

MATERIAL CONTROL FOR THE FACTORY OF THE FUTURE

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I. Introduction

Experts have announced that the automated factory of the future is imminent. Computers will direct functional areas including material requirements planning and material control. MRP requires accurate inventory records to supplement the master schedule and bills of material. From this requirement the concept of computerized material control has emerged as an effective technique to provide the highest degree of inventory accuracy. Material control systems also automate management control over physical material flow, and material handling/storage resources. This presentation provides a view of how real-time material control systems may be utilized in the factory of the future and in today's modern facilities. Material control systems are emerging as applicable to raw material, WIP or finished goods in manufacturing and distribution.

Formal manufacturing control systems such as MRP have been widely acclaimed in the past decade as the pathway to productivity.

However, most of these systems have not delivered the promised results and expectations. At the bottom line, these systems have generally not proven good, consistent cost effectiveness and the return on investment results are disappointing.

At the same time, within the repetitive manufacturing and processing industries, it is recognized that highly adaptive planning systems were never really needed. Leaders from these areas have been searching for better control techniques, as opposed to working on sophisticated planning systems.

Recent thrusts from both directions identify the need for timely and accurate control information. More specifically, the desire is to automate material control for the factory of the future.

Terms such as ICAM (Integrated Computer-Aided Manufacturing), Group Technology and AGVS (Automated Guided Vehicle Systems) are discussed greatly in current literature. Most is conceptual in nature, with some case histories.

But how does automated material control fit into this "factory of the future"? What will the impact be on material managers, systems manager,

production managers and manufacturing engineering? Will it succeed faster or better than MRVP.

This presentation addresses these concerns by zeroing in on material control as a critical design element in the automated operations of the future. A formal model is proposed which identifies the subsystems of automated material control and how they interface MRP or formal planning systems.

II. Automated Material Management

Figure 1 shows the seven-level model which depicts the system hierarchy in the automated environment. The diagram identifies levels of subsystems and at each level there will be multiple specific subsystems possible.

Note that all levels (except level 1) are scheduling systems of one kind or another. The criteria for defining the levels are:

1. What is the scheduling trying to accomplish?
2. What relative timing is required?
3. What resources are being scheduled?

The seven levels are defined below according to this criteria. Observe that the hierarchy is top-down in several ways - from general to specific, broad timeframes to very tight, and from information intensive to control intensive.

Level 7 - Master Planning Systems

- Provide the top-level operational and manufacturing schedule.
- Timing is broad-monthly/weekly update frequency.
- Resources planned are broad groups of production resources and aggregate or wall-to-wall levels of inventory.

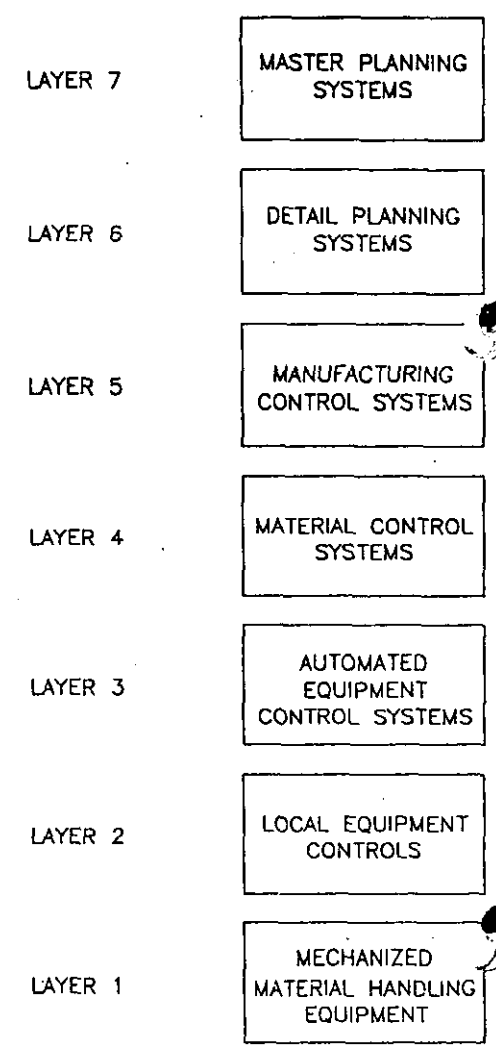
Level 6 - Detail Planning Systems

- Provides complete plan for components, assembly and distribution in order to support the master plan.
- Daily update cycle typical, or by shift.
- Inventory levels of all components and assemblies are planned concurrent with scheduling all production resources (machine tools, assembly lines, process equipment and lines).
- Provides feedback to level 7.

