The successful implementation of MRPII via a hierarchical modelling approach

Wai Hung Ip and Richard C.M. Yam

The authors

Wai Hung Ip is with the Department of Manufacturing Engineering, The Hong Kong Polytechnic University, Kowloon, Hong Kong.

Richard C.M. Yam is with the Department of Manufacturing Engineering and Engineering Management, The City University of Hong Kong, Hong Kong.

Abstract

Manufacturing Resources Planning (MRPII) is recognized as being an effective management system that has an excellent planning and scheduling capability which can offer a dramatic increase in customer service, significant gains in productivity, much higher inventory turns, and a greater reduction in material costs. Many companies world-wide have attempted to implement MRPII systems. Many of them are now using MRPII with various level of satisfaction. However, failure of MRPII implementation was in fact experienced by other companies. This paper proposes an integrated system design and implementation approach to overcome the difficulties. It aims to formulate a standard process by combining strategic elements, problem definition, MRPII solutions, technical and procedural design, and implementation management in order to minimize the frustration and conflicts commonly found in MRPII implementation as well as to reduce disconnection among different stages of design and implementation. A hierarchical analysis technique using Integrated DEFinition Method (IDEF) is used to support the design and implementation management. The examples illustrated that it provides an invaluable support in the management of MRPII system.

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Introduction

Manufacturing organization can be broadly divided into sales, logistics, production, engineering and supporting functions. The development of Manufacturing Resource Planning (MRPII) links up all these functions together with a coverage much greater than what is being focused on by traditional MRP (Material Requirements Planning). Because of its broad and far-reaching scope, MRPII should not be regarded as a simple system. Rather, it should be seen as a corporate way of life (Melnyk *et al.*, 1985).

According to Thomas Wallace (APICS Dictionary, 1992), MRPII can be defined as "a method for the effective planning of all resources of a manufacturing company". Ideally, it addresses operational planning in units, financial planning in dollars, and has a simulation capability to answer "what if" questions. It is made up of a variety of functions, each linked together; business planning, production planning, master scheduling, material requirement planning and capacity requirement planning. Output from these systems would be integrated with financial reports such as business plan, purchase commitment report, shipping budget, inventory projection in dollars, etc. MRPII is a direct outgrowth and extension of closed-loop MRP. In general, MRPII functions can be grouped into three macro elements, namely top management planning, operation planning and execution. Figure 1 shows the framework of MRPII built up by these macro elements.

The theory of MRPII has been well discussed in the literature. Focuses are normally put on concept, methodology, application and future development of MRPII. For instance, Landvater (1992), Luscombe (1993), Orlicky (1975) and Plossl (1994) discussed the detail of MRPII mechanisms. Literature for specific MRPII scheduling functions are also found in Correll and Edson (1990), Gessner (1986), Melnyk *et al.* (1985), Proud (1994) and Van Veen (1992). Implementation management is discussed by Gessner (1984), Landvater (1992), Wallace (1990) and Wight (1993). MRPII has been recognized as being an effective management system (Ormsby *et al.*, 1990) that has an excellent planning and scheduling capability which can offer dramatic increases in customer service, significant gains in productivity, much higher inventory turns, and greater reduction in material costs. Owing to these benefits, MRPII system has

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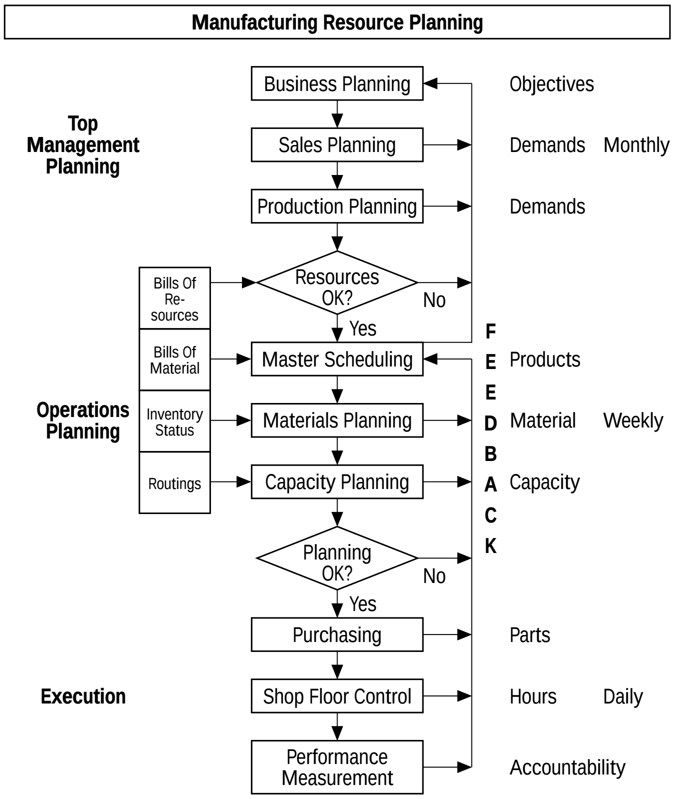
Figure 1 Framework of MRPII system



become one of the most rapidly-growing computerization areas in the manufacturing sectors in South-East Asia and much software has appeared in recent years.

Recent research, such as Ang *et al.* (1994), Lau and Ip (1993) and Turbide (1996), showed that few manufacturers were able to implement this successfully and many problems were encountered during implementation management. These problems can be classified into five areas: software, engineering, internal, customer and vendor. These problems are mainly related to incorrect practices in the design and implementation processes. Various attempts have been made to overcome these problems. Oliver Wight (1981) proposed a check-list system to evaluate the likelihood of successful MRPII implementation for companies in the process of implementing their systems. Burns and Turnipseed (1991), Cox and Clark (1984) and White *et al.* (1982), identified the critical success factors associated with the success of MRPII implementation.

