ADAPTING ERP SYSTEMS FOR SUPPORTING DEFENSE MAINTENANCE PROCESSES

Case study of a repair and overhaul organization

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Abstract: The defense sector represents one of the largest potential areas for new ERP sales. Many defense organizations have already implemented ERP solutions to manage and integrate the acquisition, maintenance, and support processes. This paper addresses specifically the defense maintenance management functions that need to be integrated into an ERP solution by adopting the view of a defense repair and overhaul facility. We first discuss the specific nature of the defense maintenance activities, and then we present the difficulties of integrating a maintenance strategy into an ERP solution. We finally conclude by proposing a coherent and integrated ERP structure model for the management of the defense repair and overhaul processes. The model has been partly applied in a Canadian repair and overhaul facility and adapted into the SAP R/3 software.

1 INTRODUCTION

Many organizations have undergone significant process changes in recent years to adapt to their new market reality. Process improvements were obtained mainly by a combination of business process reengineering (BPR) efforts, organizational restructuring, and the adoption of Enterprise Resource Planning (ERP) systems. While BPR and organization restructuring aim at eliminating non added-value activities and administration barriers, an ERP solution seeks to streamline the operation processes of an organization, which typically involve various functional units, and by integrating the information flow into one single system.

Despite the complexity of such implementation, the rate of adoption of ERP systems in the private sector have been significant in the last decade with almost 80% of the Fortune 500 firms having implemented some form of ERP system and with the growing number of small and medium sized companies now adopting the same strategy (Wagner and Antonucci, 2004). More recently, public sector organizations are following their private counterparts by adopting a business process-oriented management model (Gulledge and Sommer, 2002). Driven largely by budget reduction and efficiency concerns, public sector organizations are shifting from a purely hierarchical organizational structure to a process oriented structure which accommodates horizontal workflows (Gulledge and Sommer, 2003).

In that context, it is not surprising to note that public sector organizations are also increasingly implementing ERP systems to replace existing operational systems (Shang et al., 2000). Small and large-scale ERP implementations have been attempted in various governmental agencies in Australia, Canada, Germany, and the US (Blick et al., 2000, Boyer, 2001, Chang et al., 2001, Menard and Bernier, 2004, Wagner and Antonucci, 2004). As a result the public sector has emerged as a key initiative for the top ERP vendors which are primarily targeting at federal, state and municipal agencies (Makulowich, 1999).

Among the public sector, defense organizations have always been recognized as early adopters. Various defense organizations, such as the US Naval Air Systems Command (Blick et al., 2000), the Danish Defense Command, the Canadian Department of National Defense, the New Zealand Defense Command, and the Royal Norwegian Air Force have implemented an ERP solution and a

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large number of NATO countries are looking to do the same in the near future. In fact, the defense sector represents one of the largest potential areas for new ERP sales. For example, it is projected that the US Navy will soon spend $3B on its ERP implementation (Wagner and Antonucci, 2004).

So far, ERP projects in defense organizations are primarily concerned with the acquisition, maintenance, and support processes. This paper focuses only on the defense maintenance management functions that need to be integrated into an ERP solution. We will first discuss the specific nature of the defense maintenance activities, and then we present the difficulties of integrating a maintenance strategy into an ERP solution. We finally conclude by proposing a coherent and integrated ERP structure model for the management of the defense repair and overhaul processes. The proposed model relies heavily on the author personal experience working for a Canadian defense repair and overhaul facility.

2 ADOPTION OF ERP IN DEFENSE ORGANIZATIONS

Defense organizations are facing increasingly complex challenges as governments force them to be more flexible and efficient within existing budgets and as new technology are introduced (Gulledge and Sommer, 2003). After years of under-finding, commanders are left with only few alternatives:

- Make significant cuts in capabilities and infrastructures;
- Re-assign resources to higher priority activities;
- Realize efficiency and productivity gains.

