the MO module.	Process Change
MO-03-04 Assigning Tasks Requirements (Parts, Resources)	One or more resources, either Human Resource or any other, are required to carry out any Maintenance Activity. Also, Parts may be required for replacement, replenishment, etc. during this Activity.	Assign Items that will be required for a Task along with the Estimated Quantity of each Item in the Task Requirements of the Work Order screen.	Direct
MO-03-05 Scheduling of Work Order	Whenever any Maintenance Activity is initiated, it is scheduled to start at a particular time. A work order can also be 'Rescheduled' to another date	All Work Orders, other than Preventive and Predictive Work Orders, can be scheduled either in the Work Order screen or in the Work Order Scheduling screen. Status of Work Order becomes SCHEDULED	Direct
MO-03-06 Assigning Employee / Resources to the Work Order	After the Job Order is created, the Maintenance Engineer assigns the work to the actual Employee. He might also assign the work to some contract resource as well as allocate other resources for the work.	Once the Work Order has been scheduled, any of the three types of Resources(employee, contract, other) may be assigned to it in the Employee Assignment screen.	Direct

Table 4b: MO-03 Work Order Processing

Activity ID and Activity Name	Requirements	Solution in EAM	Solution Type
MO-03-07 Reservation of Parts required for the Work Order	As of now, there is no concept of Parts reservation. Parts needed for Maintenance purposes are issued from Stores as and when required.	Once the Work Order has been scheduled, the Parts required can be reserved in the Part Availability screen of the Task requirements Flag of the Work Order screen.	Process Change Succeeding Activity: INV-05-01
MO-03-08 Updating Stock Consumption Details	At present, Parts needed for Maintenance purposes are issued from Stores as and when required. Consumption is charged off to the corresponding Cost Center at time of issue.	After the Parts have been reserved, they can be issued from Inventory Module. When the Parts are actually utilized for Maintenance purposes, consumption of the same can be reported in the Stock Consumption Details screen in the MO module.	Direct Preceding Activity: INV-05-01 Succeeding Activity: INV-06-01
MO-03-09 Updating Employee Actual	Details of the work carried out by each Employee in terms of hours put in on each Job Order are not being captured. The daily time or the 'time type details' are also not being recorded.	Complete data capture is possible for each Employee in terms of number of hours of each 'time type' that he has put in on each Work Order. The user, however, will record the details only at the Resource level instead of the individual Employee level.	Process Change
MO-03-10 Closing of Work Order	No such practice at present.	After all the Tasks in the Work Order have been completed and all actual have been recorded, the Work Order has to be closed. This will ensure posting of all Maintenance details into the Equipment history.	Process Change

**MO-04 Maintenance Planning:** In this process maintenance plans are prepared for different situations such as planned annual shutdowns, planned monthly shutdowns etc. The plan is then mapped to all the equipments on which maintenance is to be done. For each

plan the maintenance planner has to specify a plan schedule date at which all the Work orders are to be generated by the system. Once the Work order is generated then it follows the work order cycle. The different activities of the process are listed in Table 5.

Table 5: MO-04 Maintenance Planning

Activity ID and Activity Name	Requirements	Solution in EAM	Solution Type
MO-04-01 Generating Maintenance Plan	The plant undergoes Shutdowns during which Maintenance activities are carried out on all the Equipment. A Project can also be attached to a Plan	Define Maintenance Plans as required in the Maintenance Planning screen.	Direct
MO-04-02 Mapping Equipment to the Plan	Maintenance Activities will be carried out in all Equipment of the plant during the Planned Shutdown. Jobs also can be Performed on Off-line Equipment, selected through Maintenance Planning	All the Equipment that has to be maintained in each Plan will also be specified in the Maintenance Planning screen.	Direct
MO-04-03 Mapping of Tasks / Procedures or Work Orders to the Equipment	Tasks From Preventive Maintenance schedules From Inspection schedules Standard Tasks List Shutdown Tasks from Shutdown work list Procedures From Preventive Maintenance schedules From Standard Procedures List From Shutdown Work List Work Orders All type Attaching Task requirements (parts, resources)	Map all the Tasks/Procedures and Work Orders that have to be carried out in the Maintenance Plan to the Equipment in the Maintenance Planning screen. Inspection Checklists to be carried out before and after the maintenance Plan can also be attached.	Direct
MO-04-04 Generation of Work Orders		After the actual start date of the Maintenance Plan has been finalized, generate all the Work Orders of the Plan by clicking the Generate button in the Maintenance Planning screen. Work Orders gets created equipment wise for the same Plan	Direct Succeeding Activity: MO-03-04
MO-04-05 Closing of Work Orders	Reviewing of Maintenance Plan	Close the Work Orders as discussed in Activity ID MO-03-11 above. All Work Orders belonging to the Plan have to be closed.	Process Change Preceding Activity: MO-03-10

**MO-DN Maintenance Operations (Master Definitions):** This is the component where all the master definitions are defined and entered into the system. These

master definitions are required by all the component activities and are given in Table 6a-c.