MRPII implementation management

The successful implementation of an MRPII system relies heavily on commitment and management. Wallace (1990) suggested the proven path approach which is widely used in different industries. In addition to top management commitment, involvement and support from all levels of staff in the organization are also crucial factors for success. In reality, the implementation management is much more convoluted than the simple and straightforward implementation described by the proven path. People, education and training, data, management involvement, and timing are some of the major problem areas associated with MRPII implementation. These factors are elaborated as follows:

People: The major obstacle to successful implementation comes from the people side. A study on human variable of MRPII system implementation (Turnipseed *et al.*, 1992) concluded that managers considering or beginning implementation of an MRPII system should utilize the classical approach to organization change and involve as many of the affected personnel as possible in the planning and implementation stage. Also, the channels of communication should be opened and education about the realistic benefit of MRPII should be stressed. Involvement in implementation is a powerful determinant for satisfaction. Involvement in the early stages of implementation helps to smooth the process and removes the fears of those less knowledgeable about information systems.

Training and education: This area has always been overlooked by top management which results in inadequate and incomplete training. Since training and education also aim to change people's behavior, inadequate education will lead to conformance to the objective of implementation.

Data: When inventory and BOM record cannot be maintained at 95 per cent and 98 per cent accuracy, bad data make it impossible to complete the key elements of MRPII, such as MPS.

Management involvement: Most failure can be attributed to a lack of management involvement and poor attitudes toward the system (Clark, 1982) in which management is unable to maintain the implementation project as the second highest priority.

Timing: When the duration of implementation project is extended too long, more than two years, the chance of failure increases significantly as people's attention can not be prolonged for such long implementation and also the business environment is changing.

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The proven path (Wallace, 1990) only contributes a portion of the total implementation process, in particular, the technical aspects of implementation such as system selection, hardware configuration and detail procedure flows are not addressed. They are considered as the essential part of any project in information system development. Furthermore, the integration of management and technical design, which are the vital elements of successful MRPII, have not been emphasized.

Given the limitation of the existing implementation approaches like the proven path, the hierarchical design approach adopted in this research is aimed at formulating an implementation process combining strategic elements, problem definition, MRPII solutions, technical and procedural designs and implementation management in order to minimize the frustration and conflicts commonly found in actual implementation. It will improve the effectiveness and implementation of MRPII and provide an integration of the management and technology, assist in the detailed system design of the functions, facilities, hardware configuration, interfaces, performance measurement, operations, information and procedural flows, as well as overcoming the major behavioral problems that were mentioned earlier.

Hierarchical design of MRPII implementation

Colquhoun and Baines (1989) provided an IDEF model for process planning, Hargove (1995) further applied the same approach to the design and planning of machine fixtures. Their success in the application of IDEF in the design and implementation of CAE/CAM problems have motivated our research into this implementation model. IDEF, derived from the US Air, is a structured analysis and design method based on graphic and text descriptions of functions, information and data. It includes guidance for modelling, together with rules for model syntax, diagram and model format and text presentation, as well as structured model validation, document control procedures and interview techniques.

The first step in IDEF modelling is thus concerned with establishing the objectives of the modelling effort. Moreover, this is a top-down method which starts from general applications and moves on to more specific issues, from a single page that represents an entire system to more detailed pages that explain how the subsections of the system work. It includes both procedure and a language for constructing a model of the decisions, actions, and activities in an organization. "DESIGN/IDEF" software package was selected to be the modelling tool to build the MRPII model. Based on this methodology, a set of guidelines and procedures was generated and the required documents and forms were also produced to match these procedures.

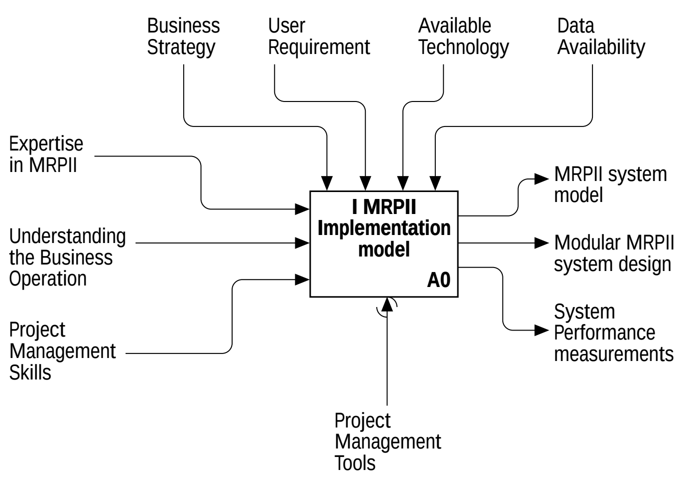
In adapting the techniques provided by IDEF, all the activities involved in the implementation of an MRPII system for the manufacturer are modelled first by defining the most important input, output, control functions and required mechanisms. Figure 2 shows the top diagram A0 of the model.

Input

It can be seen from Figure 1 that the input includes resources needed to plan the development activities, create the MRPII system and monitor the progress of this project. The details of input can be classified as follows:

- *Expertise in MRPII*
  The expertise involved in the design includes those who design the logical flow of the system, determine its database structure and configure the hardware and networking. The designer should be well versed in the MRPII philosophy. This renders a vision of what the future system will be.