Level 5 - Manufacturing Control Systems

- Translates detail plan into authorization and commitment to

FIGURE 1
AUTOMATED MANUFACTURING MANAGEMENT HIERARCHICAL MODEL



- move material.
- Daily and hourly updates - sometimes in real time.
- Three distinct phases of material movement are commanded at this level: 1) Procuring from vendors 2) Controlling in-house value-added, 3) Distributing to customers.
- Generates feedback to level 6.
- Level 4 - Material Control Systems
 - Schedules all physical movements of material throughout the facility.
 - Processes data in real-time response in seconds.
 - Tracks status of all material by component number and schedules

material movement throughout all material handling resources to balance flow and minimize queue. Provides feedback to level 5.

Level 3 – Automated Equipment Control Systems

- Directly communicates to local controls of various types of equipment (S/R machines, carousels, robots, conveyors, etc.) and schedules movements of equipment and specific loads.
- Real-time response required is milliseconds to seconds.
- Maps status of loads to physical addresses-whether in stationary (in storage) or enroute (moving on a conveyor).
- Feedback to level 4.

Level 2 – Local Equipment Controls

- Directly interfaces mechanical equipment and provides actual motion of machinery.
- Real-time millisecond and finer timing.
- Has no data knowledge-machine specific and typically on-board or wired directly to equipment.
- Feedback to level 3.

Level 1 – Mechanized Material Handling Equipment

- Designed to handle specific load cube and weight specifications.

Examples of specific subsystems which occur at each level are:

- Level 7** Business Planning
Production Planning
Rough Cut Capacity Planning
Master Scheduling

- Level 6** MRP – Material Requirements Planning
CRP – Capacity Requirements Planning
DRP – Distribution Requirements Planning

- Level 5** Procurement or Purchasing Control
Manufacturing Control
Shop Floor or Flow Control

- Distribution Control
Inventory Allocation and Order Release
- Level 4** Material Control – Receiving-
Manufacturing-Distribution
Stockroom Management
Warehouse Control
- Level 3** Real-time S/R Control
Carousel Control
AGVS Control
Man-Aboard Computer Control
Real-Time Conveyor Control and Tracking
- Level 2** S/R On-Board Controls
AGVS On-Board Controls
Local Conveyor Controls
- Level 1** S/R Machines
Carousel Units
Automated Vehicles
Conveyors
Man-Aboard Vehicles

III. What Is New?

Knowledgeable professionals will quickly recognize that levels 5-7 are already well defined areas and, in fact, have already become computer-based systems in most operations. What defines the factory of the future is levels 1-4.

Heretofore these levels were handled by people using manual means of moving material – forklift operators, crane operators, and material handlers. To off-load the drudgery of this form of labour to equipment and at the same time replicate the truly amazing intelligence of human beings requires a system organization such as that shown above. Especially when the requirement to be cost-effective finds its way into the picture.

The benefits of automating levels 1-4 are:

- The hierarchy is designed specifically to solve the material control problem – improved logistics frequently result in faster delivery of materials (lowering

inventory levels) and greater accuracy (again lower inventory). Data control is correlated in real-time to physical flow. Operators can almost not make any mistakes! No longer do transactions get lost or forgotten on the way to the data entry terminal in the stockroom office. Physical movement is automated, reducing labour and floor space requirements.

