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Guide to production control

Part 6. Computer aided production control

BSI STANDARDS

Committees responsible for this British Standard

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British Computer Society
British Production and Inventory Control Society
Chartered Institute of Management Accountants
EEA (The Association of Electronics, Telecommunications and Business Equipment Industries)
Institute of Logistics and Distribution Management
Ministry of Defence
Nottingham University
PERA International (Production Engineering Research Association)
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University of Manchester Institute of Science and Technology

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Contents

Foreword

This Part of BS 5192 has been prepared under the direction of the Quality, Management and Statistics Standards Policy Committee.

The prime objective of production control is to help a company become more competitive and profitable. An effective production control function endeavours to fulfil this objective by keeping a balance between satisfying sales demand, achieving high plant utilization and maintaining low investment in stocks and work-in-progress. An optimum balance between these often conflicting objectives will only be achieved by a production control system designed to meet the specific needs of the company and run by well trained and dedicated staff.

BS 5192 is published in six Parts and gives comprehensive guidance in those areas that are considered essential for effective production control. The Parts are as follows:

Part 1 *Introduction*:
Scope of the guide, purpose of production control, relationship to other functions, technological changes, choosing the system to fit the business

Part 2 *Production programming*:
Relationship to corporate and business programmes, planning techniques, master production scheduling, capacity planning

Part 3 *Ordering methods*:
The various types of ordering and stock control systems, comparing the advantages of each for particular applications

Part 4 *Dispatching (shop-floor control)*:
The methods of shop-floor production control and documentation involved and the increasing influence of computers

Part 5 *The relationship between production control and other management functions*:
The production control information flows in the organization, their generation, presentation, use and maintenance

Part 6 *Computer aided production control*:
The application of computer software to the production control function

Throughout this standard the use of the pronouns he, him and his is intended to be non-gender-specific.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Guide

Introduction

The planning and information flows in the various stages of a production control system (see figure 1) can be facilitated by the use of computers. This Part of BS 5192 describes the benefits of the use of computers in the production control process. The capabilities of computers to store, maintain, manipulate and share large volumes of data and communicate information very quickly is ideally suited to the present day needs of production control. Today's manufacturer can be faced with international competition, quickly changing markets, the customer's expectation of significant reductions in design-to-delivery lead times and severe profit margin erosion. Much of this pressure is brought about by the intelligent use of computers by the competition especially in the field of production control. The effective management of this area of the business is vital and can lead to significant cost reductions in the areas of work in progress and component stores; it can also lead to an overall reduction in delivery lead time.

To remain viable and to meet and beat the competition, manufacturers should seriously evaluate the use of computer aids in production control. This evaluation has to be professional in terms of the objectives and the likely costs and benefits. The effort required is large and cannot be taken lightly, but the rewards in terms of improvements in performance and management control can be enormous.

NOTE. The development of the use of computers in production control is described in annex A.

1 Scope

This Part of BS 5192 gives guidance on the use of computers in production control. It does not describe the use of computers in other areas of the business such as computer aided design, engineering management, finance, purchasing, payroll, maintenance and sales order processing. However, the techniques and requirements identified and recommended in this Part of BS 5192 for the establishment of a formal specification of requirement, selection and justification of a computerized production control system (either bespoke or a commercial package), installation and implementation of the system, together with the guidance on ongoing operational requirements and future trends, may be applicable not only to production control systems but equally to the professional evaluation, selection, implementation and operation of any business system in the manufacturing company.

2 References

2.1 Normative references

This Part of BS 5192 incorporates, by reference, provisions from specific editions of other publications. These normative references are cited at the appropriate points in the text and the publications are listed on the inside back cover. Subsequent amendments to, or revisions of, any of these publications apply to this Part of BS 5192 only when incorporated in it by updating or revision.

2.2 Informative references

This Part of BS 5192 refers to other publications that provide information or guidance. Editions of these publications current at the time of issue of this standard are listed on the inside back cover, but reference should be made to the latest editions.

3 Definitions

For the purposes of this Part of BS 5192, the definitions given in BS 3138 : 1992, BS 5191 : 1975 and BS 5192 : Part 1 : 1993 apply.

4 Specification of requirements

4.1 Business requirements

In today's business environment of international competition, world class quality for products and drastically reducing manufacturing lead times, the need for good production control systems has to be clearly understood in terms of the business requirements. These should be defined clearly in three strategy statements.

a) *Marketing strategy of the company*: it should be stated what segments of the market the company is in, what segments it is not in and where the company plans to be in 5 to 10 years.

b) *Business strategy*: the business and financial targets that the company has set for itself over the next 5 years should be stated. Examples are return on investment targets, inventory turns, production lead times, quality targets, cost reduction targets, profitability targets, training targets, market share by country.

c) *Information technology strategy*: the types of systems that will be required to meet the demands of the business and marketing strategies in the face of competition should be identified.