Figure 2 Node A0 of the MRPII implementation model



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- *Understanding the business operation*
  The analysts and designers should closely examine the current operation by investigating major documents within the organization, identifying their sources and recipients, and thus establish the existing information flows.
- *Project management skills*
  Since the scope of the MRPII system covers a wide variety of functions in the company, its design demands company-wide resource commitment, and this calls for managerial control and an allocation of resources regarding manpower and time. Project management skills are central to the effective co-ordination of manpower, and will ensure that project goals and deadlines are met.

Mechanisms

The mechanisms in Figure 2 define the tools and techniques used to perform the design and project management functions. The details of mechanisms can be classified as follows:

- *Project management tools*
  Many project management software such as PERT charts and GANTT charts, which are the basic tools for MRPII project management.

Controls

The controls are the guidelines and procedures which ensure that the desired outputs are derived from the input and other mechanisms. The details of the MRPII controls can be classified as follows:

- *Business strategy*
  The business strategy states what the company wants to achieve and gives rise to a set of organizational objectives in order to fulfill this strategy. Its prime concern is to ensure survival despite the fierce competition imposed by competitors. The objective could include increasing product variety and offering at a lower price. The strategy and the objectives provide a basic premise for evaluation of MRPII system performance.
- *User requirement*
  User requirements come second in the order of importance concerning controls. High user acceptance of the MRPII system will bring about its widespread use within the organization and thus guarantee its success.
- *Available technology*
  System developers should consider the attainable opportunities offered by MRPII technology. Obviously, a state-of-the-art system design that cannot be supported by the current available technology is unacceptable.
- *Data availability*
  Many types of data need to be managed by a company. It is necessary to collect these data for complete analysis before designing any system. However, they are not easy to obtain, and are usually related to different parts of the work, such as data relating to inventory and purchasing operations and their availability to affect the design of the MRPII system.

Output

The output that comes from the model at different stages of the MRPII system design process can be classified as follows:

- *MRPII system models*
  MRPII system models are produced in the early stage of system design. After the current working system has been thoroughly investigated and the business operation identified, models detailing the information flows and the relationships between various entities are produced and it is these on which the design of an MRPII system is formulated.
- *Modular MRPII system design*
  MRPII system design is the ultimate output from the model. Owing to the large scope and complexity of the MRPII system, it should be decomposed into subsystems and modules in order to preserve its simplicity and ease of access.
- *System performance data*
  System performance data are collected after an evaluation of the proposed system has been completed. This output provides feedback for the design of each MRPII system and may trigger a refinement in the design.

Figure 3 shows the detailed node tree of the MRPII model. This is generated by the Design/IDEF software and illustrates the node tree decomposition of the model, giving the relevant titles and page numbers. Moreover, based on the top level A0 of the model, it is split into several levels.

Figure 4 illustrates the decomposition of the implementation model derived from A331

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Figure 3 Detail node tree of the MRPII implementation model

- [A0] MRPII Implementation Model
  - [A1] MRPII system planning
    - [A11] Project scope and goal definition
    - [A12] Feasilbility study
    - [A13] Final project plan
  - [A2] Business analysis
    - [A21] Preliminary analysis
    - [A22] Detail analysis
  - [A3] MRPII system design
    - [A31] Analyze & identify requirement
    - [A32] Analyze & review current system
    - [A33] MRPII design
      - [A331] Detail MRPII functions
        - [A3311] Planning system
          - [A33111] Master scheduling planning system
          - [A33112] Capacity requirement planning system
          - [A33113] Material requirement planning system
        - [A3312] Engineering system
          - [A33121] Product data control system
          - [A33122] Lot/serial number control system
          - [A33123] Engineering change system
        - [A3313] Production system
          - [A33131] Production activity control system
          - [A33132] Job order control system
          - [A33133] Work order control system
          - [A33134] Inventory management system
          - [A33135] Purchasing/receiving system
          - [A33136] Quality control system
        - [A3314] Marketing system
          - [A33141] Sales order/marketing system
          - [A33142] Sales order quotations system
          - [A33143] Product configuration system
        - [A3315] Financial system
          - [A33151] General ledger system
          - [A33152] Accounts receivable system
          - [A33153] Accounts payable system
          - [A33154] Cost accounting system
          - [A33155] Fixed assets system
          - [A33156] Personnel system
      - [A332] System database structure
    - [A34] Test & analyze new system
  - [A4] System evaluation

of the node tree at Figure 3. These are the planning system, engineering system, production system, marketing system and financial system.

Functional MRPII implementation

MRPII planning

The MRPII implementation process is developed through this structural approach.

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Figure 4 illustrates three planning functions which comprise of design master scheduling planning system (MPS), design capacity requirements planning system (CRP), design material requirement planning system (MRP). The design criteria and the interrelationship of these systems are further illustrated in Figure 5. It demonstrates the planning system for a sales order of 100,000 electrical consumer products, the model number being C211.

The MPS in Figure 5 is designed to be used as an integrated system involving the sales order and work order control, product data control, material requirements planning, inventory management, and purchasing and receiving systems. The function of this system is to assist the master scheduler to develop a realistic production schedule that provides a level plant load. It aims to develop a plan of required resources and compares this with the resources available. As a result, inventory investment can be minimized by matching the master production schedule to actual and forecast demand. Customer service can be increased by providing accurate, time-phased services according to those promised.

The major function of the CRP system is to provide the time-phased work order input needed to estimate the work center load and work-in-process. It also provides the planned order input for manufactured items from regenerative or net change MRP schedules. One of the major elements of the CRP is to produce run time information from the production routing file, in order to calculate the work center load for planned orders and firm planned orders.