Mission preparation and deployed operations being the core business of the defense, it is not surprising to note that commanders initially focused their reduction efforts on non strategic logistics resources such as their repair and overhaul (R&O) facilities. After successive cuts, it now seems that further R&O capability reductions may jeopardize the required support for the actual war-fighting operations and peace mission level. Therefore, further productivity gain will be realized mainly through process improvements.

At the same time, defense organizations adopted the concept of integrated supply chain which aims at providing commanders the ability to plan and control the flow of logistics resources to equip, deploy, sustain, and reconstitute forces in support of military operations. To do so, the military logistics adopted and adapted best commercial practices. Consequently, their former functional information systems became obsolete.

In that context of continuous pressure to achieve productivity gains and the adoption of commercial processes, ERP implementation represents an information management strategy pillar for defense logistic organizations.

3 R&O ORGANZATIONS

Defense maintenance management covers the whole process of equipment configuration management, lifecycle analysis, maintenance program planning, condition recording, procurement of indirect goods and services, repair and remanufacturing execution, project closing, and settlement. For most armed forces, a central organization ensures the maintenance program coordination and determines the overall equipment support strategy. On the other hand, the maintenance activities are executed by a multitude of local maintenance groups organized in three lines of maintenance.

1st line organizations are relatively small and give immediate support to deployed units. Their tasks include only minor repairs on equipments.

2nd line organizations can be deployed or remained static. They possess more capabilities and perform various tasks that range from minor repairs to planned preventive inspections. Their role is to support 1st line organizations and military bases.

The 3rd maintenance line is essentially composed of R&O facilities. They are large industrial organizations and therefore are exclusively static. They perform long and complex repairs. Most R&O organizations also conduct modification and remanufacturing projects as specified by their customers, the fleet managers (Pellerin, 1997).

3.1 R&O planning process

Defense R&O organizations must respond to multiple demands. They first need to support long term equipment fleet plan by preparing large and complex life extension programs. These programs are planned in accordance with the long term user operation plan and necessitate a detailed knowledge of the commander's equipment requirements and

capabilities. They also have to respond to unplanned breakdowns as part of their support mission.

The R&O planning process starts with the equipment fleet manager supplying the R&O facility with a list of equipments to be overhauled in the future. Requirement's horizon can range from months to 10 years depending on the nature of the projects. As part of their business and budgeting plan, each R&O facility defines the maintenance content to be performed and then it uses them to determine the sequence of all activities in a project. Based on its current capacity, the facility establishes a maintenance program that specifies the estimated starting and ending dates of every project and a detailed budget.

When all the maintenance program budgets are approved at the fleet manager level, a detailed production plan is built by allocating the limited pool of resources to each project. Different production plans using different resource and equipment levels are simulated and tested in order to obtain a feasible plan that results in good utilization of resources and also meets the customer's expectations. When the proposed plan is approved by the customers, it is used as the master production schedule for the next fiscal year.

3.2 R&O execution process

The R&O execution process includes the realization of both unplanned repairs and planned remanufacturing projects. For a typical overhaul project, work starts with a disassembly activity. The project content is defined as the main equipment is inspected (Gharbi et al., 1998). The next step, the most important in terms of workload, includes the replacement and repair of a large number of parts and components. At the same time, the main structure of the equipment can be overhauled and modified to accept the new components and the repaired ones. The remanufacturing process then ends with the assembly and a final inspection. Such projects may also include paint stripping and painting operations.

The network or routing topology of a remanufacturing project is therefore divergent at its start, followed by many parallel paths representing the repair of systems or components, and converges at the end (Gharbi et al., 1999). It is important to note that not all MRPII or ERP systems can support that type of work sequence and its related bill of material (Pellerin, 1997).

The other element of complexity when executing and controlling a repair and overhaul project resides in the nature of each maintenance operation. The amount of work depends on the specific condition of the component being repaired or rebuilt. Therefore, the exact duration of any repair is never known before its end. The highly stochastic behavior of a repair operation is also responsible for a high variability in material consumption. Inventory management for spares parts is extremely difficult in that context. Parts usage must be planned according to the maintenance program and based on historical consumption data.