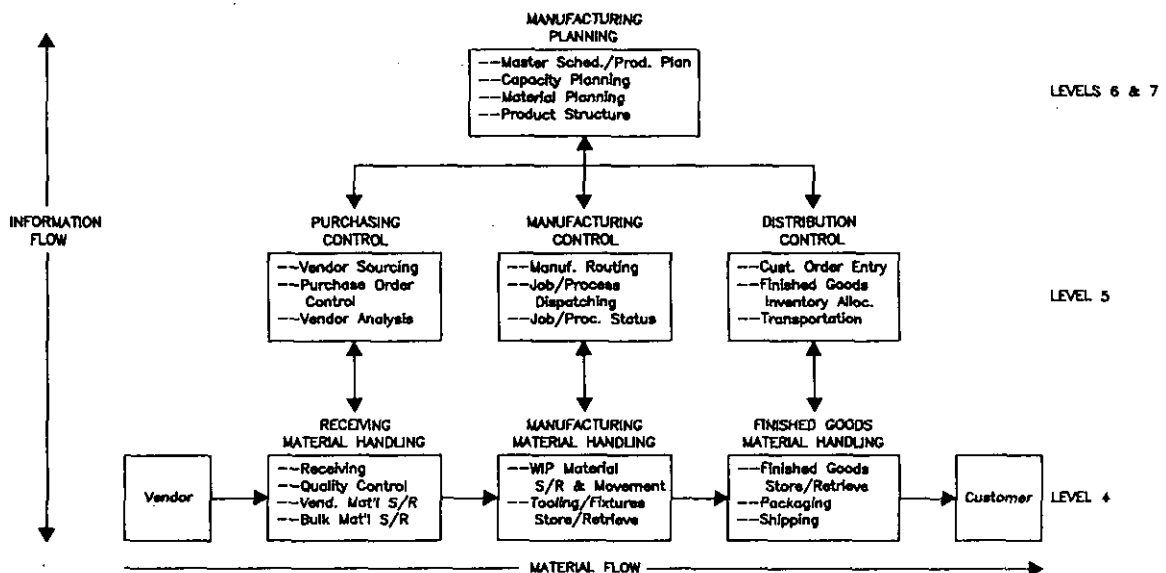
In sum, factory automation is introducing four new levels to the operational systems hierarchy. This presentation will focus on level 4 and its interfaces immediately above and below.

As shown on Figure 2, three major types of material control systems exist in the factory of the future. One is the Receiving stores system, characterized by the information processing requirements to interface purchasing in handling vendor receipts. This system frequently features tracking of QC operations such as sample tracking, bin locking (storing material in the storage system under a hold condition) and lot control (pegging specific inventory records in typically multiple storage locations back to an original vendor shipment). Systems of this type are common today as exemplified by AS/RS.

The Distribution system is also well understood – providing specific end item control with the addition of packaging shipping logistics. Again, several examples of dedicated mini-computer based systems are in use at present.

IV. Automated Material Control in Manufacturing

The newest frontier in material control is how automated systems will interface to the process/flow/shop floor control systems understood today. What functions will exist where?



Recall that what is new is automation of material control and movement – not of how the production process is designed or managed. Of course automation provides opportunities for re-evaluating manufacturing layouts and other design parameters but these changes are parallel to upgrading material control – not necessarily as a result.

In other words, the task of defining the process on a routing or process data file and determining the sequence of production (dispatching) based on the schedules from level 6 are still performed at level 5.

The intelligence required at level 4 is:

- Track real-time status of material (work pieces), tooling, fixtures, and supplies.
- Keep a map of all production resources in the facility and know how to effectively route above items from their storage areas to production and back.

Obtain a dispatch plan from level 5 and schedule automated

event-driven system which is able to concurrently accept, process, and provide immediate response to events which occur in real-time. The system provides immediate access and inquiry to pertinent inventory information. Reports and displays may be structured to operations, incorporating only data that is relevant. The system enhances decision making by allowing operational personnel to gain access to needed information which is beyond reach using manual methods.

A. Computer Hardware

A 16 bit minicomputer is usually used for the inventory control computer system. Virtually any minicomputer brand and model is suitable for this application. The key to success is in the software, primarily the operating system. In the future there are two trends. One is to install the new 32 bit superminicomputer and to locate all the application functions on one machine. The other trend is to separate the application functions and to locate each on a dedicated minicomputer or microprocessor since they are now so