The purpose of MRP is to provide information for the company to effectively manage and control the production. The information derived from this system not only indicates the material requirements and order processing necessary to meet the company's plan but also assists management in planning and monitoring cash flow. The specific objectives are to minimize the amount of inventory on-hand and on-order, to support the master production schedule, plan purchases and production with the correct timing and priority, and determine the cost impact of executing the master production schedule. Figure 6 illustrates the processing of the MRPII system. The master schedule is prepared for the products by following the workflow from A331131 to A331136.

Engineering system

The second major element of the implementation model is the engineering system which includes three sub-systems: the product data control system, the lot/serial number control

Figure 4 Decomposed page from block A331 of the MRPII implementation model

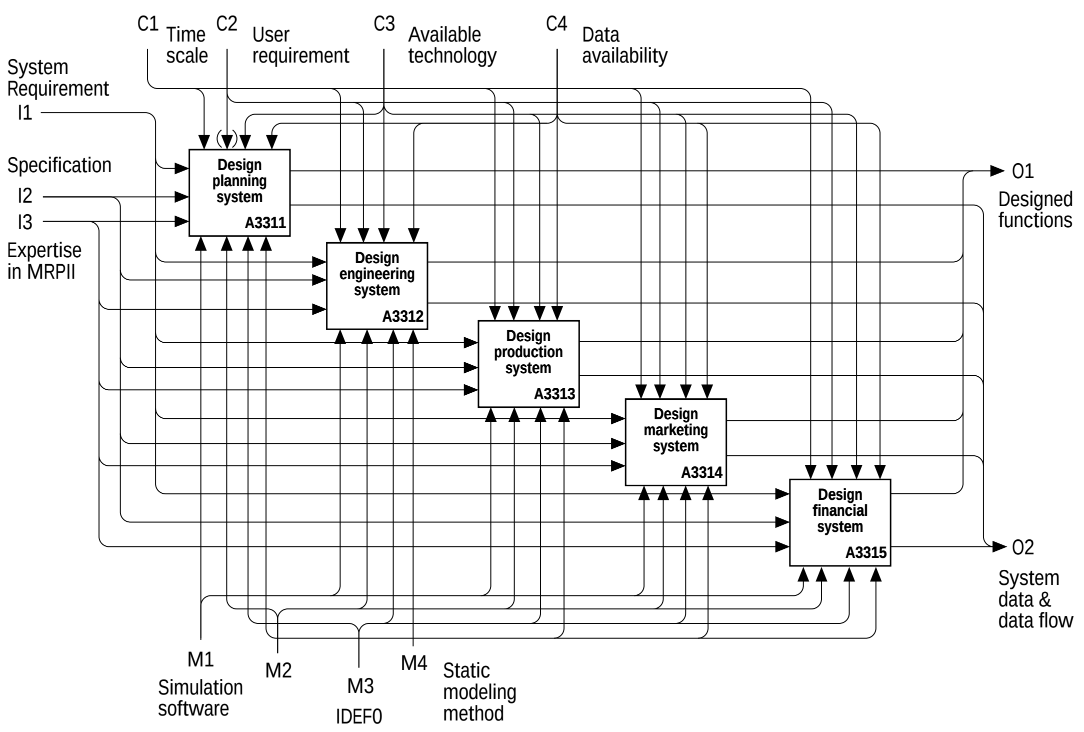

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Figure 5 Decomposed page from block A3311 of the MRPII implementation model