3.3 Integrating R&O management process into ERP

Maintenance has always been considered as a supp: ort function and rarely as a core enterprise process. Consequently, most software development companies have spent relatively little time and efforts at integrating the maintenance processes into their MRPII (Ip et al., 2000) or ERP applications (Nikolopoulos et al., 2003).

Although the role of maintenance has become more important in the last few years, most ERP providers still position their maintenance management system or module as an execution system. This may be acceptable for traditional manufacturing companies but it comes short to satisfy all the needs of purely maintenance organization such as a remanufacturing or an R&O plant. These organizations need to integrate all levels of their planning activities, from the strategic business plan to the actual detailed maintenance plan. This process requires planning, negotiating, sourcing, inventory controlling, scheduling, monitoring, quality assurance, and dispatching of the necessary resources (Nikolopoulos et al., 2003). They also need to be able to translate a customer requirement into a firm order with an expected delivery date. This is not an easy task because of the stochastic nature of any major maintenance request, as described earlier.

In the case of a defense R&O organization, the management complexity increases with the length of the planning horizon. Remanufacturing and overhaul projects are planned at the fleet level and with relatively few information at the equipment level. The generic sequence of work is known with certainty but this is not the case with the material consumption and the work duration. In practice, ERP applications are usually good at composing with the changing nature of a maintenance order but

offer very limited functionality to do effective stochastic planning and forecasting.

Maintenance program also required an increasing number of competencies as the equipment technology evolves. Manpower level and training decisions must be planned well in advance. Most ERP maintenance modules do not permit such evaluation which is normally restricted to a production management module. In addition, the long term plan must accommodate for the unplanned breakdowns that will occur in the future. Those maintenance activities are often mission critical tasks and need to be carried out in a short time frame. Those high priority orders usually need the same pool of resources as the planned maintenance projects.

Finally, some ERP applications have difficulty in tracking the parts during the repair process. When technically feasible, spare parts and repaired components may be interchanged between orders to ensure a quick completion of a high priority order while not compromising the overall maintenance program. Parts usage and tracking must be done at the equipment and order level while the impact of parts interchanges must be evaluated at the maintenance program level.

4 PROPOSED MODEL

The proposed model considers two types of maintenance management approaches:

Proactive planning: includes the project management and the planning activities required to determine the long term requirements in terms of budget, resources, and inventory levels.

Reactive planning and controlling: includes all the planning and scheduling activities required for the execution of a maintenance order. This includes activities such as repair content evaluation and changes, parts interchanges, expediting, sourcing, procurement, and testing.

The integration of both planning approaches is realized by combining a traditional MRPII structure with the one normally used by a maintenance management information system as described in the next section. Program management functionalities are also included to facilitate remanufacturing project planning and budgeting.

4.1 The ERP model

The proposed ERP structure, as shown in Figure 1, is able to compose with the nature of the R&O workload which is partly deterministic (planned programs) and also stochastic (unplanned maintenance requests).

The implementation of both maintenance management approaches is realized by integrating the following functions in our ERP model:

- Strategic planning;
- Maintenance program planning;
- Corrective maintenance management;
- Manufacturing requirement planning;
- Maintenance execution and control;
- Workforce management; and
- Material management.

The proposed structure divides the planning processes into three subsystems. The top layer, the *Strategic planning* subsystem, addresses all long term business issues. It supports the strategic planning function by defining the global priority of the R&O organization and its corresponding budget plan.

The second level of planning is supported by the *Manufacturing Requirement Planning* subsystem. Important outputs of the MRP subsystem include the Master Production Schedule and the Material Requirement Plan. Load and capacity analysis can be performed for all MRP plans.

The final planning layer of this top-down approach is done by the *Maintenance Execution & Control* subsystem which controls the actual execution, scheduling, testing, and costing of all maintenance orders.