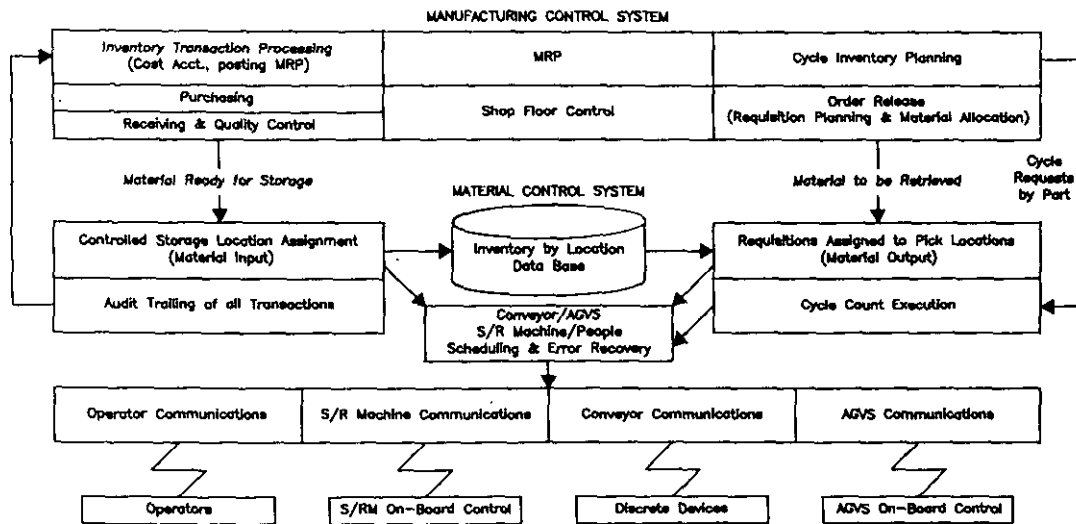
system must be able to concurrently process events and interrupts in real-time with an acceptable overall system response time. The operating system should contain a terminal handler which is capable of supporting all the terminals which are configured in the system.

3. Data Base. The data base or file structure of the data files is the heart of the system. The design of the data base and the file linkage provided for the data records is the most crucial aspect of a material control computer system. The data base determines whether a function can be included in the applications software.

4. Data Base Manager. The data base manager or file manager is the software mechanism which provides the data located in the data base to the application software upon demand. This software must be fast and efficient. It should operate in a harmonious manner with the operating system. Data base managers are provided by computer vendors and by software companies.

Quick recovery of the data base is a

OPERATIONAL SYSTEM SCHEMATIC



equipment controllers (level 3) to physically deliver all items at correct times and places.

- Interact in whatever timeframe level 5 requires (once per shift, several times per hour, or in real-time to provide the combined capability of dispatching and moving material to support the plans from levels 7 and 6.

V. Computer System

The computer system for level 4 in Figure 1 is typically a minicomputer with disc storage, a high speed printer, an assortment of terminals, and hardware interfaces. This system provides real-time material control in the factory or distribution center. It is an

powerful. Either technique is acceptable and will work effectively.

B. Software

There are four major software modules or subsystems which run on the computer.

1. Application software. This software contains the application software which operationally controls the material. It contains the terminal conversations, reports, tickets, displays and other such items. This software is usually custom tailored to a specific facility.

2. Operating System. The operating system is the key to success in a material control computer system. This software is usually provided by the computer vendor. A good operating

critical element in system design. Good data base managers will provide for constant snapshots of all updates to a non-volatile storage medium (disk or tape). Emergency restart procedures should automatically check file status and automatically restore data integrity or notify applicators to rebuild the data files from a checkpoint set of files and re-processing all transactions since. The entire process should not exceed 30-45 minutes in even the worst case.

C. Data Communications

The data which is processed by a computer system must be transmitted to an operator or to another computer system. When the data is transmitted between computers a data

communication link is provided. Currently the technique favoured is a point-to-point direct link with an acceptable line protocol which is understood by each computer. In the future there will be local area networks which use high speed data bus technology. The trend is toward a common bus which carries data to and from any computer or terminal located in the network.

VI. Central VS Distributed Processing

There has been a major argument in the computer industry for years over the central computer vs distributed computer system. The advantages and disadvantages of each has been analyzed at great length. However, the introduction of the microprocessor has definitely biased the final decision toward distributed processing. More and more functions within the factory are being controlled by dedicated microprocessors. In fact, they are appearing everywhere.