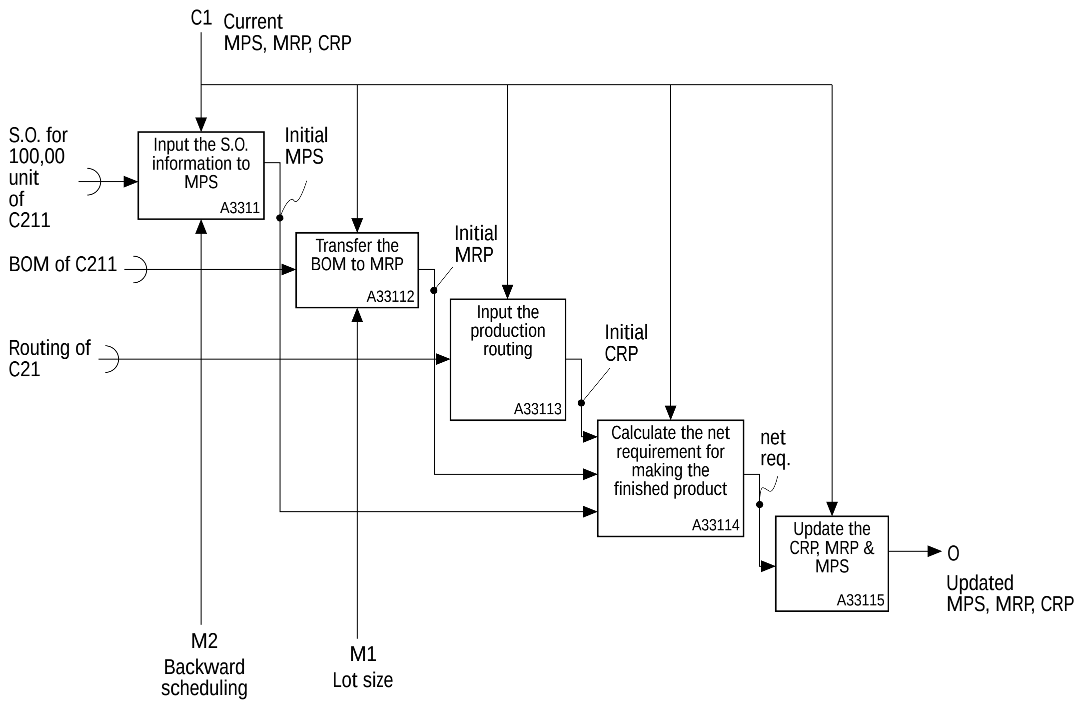
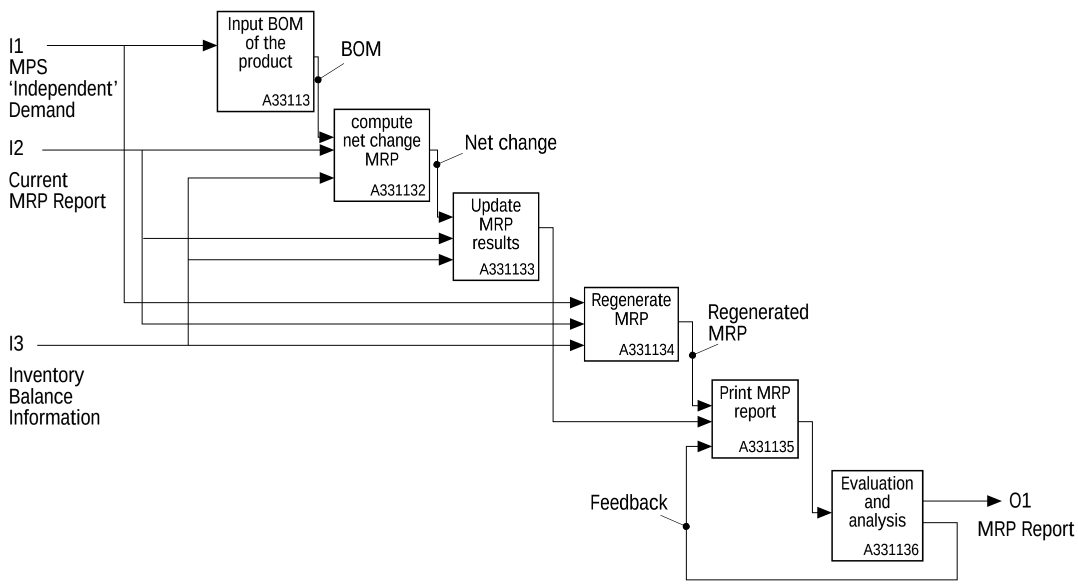


Figure 6 MRPII processing procedure



system, and the engineering change system. The purpose of the product data control is to maintain and control all product information, including the generation of the bill of material (BOM), routings, and work center related data required to manufacture the products. It is designed to handle both make to order and make to stock. The control elements are customer specification, safety standard and part numbering specification. Figure 7 illustrates the product data control system of the MRPII implementation model.

In A3313, the production system consists of five sub-systems; job order control, work order control, production activity control, purchasing/receiving, quality control and inventory management. The first element under A3313 is the design production activity control system (PAC). This is designed to be used as an integrated system with the work

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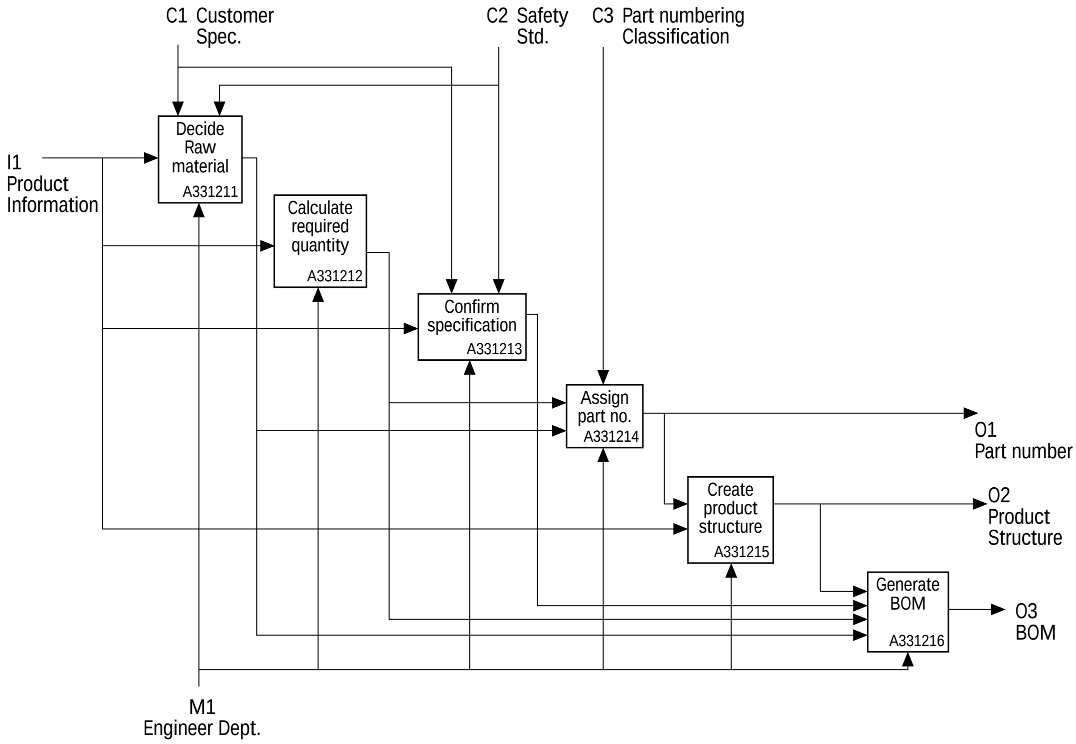
Figure 7 Product data control system of the MRPII implementation model