Table 6a: MO-DN Maintenance Operations

<b>Activity ID and Activity Name</b>	<b>Requirements</b>	<b>Solution in EAM</b>	<b>Solution Type</b>
MO-DN-01 Category Definition	Problems and their Causes are not being categorized.		Non System Activity
MO-DN-02 Problem, Cause, Delay Master		Define the various Problems encountered in the Equipment, the Causes for these Problems and the various reasons for Delay in carrying out Work Orders in the Problem Cause and Delay Code Details screen. The Problem and Cause Codes will be used for defining the Troubleshooting Guide while the Delay Codes will be used while reporting Work Order Actual.	Direct
MO-DN-03 Inspection Type Definition	Inspection Types are presently not being defined.	Inspection Types have to be defined based on the employees who are assigned a group of Inspection Tasks.	Process Change
MO-DN-04 Standard Task Definition	Almost all the Equipment has Standard Tasks defined.	Define all the Tasks that are carried out on each. Equipment in the Standard Task Details screen. Any Standard Operating Guideline for each Task will also have to be attached.	Direct
MO-DN-05 Standard Operating Guidelines (SOG) Creation	All the Equipment procured from reputed manufacturers has Standard Maintenance Instructions. Work Instructions have also been defined for various Tasks that are carried out on Equipment.	Define all such Instructions as Standard Operating Guidelines in the Standard Operating Guidelines screen.	Direct
MO-DN-06 Standard Procedure Creation	There are groups of tasks that are defined together in various Preventive Maintenance Schedules and Work Orders.	Define these groups of Tasks as Procedures in the Standard Procedure Details screen. This makes the definition of new PM Schedules, Troubleshooting Guides and Work Orders.	Direct
MO-DN-07 Troubleshooting Guide Definition	No formal Troubleshooting Guides are being used at present. However, some Work Instructions are being used for some Equipment.	Any standard Troubleshooting Guides available with new Equipment or existing Work Instructions can be defined. Also, Troubleshooting Guides can be developed from experience and defined in the Troubleshooting Guide screen in the Maintenance module.	Direct Process Change
MO-DN-08 Parameter Definition	Various Parameters such as Temperature, Vibration, Current, etc. are used to monitor the condition of Equipment.	Define all the Parameters required in the Parameter Details screen in the Equipment module.	Direct
MO-DN-09 Common Structure Definition	Some Equipment have a Common Structure.	Define the required Common Structures in the Spares Structure Master screen in the Equipment Module.	Direct

Table 6b: MO-DN Maintenance Operations

Activity ID and Activity Name	Requirements	Solution in EAM	Solution Type
MO-DN-10 Structure Details Definition		Define the details for any Structure defined in Activity ID MO-DN-12 above in the Spares Structure Details screen in the Equipment Module.	Direct
MO-DN-11 Equipment Master Definition		Define each Equipment in the correct Location in the Equipment screen in the Equipment Module.	Direct
MO-DN-12 Rotable Definition	Some Equipment, e.g. motors, can be attached to different Parent Equipment and are moved across such Equipment.	Define all such Equipment as Type Rotable in the Equipment screen in the Equipment Module.	Process Change
MO-DN-13 Failure Group, User Defined Group Definition	No concept of Failure Group or any User defined Group at present.	The user will have to define Failure Groups in case Troubleshooting Guides are to be created.	Process Change
MO-DN-14 Equipment Dependency Definition	Many Equipment are dependant on other Equipment from the operational point of view, i.e. if particular Equipment is Down, one or more other Equipment have to be Shut Down.	Classify all the Equipment Dependency as either 'Also Down' or 'Ganged'.	Direct
MO-DN-15 Maintenance Year Details Definition	At present, there is no concept of specific Maintenance Year or Periods.	Define the fiscal years as Maintenance Years, split into 53 weekly Periods in the Maintenance Year Details screen in the Maintenance management Module. The length of the first Period will be adjusted to ensure that the Maintenance Year corresponds to the fiscal year.	Process Change
MO-DN-16 Attendance Type Details	Apart from 'Normal' Attendance, there are other Attendance types like 'Overtime', etc. in use.	Define all the Attendance Types that are in use, along with the relevant payment Factor, in the Attendance Type Details screen in the Maintenance management Module.	Direct
MO-DN-17 Work Group Definition	There are various Maintenance Departments like Control and Instrumentation, Mechanical, Electrical, etc.	Define all the Maintenance Departments as Work Groups in the Work Group Details screen in the Maintenance management Module. The Work Group (Maintenance Department) that has the primary responsibility of maintaining any Equipment will be assigned to it during Equipment Master Definition (Activity ID MO-DN-14).	Direct

Table 6c: MO-DN Maintenance Operations

Activity ID and Activity Name	Requirements	Solution in EAM	Solution Type
MO-DN-18 Resource Definition	Various Resources like Employees as well as Tools and Machinery are utilized to carry out different Maintenance Activities.	All the Resources used for Maintenance purposes will be classified as 'Employee', 'Contract' or 'Others'. Contract type Resources are defined as either people or Equipment that have been taken on Contract basis from external sources	Direct
MO-DN-19 Employee Creation	Specific Employees are identified for Maintenance purposes, whether for carrying out the actual Maintenance Activities or for monitoring the work.	The user will inherit all such Employees into Plant Maintenance by identifying them in the Employee Details screen in the Maintenance management Module.	Direct
MO-DN-20 Equipment Location Definition		The user will define various Locations in the Apex Location of each Company. Each of these Locations will correspond to a physical or logical area in the Apex Location that is typically looked after by separate Maintenance users for planning, review and analysis purposes.	Process Change
MO-DN-21 Equipment Location Structure Definition		The user will define the complete Location structure of the Apex Location in terms of different Equipment Locations.	Process Change

**BMR of Materials Function:** The Material functions of Maintenance management consist of two basic components, Purchase and Inventory coded by PU and IN respectively.

**Purchase Process / Components:** Purchasing includes all those activities that results in the procurement of materials and services to meet the objectives of the organization. The Purchase department procures stock

against purchase requisition raised by various departments. Once the requisitions are received, the purchase department sends the request for quotations to the vendors. On receiving the quotations, they are analyzed and selected based on factors such as price, quality, quantity, payment terms, delivery schedules etc. Purchase orders are then released to the selected vendor for supply of the materials. The different processes are listed in Table 7.

Table 7: Purchase Process / Components

Sl. No.	Process	Name
1.	PU-01	Purchase Request/Requisition
2.	PU-02	Enquiry
3.	PU-03	Quotation
4.	PU-04	Purchase Ordering
5.	PU-05	Blanket Ordering
6.	PU-DN	Master Definitions

**PU-01 Purchase Request/Requisition:** Purchase request is generated by the user departments by specifying the items required with their specification, quantity etc. The

different activities are listed in Table 8 with details of each activity.