After the business, marketing and information technology strategy statements are known and agreed within a company, the informational subset that is now required to support the production control part of the business can be defined.

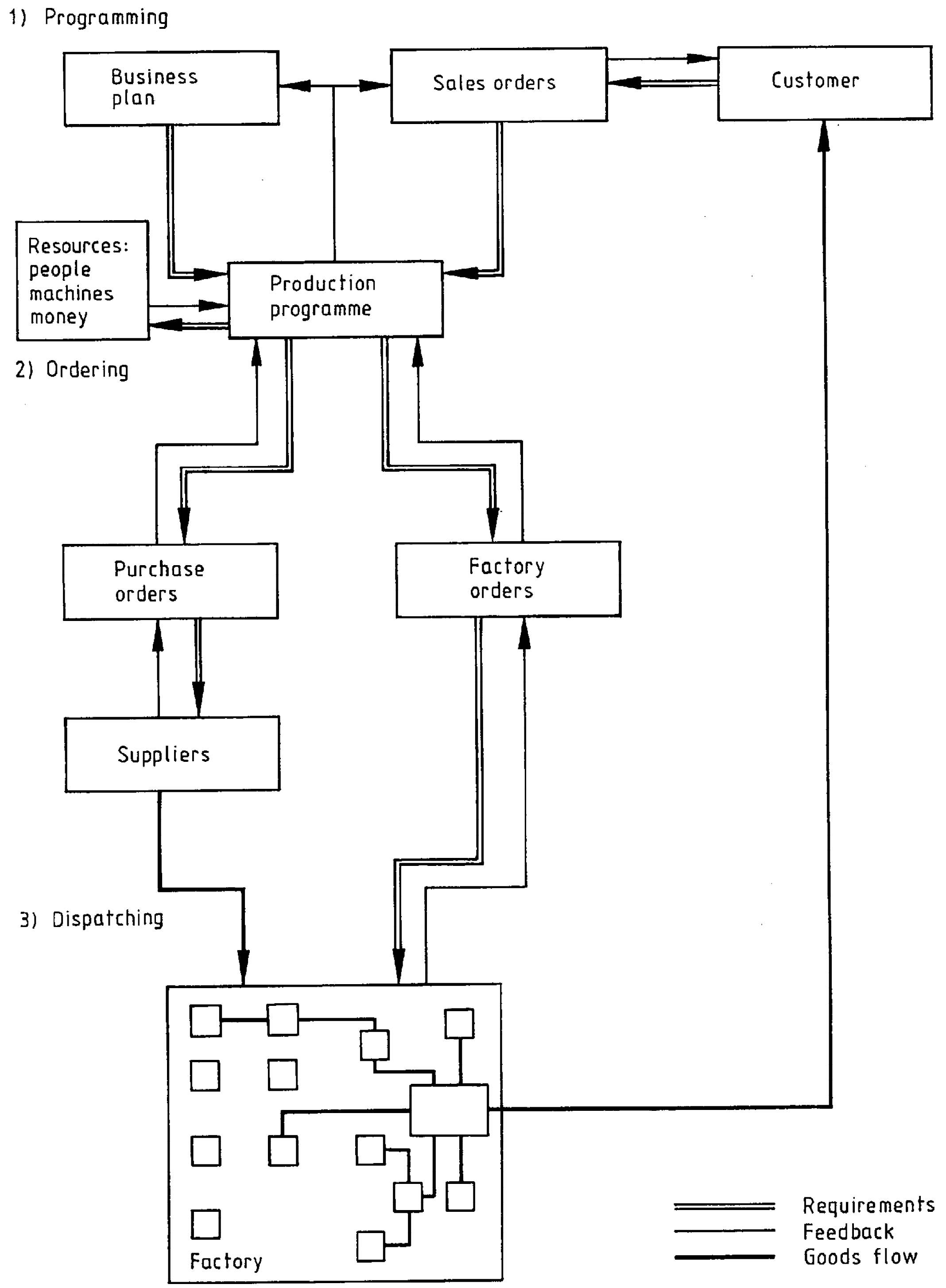

Figure 1. Stages of production control

4.2 Problem definition

Once the business, market, and information technology objectives have been established, the problem for production control is to define how to achieve them. It is necessary to identify the main problems that have to be overcome in the production control function to support these strategies and at the same time fit into the overall framework of present and future system communication requirements implied by the strategies. The problem definition phase should describe the production problems in terms of the following requirements:

a) batch sizes;

b) routeing options;

c) contract control;

d) traceability;

e) frequency of change over;

f) work-in-progress value;

g) engineering change control;

h) bottlenecks;

i) overall manufacturing lead time objectives;

j) quality/rework objectives;

k) volume;

l) warranty control;

m) key equipment maintenance;

n) multi-site manufacturing;

o) centralized or decentralized purchasing;

p) centralized or decentralized production planning and control;

q) cost of space;

r) cost of people skills;

s) space contraints.