order control and capacity requirements planning system. The PAC system is used to monitor the progress of the released work order, reduce work-in-process inventories and lead times, as well as improve vendor performance. A key element of an effective PAC system is the feedback on shop and suppliers' performance against plans. The PAC is closely related to job order control system (A33132) and work order control system (A33133). The major function of the job order control system is to allow the company to tie multiple work orders and costs to a job. Production budgets and job estimates can be built from the cost data defined for the components and assemblies to be used in the job. Detailed cost reporting is provided to monitor all costs charged to the job. The job order control system monitors the progress of jobs through the production processes and, hence, provides actual cost variance reporting.

The work order control system provides detailed work order instructions in the work center. The instructions include: cost, materials, tooling, labor, routing and lead time for each work order. The creation of the work order is implemented by the checking of the component availability, and is then released to the work center. Once the order is released, the necessary quantities of components are allocated to this order. Picking tickets are also created and sent to the stockroom. The allocation is removed and the on-hand balance is reduced after the order is completed.

The operation of the PAC system is illustrated in Figure 8. First, a work order for producing 100,000 units is entered into the MRPII system. The BOM and routing records of the product are edited and the required components are allocated to the work order. It is then released to production. Picklist, parts labels and labor tickets are printed. The allocated components are physically picked to the production work center and the inventory record is updated to notify the movement of the components. After the operation has been completed, the labor, machine and time used for this operation are recorded for the calculation of the actual production cost. Furthermore, any changes for the work order or any scrap produced during the operation are recorded. The assemblies are transferred to the next work center for further processing or stored in the desired inventory, their location is also recorded for monitoring of the work in process (WIP). Finally, the completed work order is notified to the MRPII system.

The next important element in A3313 is to control purchasing and receiving activities.

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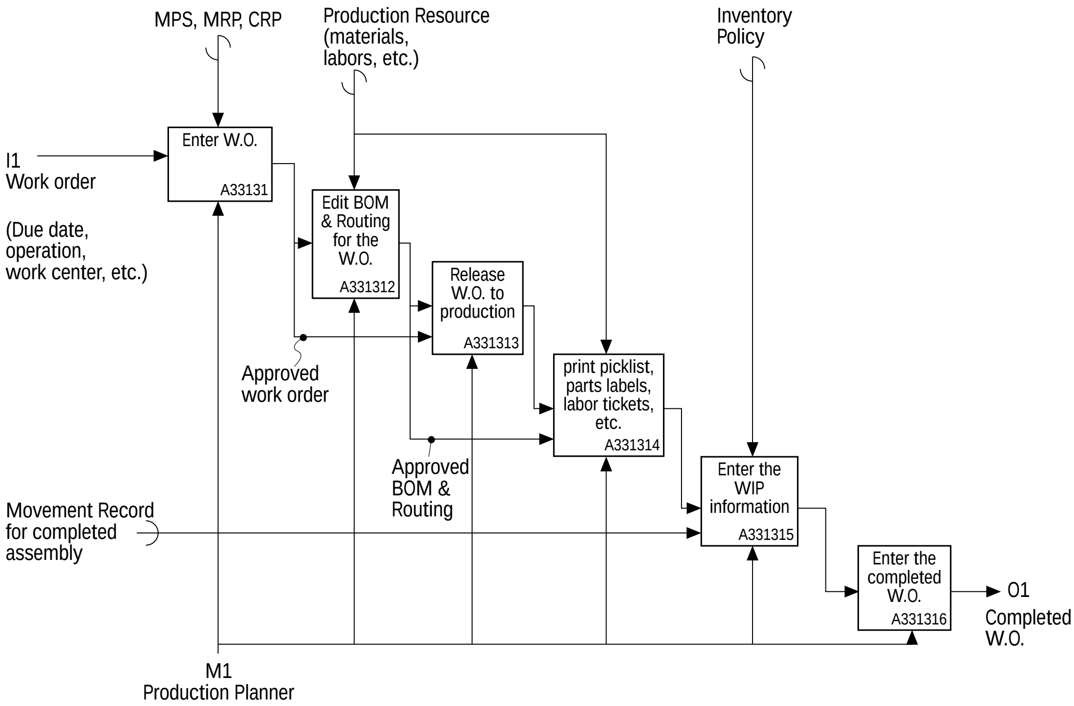
Figure 8 Production activities control of the MRPII implementation model



This sub-system maintains information about approved vendors and approved manufacturers, produces purchase orders for multiple parts and multiple scheduled deliveries per part, performs receiving actions, whilst receiving inspection, vendor shipments, and buyer performance. It accumulates information for both purchasing and vendor performance evaluation. Vendor information is placed into the purchase order. The purchase order data are placed into the receipts and, finally, the receipts information is transferred into accounts payable receipts and material inventory movements. Figures 9 and 10 illustrate the purchasing system and material transfer system of the model.

Inventory management

The purpose of this system in A33134 is to maintain accurate information on the quantity, location and value of all inventory items. It aims to reduce inventory investment and handling costs and to improve customer service through better delivery schedules. By improving the integrity of inventory data, a basis for better inventory planning and control is established. This enables improved customer service through shorter lead times and reduces late customer deliveries, thereby improving a company's competitive position. Furthermore, it improves the integrity of inventory on-hand data and provides a basis for better inventory planning and control.