Table 8: PU-01 Purchase Request/Requisition

Activity ID and Activity Name	Requirements	Solution in EAM	Solution Type
PU-01-01 Request Generation	User departments are generating Purchase Requests for all Items. However, ITPS wishes to go in for Min-Max Level type of planning for most Items in future.	Manual Purchase Requests can be generated for any Item(s) in the Purchase Request screen in the Purchase module. If the planning type of an Item is set to Min-Max Level, the System will automatically generate Purchase Requests whenever the Stock goes below the Minimum Level.	Direct
PU-01-02 Request Modification		The User can modify the manual Purchase Request at any point before the Request has been authorized.	Direct
PU-01-03 Request Authorization	The Purchase Requests raised by the User departments are checked by the Purchase department for availability of the Material in Stock and other details and then approved for Purchase action.	The Purchase Users can authorize the Purchase Request(s) based on the individual powers laid down in the Multilevel Authorization. The Purchase Requests can either be authorized one at a time in the Purchase Request screen in the Purchase module or in bulk in the PR Mass Authorization screen in the Purchase module.	Direct Succeeding activities are OR: PU-02, PU-04, PU-05

**PU-02 Enquiry:** This process generates the quotation enquiry to the vendors from vendor list after receipt of the authorized Purchase request, which is listed in Table 9.

Table 9: PU-02 Enquiry

Activity ID and Activity Name	Requirements	Solution in EAM	Solution Type
PU-02-01 Enquiry Generation	After the Purchase Requests have been approved for Purchase action, Requests for Quotation are sent to select Vendors.	The User has the option of generating the Requests for Quotation for all Vendors or for selected Vendors only.	Direct Preceding Activity: PU-01-03 Succeeding activity: PU-03

**PU-03 Quotation:** In this process the details of each quotation are entered into the system for each vendor and

a comparison is made for selecting suitable vendor. The activities are listed in Table 10.



Table 10: PU-03 Quotation

Activity ID and Activity Name	Requirements	Solution in EAM	Solution Type
PU-03-01 Quotation Generation	All the Quotations that are received from different Vendors against a particular Request for Quotation are compiled together.	All the Quotations received from different Vendors to whom the Requests for Quotation were sent have to be entered in the Quotation screen in the Purchase Module. All information in the Quotations like Validity; Schedule; Taxes, Charges and Discounts; Quantity Price Break, if any; etc. can also be entered. Any standard Price List sent by a Vendor can also be entered using this screen.	Direct Preceding Activity: PU-02-01
PU-03-02 Quotation Comparison (Comparison of Quotations of different Vendors)	A Comparative Statement is drawn up for the various Quotations received for a particular Request for Quotation. This is used as a basis to select the Vendor on whom the Purchase Order has to be placed.	All available Quotations (as well as Blanket Purchase Orders) can be compared using the Purchase List screen in the Purchase Module. Graphical Analysis of the various Quotations is also possible. Purchase Orders can be directly placed on the selected Vendor(s) from this screen. The User also has the option of placing part Orders on more than one Vendors.	Direct Succeeding Activity: PU-04

**PU-04 Purchase Ordering:** Purchase order is the formal document that will be sent to the vendor communicating the material requirements. The document consists of the reference quotation number, vendor number, schedule requirement, payment terms, delivery details etc. The different activities are listed in Table 11.

**PU-05 Blanket Purchase Ordering:** Blanket Purchase order is a contract with vendor to purchase a quantity

during a specified period, usually a year. The advantage of such an order is the price discounts because of quantity commitments and elimination of costs for repetitive purchase orders. Release slip is the actual order communicating the quantity and date of requirement to the vendor against a valid Blanket Purchase Order. The different activities are almost same as general Purchase order and listed in Table 12.

Table 11: PU-04 Purchase Ordering

Activity ID and Activity Name	Requirements	Solution in EAM	Solution Type
PU-04-01 Order Generation	Once the User has selected the Vendor on whom the Purchase Order has to be placed and the quantity thereof, a printed Purchase Order is sent to the selected Vendor. In some cases, a preliminary Letter of Intent is also sent before the formal Purchase Order.	The Purchase Order can be generated from the Purchase List as explained in Activity ID PU-03-02 above. Purchase Orders can also be automatically generated against one or more Purchase Requests from the Automatic PO Generation from PR screen in the Purchase Module or directly generated in the Purchase Order screen in the Purchase Module.	Direct Preceding Activity: OR: PU-01-03, PU-03, None (Direct Entry)
PU-04-02 Order Modification		Any changes required in the Purchase Order can be carried out before it is authorized, by setting the Modify mode in the Purchase Order screen in the Purchase Module.	Direct
PU-04-03 Entering Taxes and Charges	Various Taxes are payable on the Items procured through Purchase Orders like Excise Duty, Sales Tax, etc. based on current laws.	All such Taxes and Charges can be entered in the T/C/D tab of the Purchase Order screen in the Purchase Module. Taxes and Charges specific to particular Item(s) can be entered separately, while those applicable to the Purchase Order as a whole can also be entered.	Direct
PU-04-04 Entering Discounts	The Vendor may have offered Discounts for one or more Items in the Quotation.	All such Discounts can be entered in the T/C/D tab of the Purchase Order screen in the Purchase Module. Discounts specific to particular Item(s) can be entered separately, while those applicable to the Purchase Order as a whole can also be entered.	Direct
PU-04-05 Order Validation		After all details for a Purchase Order have been entered, it may be validated in the Purchase Order screen in the Purchase Module. This ensures that all the particulars have been correctly entered and that there is no inconsistency in the Purchase Order.	Process Change
PU-04-06 Order Authorization	Based on its value, each Purchase Order has to be approved by a particular User Level.	A particular Purchase Order may be authorized by the User in the Purchase Order screen in the Purchase Module. In case the User wishes to authorize more than one Purchase Order at a time, it can be carried out in the PO Mass Authorization screen in the Purchase Module.	Direct Succeeding Activity: OR: IN-01
PU-04-07 Order Amendment	Even after the Purchase Order has been sent to the Vendor, there is the possibility of some modifications being required.	Modifications in an authorized Purchase Order are possible by carrying out amendments to the Purchase Order in the Purchase Order — Amendment screen in the Purchase Module.	Direct Succeeding Activity: PU-04-06
PU-04-08 Order Closure		After all the Items have been received against a particular Purchase Order or the User decides that no further Items will be received against that Purchase Order, the Purchase Order will have to be Closed / Short Closed.	Process Change