The objective here is to define the production control problems that are specific to this business and then prioritize their importance.

4.3 Functional requirements specification (FRS)

After the objectives have been established and the specific problems defined, a functional requirements specification (FRS) should be drawn up. This step is absolutely crucial and cannot be ignored. It establishes the basis for the system design and provides the reference point for comparing all proposed solutions (whether in-house or third party).

Without this vital reference point the evaluation of all possible solutions is haphazard and unprofessional. Without it there is a risk of comparing one solution against another rather than always comparing a proposed solution against an agreed standard (the FRS). In the case of purchasing computer software, shopping around for a solution is useless without the agreed specification against which to compare it. The FRS has to be agreed formally by the major business divisions within the company such as finance, manufacturing, sales/marketing, engineering and data processing. Otherwise the resulting solution will not be used seriously by the end users.

The FRS should describe in detail the flow of information required, the volumes anticipated and the business issues to be serviced. For example the following sizing requirements may be specified:

a) number of parts;

b) number of product structures;

c) number of operations;

d) the need for alternative structures and routeings;

e) contract control requirements;

f) traceability requirements;

g) batch sizes;

h) quality control targets;

i) shop-floor data collection requirements;

j) finite scheduling requirements;

k) capacity modelling;

l) master scheduling modelling;

m) re-order levels;

n) material requirements planning (MRP) capabilities;

o) links to cell controllers;

p) links to other business systems such as

- accounting/finance/ledgers
- purchasing
- finished goods
- receiving
- engineering/design
- sales orders
- sales forecasts.

The objective of the functional requirements specification is to think through and address in detail the type and flow of information required to support the business objectives and to solve the business problems. The actual systems required to implement the specification range from face to face verbal communication in a small partnership to large scale integration in very large companies. However, without the agreed specification a detailed computer software solution (if required) cannot be designed.

4.4 Feasibility study

Once an agreed functional requirements specification has been obtained, the feasibility of the alternative solutions should be examined so that a recommendation can be made. At this stage the feasibility of manual systems, bespoke software, commercial software, or the combined use of two or all three of these is evaluated.

Manual systems are most effective when volumes are low and the timeliness of data is not critical. However, manual systems still require documented procedures and controls.

If part of the solution deemed appropriate to address the functional requirements definition of production control is computer based, there are two options: develop a bespoke production control system in-house or using a third party; or find a commercially available product that has a reasonable fit to the requirements. The best fit will always be from a system specifically designed and programmed for the defined requirements. However, this is a costly and time consuming task even with the use of the most modern development tools. The costs are in two areas:

- development of a system requirement specification that is a detailed computer specific specification;
- development of a system design specification that is a detailed code level specification.

There is an associated cost and talent requirement for each of these plus the ongoing maintenance and error correction support costs of the finished product.

Bespoke systems provide the best fit but they are usually not undertaken because of the huge overhead costs in developing and maintaining a one-off system. The usual compromise is to find a commercial product which is a close fit (80 % is satisfactory) and either to modify the last 20 % in agreement with the vendor or to modify the company procedures to fit the standard. The benefits of commercially available systems are:

- ongoing maintenance and development;
- error correction support;
- consultancy and training availability.

It is the function of the feasibility study to evaluate these options and to choose the most cost effective direction.

4.5 Market appraisal

If the recommendation of the feasibility study is to utilize a commercial software product, a market appraisal may be necessary to find the best solution. This is where the FRS is particularly valuable and forms the basis for the capability evaluation. This view, balanced with system costs, return on investment views, software availability, adherence to system standards, financial health of the vendor and total system cost of ownership including hardware and supporting system software, will enable the company to make a product/vendor selection.

4.6 Computer software definition

An important aspect of the computer based solution is its ability to coexist with and link into other existing and proposed systems. Therefore, the standards which the company wishes to utilize in support of their objectives should be defined first. Areas to be considered are as follows:

a) communication standards;

b) the database structure to be used;

c) the programming language to be used;

d) the operating system standard;

e) security and access control.

4.7 Computer hardware definition

A further definition of the system standards the company requires may be appropriate for the hardware.

Considerations are:

a) the need for colour graphics;

b) remote communication;

c) speed of transaction response;

d) maintenance and training costs;

e) use of standard packages on the hardware;

f) programming language availability;

g) vendor's financial health.

5 Option selection of standard packages

5.1 General

For each new system introduction it is essential to study the specification of requirements outlined in clause **4**. After the functional requirements specification (see **4.3**) has been completed a key decision should be made: whether the functionality defined can be obtained by using a standard package or whether it will be necessary to develop a bespoke system.