The other important functions in the MRPII implementation model can also be seen in Figure 3. These are, for example, the lot/serial number control and engineering change sub-system under the engineering system. The purposes of the lot/serial number control modules are to document the content of lot and serial numbers, track where lot and serial numbers have been used, and control the expiration of lot and serial numbers. Similarly, under the engineering system, the engineering change sub-system provides a facility for the engineering department to add and change parts; the BOM and bill of operations are held in a separate database without affecting the manufacturing database. This provides the engineering capability to develop, change and complete engineering change orders and then incorporate the changed orders into the regular manufacturing database at the appropriate time. These systems and their corresponding IDEF analysis are not described in detail because of space limitations.

Another important feature of the implementation model is the quality control subsystem under the production system. The quality control system is designed to maintain inspection records and facilitate the inspection process of incoming material and

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Figure 9 The purchasing system of the MRPII implementation model

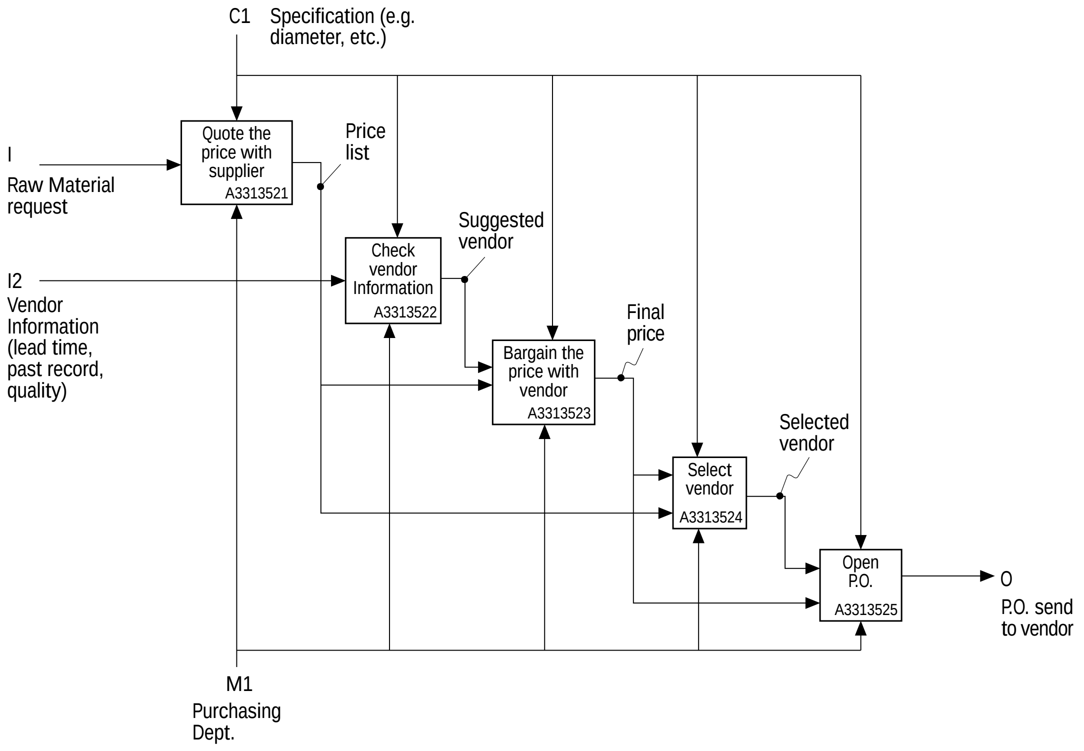
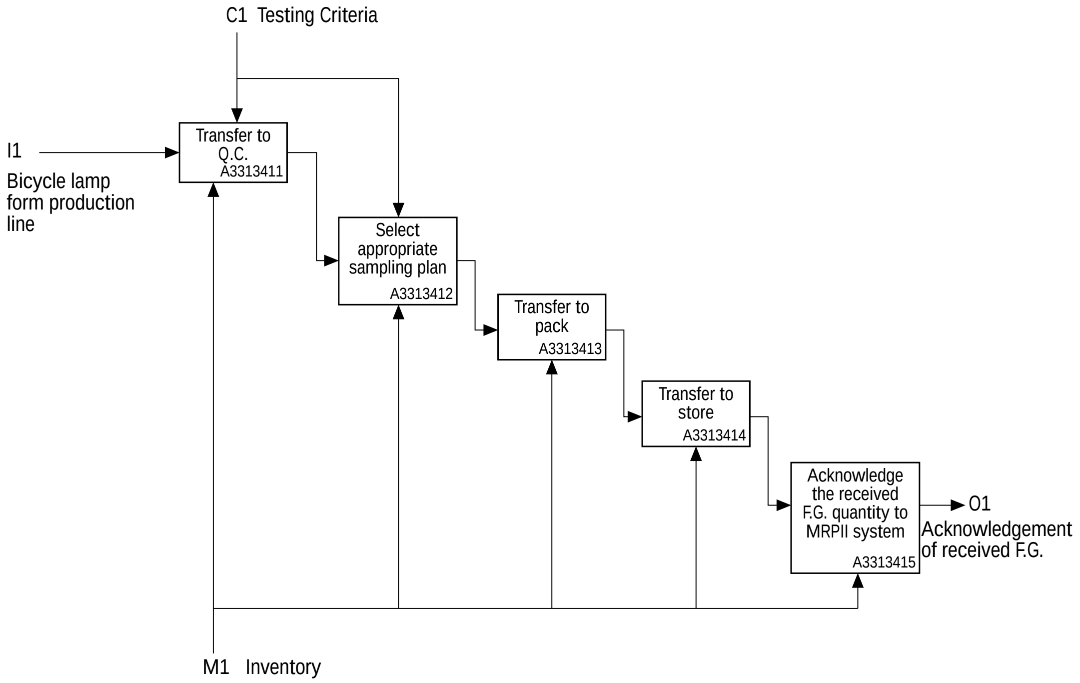


Figure 10 The material transfer system of the MRPII implementation model



in-process material. It is designed to be used as an integrated system with the product data control, work order control, inventory management, lot and serial number control, and purchasing and receiving system. The quality control system aims to control incoming and in-process material inspection, ensuring that material is inspected according to the inspection criteria and correct sampling plan. Moreover, it allows vendor selection through vendor analysis based on quality, price, and delivery performance.