Table 12: PU-05 Blanket Purchase Ordering

Activity ID and Activity Name	Requirements	Solution in EAM	Solution Type
PU-05-01 Blanket Order Generation	ITPS has some Rate Contracts and other Blanket Purchase Orders with Vendors for supply of regularly consumed Material.	Enter details of all Blanket Purchase Orders in the Blanket Purchase Order screen in the Purchase Module.	Direct Preceding Activity OR: PU-01-03, PU-03, None (Direct Entry)
PU-05-02 Blanket Order Modification		Any changes required in the Blanket Purchase Order can be carried out before it is authorized, by setting the Modify mode in the Blanket Purchase Order screen in the Purchase Module.	Direct
PU-05-03 Entering Taxes and Charges	Various Taxes are payable on the Items procured through Blanket Purchase Orders like Excise Duty, Sales Tax, etc. based on current laws.	All such Taxes and Charges can be entered in the T/C/D tab of the Blanket Purchase Order screen in the Purchase Module. Taxes and Charges specific to particular Item(s) can be entered separately, while those applicable to the Blanket Purchase Order as a whole can also be entered.	Direct
PU-05-04 Entering Discounts	The Vendor may have offered Discounts for one or more Items for which the Blanket Purchase Order is being placed.	All such Discounts can be entered in the T/C/D tab of the Blanket Purchase Order screen in the Purchase Module. Discounts specific to particular Item(s) can be entered separately, while those applicable to the Blanket Purchase Order as a whole can also be entered.	Direct
PU-05-05 Blanket Order Validation	No process of validating Blanket order	After all details for a Blanket Purchase Order have been entered, it may be validated in the Blanket Purchase Order screen in the Purchase Module. This ensures that all the particulars have been correctly entered and that there is no inconsistency in the Blanket Purchase Order.	Process Change
PU-05-06 Blanket Order Authorization	Based on its value, each Blanket Purchase Order has to be approved by a particular User Level.	A particular Blanket Purchase Order may be authorized by the competent User in the Blanket Purchase Order screen in the Purchase Module.	Direct Succeeding Activity: PU-05-08
PU-05-07 Blanket Order Amendment	Even after the Blanket Purchase Order has been placed on the Vendor, there is the possibility of some modifications being required.	Modifications in an authorized Blanket Purchase Order are possible by carrying out amendments to the Purchase Order in the Blanket Purchase Order — Amendment screen in the Purchase Module.	Direct Succeeding Activity:
PU-05-08 Release Slip Generation	Whenever supplies are required against a particular Rate Contract or Blanket Purchase Order, a Delivery Order is placed on the Vendor against whom the Blanket Purchase Order has been placed.	A Release Slip will have to be generated and placed on the Vendor against whom the Blanket Purchase Order has been issued. This will be carried out in the Release Slip screen in the Purchase Module.	Direct PU-05-06
PU-05-09 Release Slip Authorization	Based on its value, each Delivery Order has to be approved by a particular User Level.	A particular Release Slip may be authorized by the competent User in the Release Slip screen in the Purchase Module.	Direct Succeeding Activity: OR: IN-01

**PU-DN Definitions:** This is the process of defining all master definition to the system, which are then used in all components of Purchase function, which is listed in Table 13.

Table 13: PU-DN Definitions

Activity ID and Activity Name	Requirements	Solution in EAM	Solution Type
PU-DN-01 Vendor Master Creation	A list of standard Vendors is available with the Users that is utilized for sending Requests for Quotation and placing Purchase Orders.	Vendors and the basic information about them will have to be added in the Vendor Details screen in the Purchase Module.	Direct
PU-DN-02 Payment Terms Master	The Purchase Orders that are placed may have different Payment Terms with regard to Due Days, Due percentage, etc.	All the standard Payment Terms that are to be used will have to be defined in the Pay Term Details screen in the Purchase Module.	Direct
PU-DN-03 Taxes/Charges/ Discounts Master	Various standard Taxes and standard charges / Discounts as applicable on purchased Items.	All such standard Taxes, Charges and Discounts, along with the formulae applicable, if any or the Flat value, will have to be defined in the T/C/D Details screen in the Purchase Module.	Direct
PU-DN-04 Vendor Location Master	A list of standard Vendors is available with the Users that is utilized for sending Requests for Quotation and placing Purchase Orders.	Additional details for each Vendor created in Activity ID PU-DN-01 above can be entered in the Vendor Details (Location Specific) screen in the Purchase Module.	Direct
PU-DN-05 Vendor Rating Criteria	All the standard Vendors are rated on various factors and this rating is used as one of the measures for selecting a Vendor while placing a Purchase Order.	Define the various parameters on which the Vendors are to be rated as well as the weightages for each of these parameters in the Weightages Details (Vendor Rating) screen in the Purchase Module.	Direct
PU-DN-06 Authorization Criteria	Different Users have the authority to approve Purchase Requests and Purchase Orders of different values based on their Levels in the hierarchy.	The Level to which each User belongs and the maximum value of Purchase Requests and Purchase Orders that he can authorize have to be specified in the Multilevel Authorization screen in the Purchase Module.	Direct

**Inventory Process / Components:** The role of Inventory management is important in order to achieve an effective maintenance management. The different processes of the Inventory management are listed in Table 14.

Table 14: Inventory Process / Components

Sl. No.	Process	Name
1.	IN-01	PO Based Goods Receipt
2.	IN-02	Goods Return to Vendor
3.	IN-03	Direct Receipt
4.	IN-04	Material Requesting
5.	IN-05	Stock Issue
6.	IN-06	Internal Goods Return
7.	IN-DN	Master Definitions

**IN-01 PO Based Goods Receipt:** This Process deals with the receipt of materials from vendors against a Purchase order. Once the materials are received, they are unloaded at the warehouse and a goods receipt note is prepared for the items received. Then the items are accepted after

inspection by the respective user department. After acceptance the materials are moved to their respective warehouse and stocks are updated. The different activities are listed in Table 15.