The distributed network is excellent and can be very effective if two elements are considered in the design. The processing on each of the units or computer nodes must be essentially independent and self-contained. The data must be located on the unit and a minimum of data should be required

from any other computer or data base during the processing. An example of a good computer unit is shown in Figure 3. The data required for input to the material control computer is the store/pick information from the Host system. The inventory, locations, hardware data and other information is contained locally. The information which is transmitted when processing is complete are the inventory transactions.

If these two guide lines are followed, then there will not be an excessive amount of data transmitted on the data communication network. Excessive data communications can cause poor response time, potentially lost data, and complex system synchronization.

Most of the industry experts foresee that companies will install extensive distributed processing with distributed data bases. An idea often expressed is that companies should install islands of automation and then integrate the islands together. If this philosophy is followed there should be a master plan which is modular. Then areas can be automated as required in harmony with the master plan.

Recall the hierarchy model in Figure 1 which defines the functional partitioning of subsystems for the factory of the future. Because this partitioning considers the natural

grouping of data flow and control responsibility distributing the processing also follows this model. In fact, descending through the levels the processing required steps from main frame at the top level to super-minis at middle levels to micro-computers and microprocessors at the bottom.

VII. Summary

The primary reason to utilize computers for material control is to establish a high degree of inventory accuracy. Industry experts continually reiterate that for MRP and production scheduling to be effective there must be inventory accuracy of 98% or greater. It is possible to provide manual inventory control systems which are accurate; however, in medium or large organizations with thousands of part numbers and a variety of product lines, a computer is required if the inventory system is to be cost effective.

In the factory of the future the material control function will certainly be computerized. In addition, personal computers will be interfaced to the company computer network and will be used by personnel at all levels to access the data base and extract required information for decision making. When the level 4 material control system is

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small, personal computers may soon provide the computer power needed and will be a direct part of the hierarchy.

The basic subsystems and components of manufacturing automation are now available to build an automated factory in the United States. The use of lower-priced computers to automate the manufacturing planning and control functions is what makes an automated factory feasible. Distributed computer systems and communication networks are becoming common. However, the automated factory requires that these technologies and subsystems be interfaced together into a fully integrated system which includes all areas of the factory from product design to shipment to the customer. When this complex integration has been accomplished the truly automated factory will exist.

Material control is a critical link between manufacturing systems and actual factory operations. A computer material control system makes it easier to determine what is inventory, improve the efficiency of storing and retrieving parts, and optimize transaction processing and material delivery. The inventory accuracy is particularly important since accurate, accessible records are the foundation for a fully automated manufacturing management system.

In brief . . .

Can you devise a crossword for the Christmas edition of Control?

The Editorial Committee will present £10.00 to any member submitting a crossword which is printed in the magazine. Closing date for entries: 1st October 1983.

Our apologies are due to the committee and members of the Yorkshire and Humberside Region. We missed the change of arrangements for the meeting originally planned for 17 May and trust it did not cause too much confusion.

NOMINATIONS FOR ELECTION TO COUNCIL

As the number of nominations does not exceed the number of vacancies on the Council there will be no postal ballot.

D. L. Millar

F. Blaize Cooke has extensive experience in the definition, design, development and installation of real time systems. At this time he is the technical adviser to the General Manager of Eaton-Kenway, whose primary product is turnkey, real-time automated storage/retrieval systems (AS/RS) for material handling in manufacturing facilities and distribution centers. He was appointed to this position after he served as the Software Engineering Department Manager for three years. During this time he was responsible for the System Engineering and Software development of approximately thirty (30) AS/RS projects. His responsibilities included the installation of the control systems on site and customer acceptance. Prior to Eaton-Kenway, Mr. Cooke worked in the aerospace industry for eighteen years on real-time systems for missiles and jet aircraft. He has a degree in Physics.

David W. Nelson is the Manager of Computer Concepts Development for Eaton-Kenway. He has responsibility for designing control systems in Automated Storage/Retrieval applications. Eaton-Kenway is the world's leading supplier of AS/R systems for material handling in manufacturing facilities and distribution centers. Mr. Nelson has eight years experience in industrial engineering, materials management and systems development. He has managed warehouses, material control departments and been an MRP coordinator. A graduate of the University of Michigan in Industrial Engineering, Mr. Nelson is currently a senior member of AIIE. He has been affiliated with APICS for five years and is the President of the Salt Lake City Chapter. He is a Certified Fellow of APICS.

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