Conclusion

The importance of this study is the integration of management and technology in the MRPII planning and implementation as opposed to the check list approach from Wight (1981) and the organization approaches (Burns and Turnipseed, 1991; Cox and Clark 1984; White *et al*., 1982). The basis of this hierarchical design approach is the use of the IDEF0 analysis, together with the node index of the model. Each system, represented in the node index by a number, is broken down into its component parts. Detailed notes are provided with each low-level diagram to outline the management and technology requirements in each area. By comparing existing practice with the implementation requirements through the IDEF analysis, any company, regardless of its size, is able to identify ways in which its MRPII system should be implemented. It provides a master plan which integrates the technology and management of the strategic elements, problem definition, MRPII solutions, technical and procedural design, and implementation management in order to minimize the frustration and conflicts commonly found in MRPII implementation process as well as to reduce disconnection amongst different stages of the implementation process.

References

Ang, J.S.K., Sum, C.C. and Yang, K.K. (1994), "MRPII company profile and implementation problems: a Singapore experience", *International Journal of Production Economics*, Vol. 34, pp. 35-45.

APICS Dictionary (1992), *American Production and Inventory Control Society*, Falls Church, Virginia.

Burns, O.M. and Turnipseed, D. (1991), "Critical success factors in manufacturing resource planning implementation", *International Journal of Operation & Production Management*, Vol. 11 No. 4, pp. 5-19.

Clark, S.J. (1982), and others, "How to evaluate your material requirements system", *Production and Inventory Management*, 3rd quarter, pp. 15-32.

Colquhoun, G.J., Gamble, J.D. and Braines, R.W. (1989), "The use of IDEF0 to link design and manufacture in a CIM environment", *International Journal of Operations & Production Management*, Vol. 9 No. 4, pp. 48-65.

Correll, J.G. and Edson, N.W. (1990), *Gaining Control – Capacity Management and Scheduling*, Oliver Wight Publications, Brattleboro, VT, pp. 92-106.

Cox, J.F. and Clark, S.J. (1984), "Problems in implementing and operating a manufacturing resource planning information system", *Journal of Management Information Systems*, Vol. 1 No. 1, pp. 81-101.

Gessner, R.A. (1984), *Manufacturing Information Systems Implementation Planning*, John Wiley & Sons, New York and Chichester.

Gessner, R.A. (1986), *Master Production Schedule Planning*, John Wiley & Sons, New York and Chichester.

Hargrove, S.K. (1995), "A systems approach to fixture planning and design", *International Journal of Advance Manufacturing Technology*, Vol. 10, pp. 169-82.

Landvater, D.V. (1992), *World Class Production and Inventory Management*, Oliver Wight Publications, Brattleboro, VT.

Lau, K.H. and Ip, W.H. (1993), "Implementation of an MRPII system: a case study of a Hong Kong manufacturing company", *Proceedings of the Sixth International Manufacturing Conference with China*, IMCC 2, pp. 555-60.

Luscombe, M. (1993), *MRPII : Integrating the Business*, Butterworth-Heinemann, Oxford, pp. 1-20, pp. 137-45.

Melnyk S.A., Carter, P.L., Dilts, D.M. and Lyth, D.M. (1985), *Shop Floor Control*, Dow Jones-Irwin, Homewood, IL, pp. 33-60, pp. 115-24.

Orlicky, J.A. (1975), *Material Requirements Planning*, McGraw-Hill, New York, NY.

Ormsby, J.G., Ormsby, S.Y. and Ruthstrom, C.R. (1990), "MRPII implementation: a case study", *Production and Inventory Management Journal*, Vol. 4, pp. 77-80.

Plossl, G. (1994), *Orlicky's Material Requirements Planning*, McGraw-Hill, New York, NY.

Proud, J.F. (1994), *Master Scheduling*, Oliver Wight Publications, Brattleboro, VT, pp. 1-15.

Turbide, D.A. (1996), *Why Systems Fail, and How to Make Sure Yours Doesn't*, Industrial Press, New York, NY.

Turnipseed, D.L., Burns O.M. and Riggs, W.E. (1992), "An implementation analysis of MRPII systems: a focus on the human variable", *Production and Inventory Management Journal*, first quarter, pp. 1-5.

Van Veen, E.A. (1992), *Modelling Product Structure by Generic Bills of Materials*, Elsevier Science Publishers B.V.

Wallace, T.F. (1990), *MRPII – Making It Happen*, Oliver Wight Publications, Brattleboro, VT.

White, E.M., Anderson, J.C., Schroeder, R.G. and Tupy, S.E. (1982), "A study of the MRPII implementation process", *Journal of Operations Management*, Vol. 2 No. 3, pp. 39-47.

Wight, O.W. (1981), *MRPII – Unlocking America's Productivity Potential,* CBI Publishing, Boston, MA.