Table 15: IN-01 PO Based Goods Receipt

Activity ID and Activity Name	Requirements	Solution in EAM	Solution Type
IN-01-01 Unloading	No concept of Unloading without Goods Receipt at present.	Receipt after Unloading	Process Change Preceding Activity: OR: PU-04, PU-05
IN-01-02 Goods Receipt	Once Material is received against a particular Purchase Order, a Material Received Note is prepared. This contains all the details of the Material received, including the value. <ul style="list-style-type: none"> <li>• Direct Receipt without Unloading.</li> <li>• Receipt after Unloading</li> </ul>	As soon as a consignment is received against a particular Purchase Order, generate a Goods Receipt in the Goods Receipt screen in the Purchase Module. Most of the information will be defaulted from the Purchase Order against which Receipt is being made. These can, however, be modified to match the actual consignment particulars. After all details have been finalized, the User will have to carry out a Freeze Receipts in the Goods Receipt screen in the Purchase Module.	Direct Preceding Activity: XOR: IN-01-01, OR: PU-04, PU-05
IN-01-03 Goods Inspection	After the Items have been received, they are sometimes inspected by the Stores Users themselves. In some cases, an inspection call is sent to the User department. Supplier inspected Items or Items from reputed Manufacturers are normally not inspected.	If the Items are not being inspected, set the Inspection column to None in the Main tab in the Goods Receipt screen in the Purchase Module.  In case the Items are to be inspected either by the Stores User or by the User department, set the Inspection column to Self in the Main tab in the Goods Receipt screen in the Purchase Module. After the Items have been inspected, the User carrying out the Inspection should update the Inspection details in the Inspection tab in the Goods Receipt screen in the Purchase Module.	Direct
IN-01-04 Goods Acceptance	After the incoming Material has been inspected, the consignment is either accepted in full or part or rejected as a whole.	Once the Inspection details have been updated as in Activity ID IN-01-03 above, the Acceptance will have to be finalized by carrying out a Freeze Acceptance in the Goods Receipt screen in the Purchase Module.	Direct
IN-01-05 Goods Movement	After part or whole of the consignment has been accepted, the accepted Material is moved to the corresponding Warehouse / sub-Store and Stock Ledgers updated.  In some cases, the Material is directly sent to the User department for consumption.	Once Freeze Acceptance has been carried out as in Activity ID IN-01-04 above, the accepted Items will have to be moved to the corresponding Warehouse through the Movement to Warehouse tab in the Goods Receipt screen in the Purchase Module.  In case the Items are directly consumed instead of being moved to Stock, the Items will be directly moved to the corresponding Cost Center through the Movement to Cost Center tab in the Goods Receipt screen in the Purchase Module.	Direct

**IN-02 Goods Return to Vendor:** The materials, which fail to satisfy the specification in the inspection stage or

the materials, which are damaged during transit, are returned to the vendor, which is listed in Table 16.

Table 16: IN-02 Goods Return to Vendor

Activity ID and Activity Name	Requirements	Solution in EAM	Solution Type
IN-08-01 Goods Return to Vendor	There are cases where the Items supplied by a Vendor are not acceptable for various reasons. These Items are then returned to the Vendor, usually for replacement.	Once Items have been received from a Vendor against a particular Purchase Order through a Goods Receipt, rejected or even other Items may be returned to the Vendor through the Goods Return to Vendor screen in the Purchase Module. Returned Quantity in corresponding Goods Receipt is updated	Direct  Preceding Activity: OR: IN-01, IN-02

**IN-03 Direct Receipt:** This is unplanned receipt, which is made without preparing a goods receipt note. This type of receipt is required when the material is purchased directly

from the market without any purchase order, which is listed in Table 17.

Table 17: IN-03 Direct Receipt

Activity ID and Activity Name	Requirements	Solution in EAM	Solution Type
IN-03-01 Material Receipt	Unplanned Receipt	In case the User wishes to carry out an Unplanned Receipt of any Item(s), it can be done through the Receipt screen in the Inventory Module.	Direct

**IN-04 Material Requesting:** When the user department requires items from warehouse, they generate the Material request for that item, which is shown in Table 18.

Table 18: IN-04 Material Requesting

Activity ID and Activity Name	Requirements	Solution in EAM	Solution Type
IN-04-01 Material Request	Whenever any User requires a particular Item, he fills up a Material Issue Note specifying the Items and the quantity that he requires, along with other details.	The User will enter the details of the Items he requires in the Material Request screen in the Inventory Module. The Material Request will also have to be authorized before Issues can be made against it. Material Requests need not be manually entered for Items required for maintenance purposes.	Direct Preceding Activity: None (Direct Entry) Succeeding Activity: OR: IN-05-01, PU-01

**IN-05 Stock Issue:** The warehouse issues the Material after receipt of the authorized material request. Issue can

also be made directly form the maintenance work order, which is shown in Table 19.

Table 19: IN-05 Stock Issue

Activity ID and Activity Name	Requirements	Solution in EAM	Solution Type
IN-05-01 Material Issue	If the Material requested by the User is available in stock, the Stores will issue the Material against the Material Issue Note and fill up a Gate Pass for the same.	After the Material Request has been received, the Stores User can issue the Items through the Issue screen in the Inventory Module. In case of Issue of Items for maintenance purposes, the Issue will be made directly against the Maintenance Work Order. In that case, the Transaction Type should be Maintenance and the Work Order No should be entered as the Reference Document Number.	Direct Preceding Activity: OR : IN-04-01, PM-MO-03-08, None (Unplanned Issue)

**IN-06 Internal Goods Return:** This is the process where all the items issued to the maintenance work is not completely consumed the maintenance user has to return

the balance unused item to the warehouse, which is shown Table 20.

Table 20: IN-06 Internal Goods Return

Activity ID and Activity Name	Requirements	Solution in EAM	Solution Type
IN-06-01 Material Returns	Sometimes all the Material issued for a particular purpose, especially maintenance activities, is not completely consumed. In such cases, the balance Material is returned to the Warehouse or sub-Store from where it was issued. In some cases, the balance Material is sent to a different sub-Store from the one from which it was issued.	The Stores User can enter the Return of issued Items through the Return screen in the Inventory Module. In case of Return of Items after maintenance activities, the Return will be made against the Maintenance Work Order. The Transaction Type should be entered as Maintenance and the number of the corresponding Maintenance Work Order should be entered as the Reference Document Number.	Direct Preceding Activity: OR: IN-05-01, PM-MO-03-09, None (Direct Return)

**IN-DN Definitions:** This process defines the entire master definitions such as stock address, item codes etc.

required for the operation of all the components, which is shown Table 21a and Table 21b.