The *Maintenance Program Management* and the *Corrective Maintenance* subsystems capture customer demands which become the input of all planning subsystems. The *Maintenance Program Management* subsystem includes all required functionalities to effectively prepare a planned maintenance project. On the other hand, the *Corrective Maintenance* subsystem manages the unplanned requests. Both inputs are required to establish a complete master production schedule.

The *Material Management* subsystem support the critical tasks of establishing and procuring the appropriate level of spare part inventory and of

managing outsourced work in accordance with the detailed production schedule.

The last subsystem, *Workforce management*, is used to ensure that the R&O organization personnel are skilled and available to accomplish the production plan. Competency planning includes fit-gap analysis to determine the required skills and competencies for a maintenance project. This task is usually performed after each maintenance program approval in order to give sufficient time to proceed with training or recruiting activities as required. The *Workforce management* subsystem also performs operations dispatching and time recording transactions in support of the maintenance execution process.

4.2 Implementation issues

The proposed model aim at effectively integrating all aspects of the R&O defense requirements. With that objective in mind, we built the model by separating the main processes into subsystems. Each subsystem contains functions or transactions that are mostly included in commercial ERP solutions. Nevertheless, the adaptation of an ERP system, which goes beyond the normal configuration of the software, is still required since the proposed model do not use the traditional integration points that normally prevail in such system. Workflow modifications, user-exit or function programming, and report developments are therefore required.

The proposed model has been successfully applied by a Canadian repair and overhaul facility. This facility repairs and remanufactures several types of army vehicles and components for the Canadian Armed Forces. The model was used to adapt a well known commercial ERP system, SAP R/3. Selected modules for this ERP implementation project are presented in figure 2. The ERP structure makes use of the Human Resources (HR), the Controlling (CO) modules, and most of the SAP R/3 logistic modules (Project System (PS), Plant Maintenance (PM), Production Planning (PP), Material Management (MM), and Quality Management (QM)).

Initial work was conducted to integrate the manufacturing requirement planning processes with the maintenance transactions that support the execution of maintenance orders. As of today, demand planning and forecasting of remanufacturing programs is used to build an aggregate production plan. Multiple versions exist to allow load simulation and rough-cut capacity planning analysis. The active version of the plan is used to generate planned orders into a detailed master production schedule (MPS). Unplanned requests, recorded by the maintenance order subsystem, are also included in the MPS.

Material Requirement Planning (MRP) is performed based on this global master production schedule. The execution process then follows the typical maintenance execution process and is tightly integrated to the Material Management (MM), Quality Assurance (QM), Cost Controlling (CO), and Human Resources (HR) modules.

This approach has contributed to achieve significant productivity gains and inventory reductions while allowing the organization to better plan its workload.

5 CONCLUSION

This paper recognizes the difficulty to integrate defense maintenance strategy and planning processes into
existing ERP applications. The defense needs in terms of integrated logistics requires that R&O organizations be