Table 21a: IN-DN Definitions

Activity ID and Activity Name	Requirements	Solution in EAM	Solution Type
IN-DN-01 Stock Address Configuration	The Central Stores has two Sheds (Warehouses) apart from which most of the Teams (Departments) have their own sub-Stores. Within these Warehouses, there are further sub-divisions made for ease of storage and operational convenience.	Define each major Shed/Store in ITPS as a Normal Warehouse in the Warehouse Detail screen in the Inventory Module. Each such Warehouse can be further sub-divided into Zones and if required, Bins. This can be done in the Zone Detail and Bin Detail screens in the Inventory Module.	Direct

Table 21b: IN-DN Definitions

Activity ID and Activity Name	Requirements	Solution in EAM	Solution Type
IN-DN-02 Defining Item Details	Various Materials, typically for maintenance purposes, are stocked in the Warehouses and sub-Stores.	Define all the stocked Items with type Spare Part or Consumable as the case may be in the Company Item Detail screen in the Inventory Module. Inherit all these Items in the Item Detail screen in the Inventory Module. All the relevant details like various Accounts, Costing Method, etc. for each of these Items should also be entered in these screens.	Direct
IN-DN-03 Defining Units of Measure	All the Items that are stocked have one or two Units of Measure on the basis of which they are stocked and/or purchased.	Define all the Units of Measure that are required for Item stocking and purchase as well as for Equipment Parameters in the Main tab of the Unit of Measure screen in the Inventory Module.	Direct
IN-DN-04 Defining the Conversion Factors	The Units of Measure that are in use can be converted to each other, either through standard conversion factors or through Item dependent conversion factors.	Define all the conversion factors between pairs of Units of Measure in the Conversion Details tab of the Unit of Measure screen in the Inventory Module.	Direct
IN-DN-05 Entering Opening Stock		Before starting Inventory transactions in the Inventory Module, the current stock of Items will have to be updated in the System. This can be done in the Opening Balance Creation — Standard Cost Item and Opening Balance Creation — Other Item screens in the Inventory Module.	One Time Activity
IN-DN-06 Defining Storage Rules	There are some Items that are specifically stocked in particular Warehouses / sub-Stores only.	Define the Storage Rules required (if any) for each Warehouse – Item combination in the Storage Allocation Detail screen in the Inventory Module.	Direct
IN-DN-07 Item - Item Group Mapping	Items are not being grouped at present.		Non System Activity
IN-DN-08 Item Substitute Definition	Some of the Items stocked have substitute Items that can be used instead of the primary Item if it is not available.	Define such Substitute Items in the Item Substitute screen in the Inventory Module.	Direct

### DATA FLOW DIAGRAM

Graphical Description of a System's data and how the process transforms the data is known as Data Flow Diagram or simply DFD [11]. Unlike detail flowcharts, DFDs do not supply detailed descriptions of modules but graphically describe a system's data and how the data interact with the system. Systems flowcharts are

graphic illustrations of the physical flow of information through the entire system. A systems flowchart is commonly used in analysis and design. Flow lines represent the sequences of processes, and other symbols represent the inputs and outputs to a process. Data flow diagrams present the logical flow of information through a system in graphical or pictorial form. Data flow diagrams are useful for communication between analysts and users. Data flow diagrams (DFDs) show the data



used and provided by processes within a system. The DFDs are prepared for the Maintenance and Materials function of the EAM to be implemented for ready reference for the users. The purpose of data flow diagrams is to track the flow of data through an entire system by representing data and processes that are critical to the understanding of a system. The various symbols used in the DFD are as follows: i) Open-ended rectangles: Data collection points (Data Store /Database); ii) Ovals: Processes; iii) Open ended rectangles with “horns”: Interfaces with other Modules; iv) Rectangles: Processing reports; v) Square: external entity.

**Data Flow Diagram of Maintenance Process:** The maintenance process of equipment consists of work order generation, work order scheduling work order execution and work order closing. Work Order can be generated (i) directly by the maintenance people, (ii) from Maintenance

Request given by the operation staff, (iii) from maintenance planning, (iv) from parameter trigger.

**Work Order Generation from Maintenance request:** The operation people can raise Maintenance request for rectifying defects in equipment. The maintenance people after verifying the defect approve the request. This automatically generates the Work Order shown in Fig. 1(a).

**Work Order From Maintenance Planning:** Maintenance Planning department prepares the planning for preventive maintenance of the equipments for a period. The maintenance period for different equipments are planned at different times. After authorizing the Planning schedule Work orders are automatically generated for the equipments at the desired period, whose DFD is shown in Figure 1 (b).

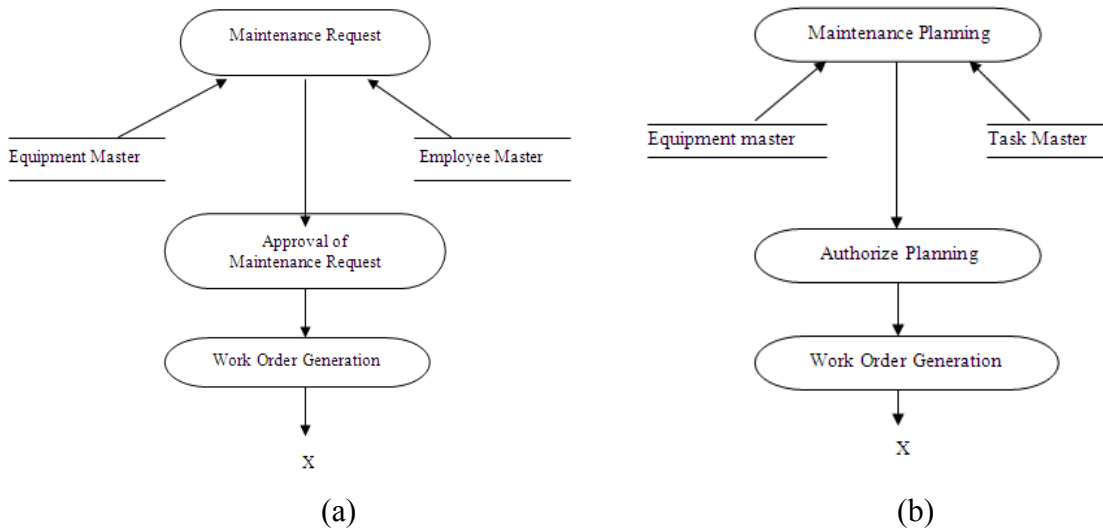


Figure 1: (a) DFD for Work Order Generation for Maintenance Request; (b) DFD for Work Order Generation for Maintenance Planning

**Work Order Generation and Scheduling:** Once work order is generated, it is to be scheduled for execution. Scheduling of work order is the most important phase of work order cycle. In this the maintenance people defines the various tasks for the job, the spare parts required for

executing the task, planning and assigning manpower to the tasks and defining clearance permit for safely executing the job, which is shown in Fig 2. Once these are defined, the work order is scheduled and released for execution

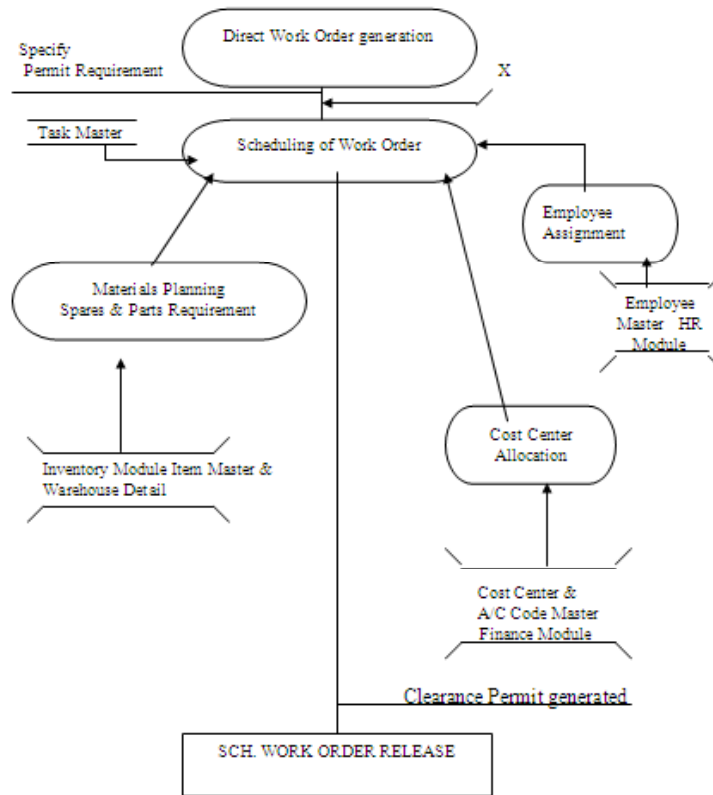


Figure 2: DFD for Work Order generation and Scheduling

**Work Order from Parameter Trigger:** Parameters are entered into the system for each equipment as per the inspection checklist defined for that equipment. Everyday these parameters are updated from the field data. Predictive Triggers are defined for the equipment for the limiting value of the parameter. When this limit is reached automatically the system will generate work order for maintenance of the same. This has been shown in Fig. 3(a).

**Work Order Execution:** After completing all the tasks for the work, the date and time of starting the job, Completion time, Problem description, actual manpower deployment, actual spares issued and utilized are entered into the system. Then the work order is closed. The system then updates the equipment history database. This has been shown in Fig. 3(b).

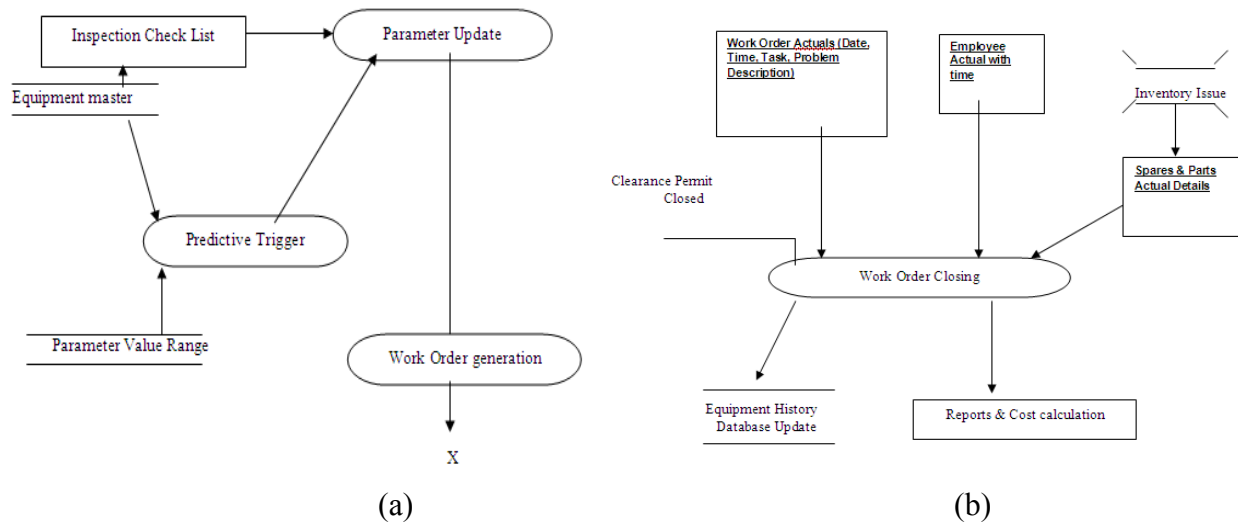


Figure 3: (a) DFD for Predictive Trigger; (b) DFD for Work Order Execution

**Data Flow Diagram of Inventory Process**

The main activity of Inventory process consists of Issue and receipt of material required for maintenance.

**Issue Cycle:** Issue Cycle consists of issue of material from a warehouse and then stock updating with financial posting. Material issue is made from material request, from work order scheduling or from stock transfer from one warehouse to other. Once the issue is confirmed, the warehouse stock is updated accordingly and the issue

value is computed by the system and booked to respective cost center. This has been illustrated vide Fig. 4(a).

**Receipt Cycle:** Receipt Cycle consists of receipt of material to warehouse and then stock updating with financial posting. Material receipt is made from goods receipt by Purchase Order, balance item returned from a work order or from stock transfer from one warehouse to other. Once the receipt is confirmed, the warehouse stock is updated accordingly and the receipt item value is booked to respective cost center. This has been illustrated vide Fig. 4 (b).