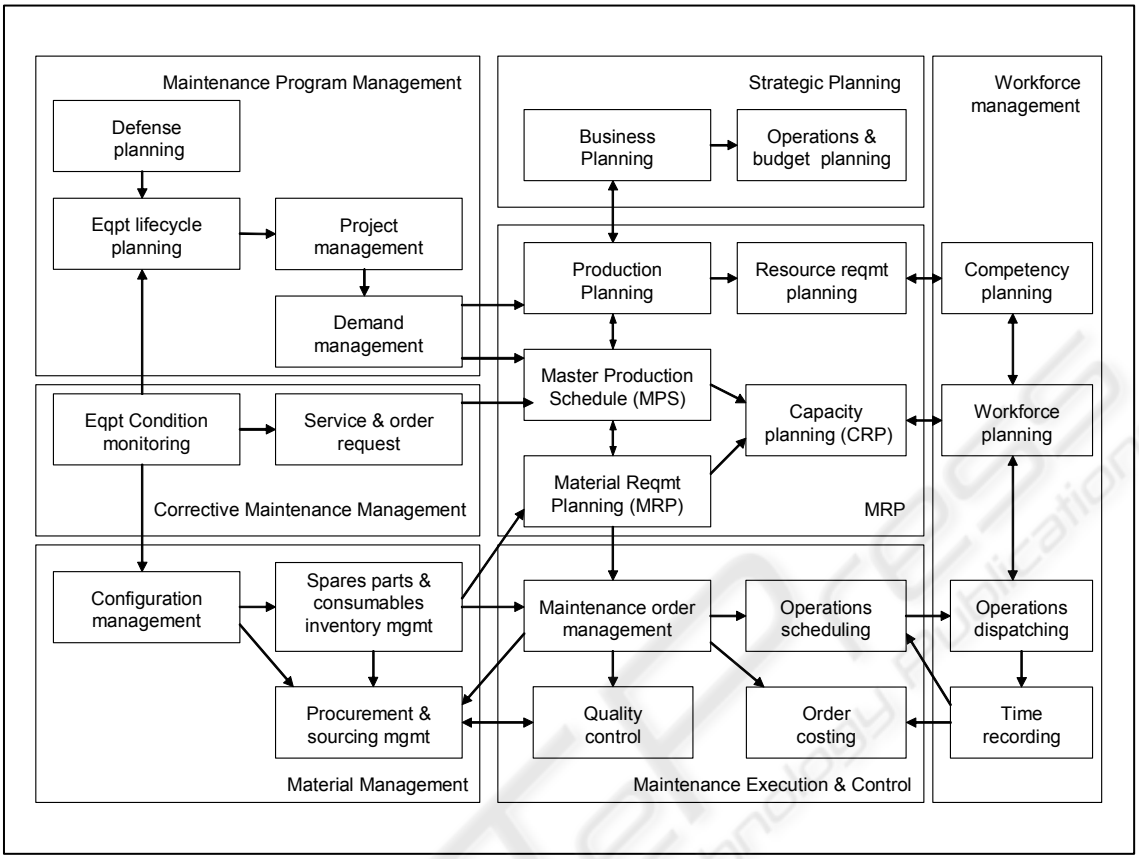

Figure 1: A proposed ERP structure for defense R&O

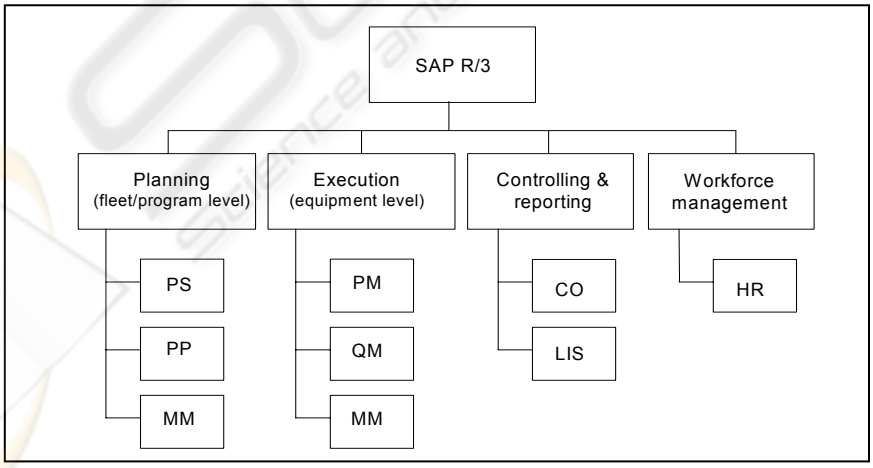

Figure 2: SAP R/3 selected modules for defense R&O management

able to plan maintenance activity at the fleet or program level while monitoring and controlling the specific condition of any equipment. The proposed model contributes to provide a modular and generic structure for adapting an ERP system in that context.

The model covered all practical aspects of the defense R&O planning process and has been implemented successfully in a real defense R&O environment. Our further research will focus on adapting the actual model for commercial R&O organizations. As an example, integration between the sales and the production planning processes need to be resolved. Management of returnable items is also an important issue to address in the future.

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