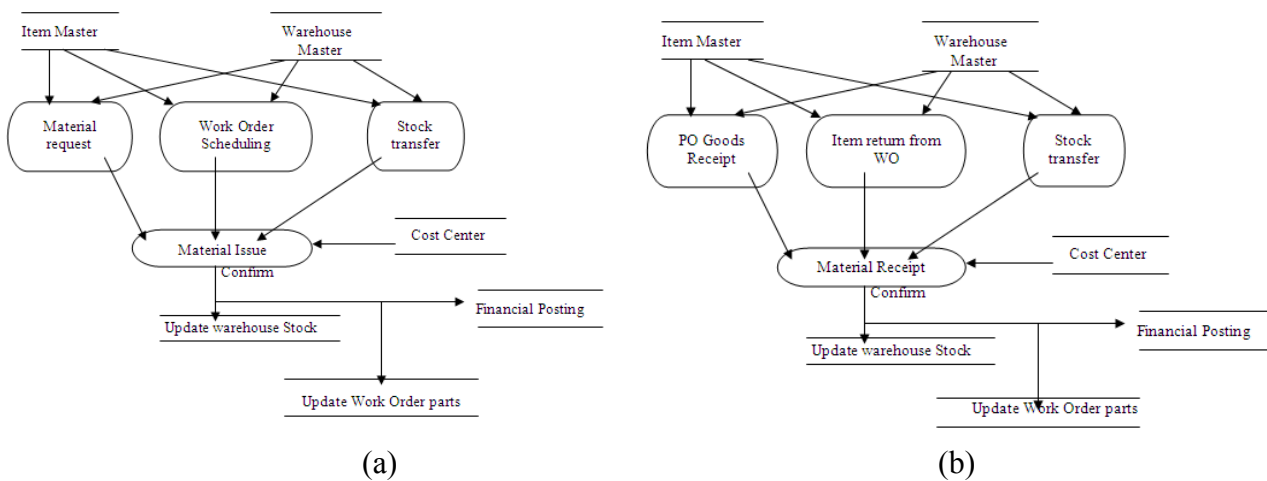


Figure 4: (a) DFD for Issue of Materials; (b) DFD for Receipt Cycle

## **CUSTOMIZATION AND IMPLEMENTATION**

After the system Study, scoping analysis and preparation of BMR is done in various stages such as: i) System selection and installation of the software; ii) Codification, Master Data Preparation and porting the data to the system; iii) Customization of Reports and other functionality; iv) Test Run and v) Live run. EAM software generally supports multi-server distributed application architecture, which enables enterprises to connect, manufacturing plants, sales offices, distribution points and the corporate office on-line and share information. The configuration of servers / clients / networks required by an organization depends on the nature of its business, data processing requirements, the extent of geographical distribution of information centers and the budget earmarked for IT solutions. The system selected for EAM Installation at IBTPS was as follows: i) Server: Compaq Proliant 3000 server, 3X9.1GB HDD, 1GB RAM with RAID5 configuration; ii) OS: Windows NT4.0; iii) Database: MS SQL 7.0; iv) Users: 25; v) Client OS: Win98.

The installation creates the front-end applications and the required backend databases. The front-end was shared and mapped to the user. The backend connectivity is given by configuring ODBC at client end. This type of configuration was flexible as if at any time the front is modified then it would be changed from one point not at all client location. Before preparing the Master data, necessary codification was made. The codification is highly essential for better manageability of the master data. The major codification was required for the equipments and Spares. After codification, all master data were prepared and ported to the system by using MS Visual Test software. Before the test run all required customization was carried out as per the BMR and Gap analysis by various extension tools like User Defined screens, Stored procedure builder, screen customization, Report writer etc. Data is processed using the Stored Procedures written by the user or by the UDS utility itself.

## **CONCLUSIONS AND FUTURE DIRECTIONS**

It is well known that a fully functional Enterprise Asset Management (EAM) System is a fundamental building block for improving maintenance and reliability. Almost everyone in the company had desired a functional EAM for many years. Most viewed the implementation of an EAM more as the solution to improving maintenance and reliability and less as a fundamental part of a larger

program. As a result, many people in the company thought the EAM would solve all of the maintenance and reliability problems. This led to numerous unrealistic expectations.

It took a considerable and sustained effort to constantly explain that the EAM was merely a tool to facilitate a process that was executed by well-trained people. Because the maintenance function had been decentralized for decades, many in the company had built their own tools and processes to facilitate it. These were difficult to sustain on an individual basis and over the time lacked coordination. Everyone wanted to migrate from these processes, but they wanted the new tool to provide the same functionality that they were accustomed to.

Lacking any communication to the contrary, the field users expected or assumed that the new tool would do what they had always done, only better and faster. Again, it took considerable effort to explain that many of these were not really EAM issues, but were process issues. Frequently, they believed that the software should be able to do everything they wanted it to do. When they experienced limitations with what the EAM software could do, their first impulse was to redesign and reconfigure software.

Customization of the software that requires code modifications is the most costly and time-consuming aspect of an implementation and should be avoided. It is imperative that the team selects a software platform that meets the needs and is easily configured to avoid code modifications. It is easy for users to justify the need for software changes and then demand that the functionality is put in place.

The future area of implementation is focused towards integrating the capabilities of a Geographic Information System (GIS) into the EAM solution, which means the ability to manage the asset inventory even more efficiently [2]. The GIS enables map-based views of the asset and work information that is managed using an EAM system. Because there is a database relationship between the spatial data in the GIS and details of the assets and the work performed on those assets in the EAM, extended graphical display and data analysis functionality becomes possible. In an integrated solution, the graphical perspective can be presented along with a detailed work history of the selected set of assets. Asset-related information can be spatially analyzed to help identify trends or to determine impacts of proposed operations. Analysis results and trends can be displayed on a map to further assist in the decision making process.

From a business perspective, organizations such as those in the utilities and public works sectors are being challenged to do more with less. For example, in the

electric utility market, de-regulation is forcing companies to ensure that assets are being operated in the most efficient manner to keep rates down. With recent and emerging technology advances such as the componentization and standardization of software, enterprise-wide systems are feasible and even required in order to manage the volume of information associated with infrastructure assets.

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