The development of a bespoke system or indeed a major tailoring of a standard system is a costly and time consuming route. It is therefore recommended that companies should re-examine the requirement for the functions not provided by a standard package and check whether there is an alternative standard function that would fulfil the same need. They should also question whether that function is essential or just attractive and whether the extra cost and time of implementing it would be justified.

A distinction should be drawn between the incorporation of a new function and changes to the input and output screens and forms. The latter case, in general, will be relatively easy to amend to meet users' preferences.

In **5.2** to **5.4** some of the main categories of application package which might be considered for use within a manufacturing company are outlined. For each category there is a brief description of:

a) the major functions that would be expected in a standard package;

b) the areas and industries where the category of package is generally applied;

c) possible problems and an indication of how an improved solution can be achieved.

An application package will usually consist of a number of modules. Annex B lists the major package modules and the functions typically found in them. Additional modules are also available to handle specific manufacturing requirements and those of other parts of the company. To be effective all these should be integrated, so that users have the minimum of inconvenience in switching between modules and duplicated data entry is avoided.

5.2 Stock control application packages

5.2.1 *General*

Applications for stock control are usually one of the following two types:

- those that are made up of modules (e.g. part data, purchasing, inventory control) that interlink and to which further modules can be added as required (e.g. financial, planning);
- those that are not modular but carry out similar functions; such applications often have more sophisticated statistical control and reporting features.

5.2.2 *Major functions*

Stock control application packages enable users to control the stocking and replenishment of materials. Users maintain a database of stock item information and the quantity of stock on-hand. The usage of stock is recorded and forecasting techniques may be used to predict future usage and hence when or how much to re-order to prevent stockout. The re-order decision may be based on the following:

a) fixed order quantity (see **6.3** of BS 5192 : Part 3 : 1993);

b) fixed interval re-order (see **6.4** of BS 5192 : Part 3 : 1993).

Re-order recommendations may be handled by a purchase order module.

5.2.3 *Application areas*

This type of package may be suitable for companies or departments that buy and resell goods, or use material with no or minimal processing. Examples might be those engaged in maintenance, spares or retail activities.

5.2.4 *Possible problems*

The following aspects of stock control application packages may cause problems.

a) *Production control.* The basic stock control functions are not supplemented by any planning function. Therefore, any associated manufacturing activity is not planned or controlled. These functions are left to manual procedures or stand-alone systems.

b) *Priority control.* The due-date of the orders is assigned at the re-order point (ROP) or the review point, but the standard functions do not revise the due-date with changing events. The tendency is therefore to expedite the urgent requirements but not de-expedite the non-urgent. This rapidly destroys any priority for internal or external supply orders.

c) *Dependent demand.* Where any conversion, process or treatment is carried out on a raw material to turn it into a product, then the demand for that raw material is dependent on the requirement for the product. It is therefore unnecessary to forecast the raw material demand. Companies that do so run the risk of a change in product requirement pattern causing shortage or excess of the raw material.

d) *Item parameters.* Each item is replenished according to certain key parameters, e.g. lead time, order quantity, safety stock, forecast mean, trend and seasonality. Maintaining all these parameters is a major task that is often overlooked, with the result that external information is not incorporated. System calculated parameters also need to be examined frequently to ensure the assumptions within the calculations are correct.

e) *Forecasting*. Predicting future usage on the basis of past history will never be perfect. It should be supplemented by extrinsic knowledge i.e. industry trends, marketing plans, etc. However, sophisticated systems can vary the calculation according to the pattern of demand, e.g. steady, lumpy, rising or falling trend. This may be done automatically or by user decision. Users should ensure that demand pattern changes are identified as early as possible and appropriate action is taken.

5.3 Manufacturing resource planning (MRP II) application packages

5.3.1 *General*

Application packages for manufacturing resource planning (MRP II) are, almost without exception, made up of a number of modules that are selected to suit the specific environment in which they are to be used. The major modules are listed in annex B. However, total systems can often also link to modules such as financial ledgers, computer aided design (CAD), computer aided manufacturing (CAM), payroll, distribution, automated guided vehicles (AGV) control, contract costing, sales order processing and shop-floor data collections that are outside the scope of this Part of BS 5192.

5.3.2 *Major functions*

Application packages for MRP II enable users to plan and control the materials, people and machines in a company at three or four levels. Users maintain databases of information on the parts, the bills of material, the routeings, the work centres and the vendors. There are facilities to plan the major resources of the company and to master schedule the existing or forecast orders well into the future. When these orders and resources are in balance the material requirements plan is generated, giving recommendations on orders that should be placed, amended or cancelled at all planning levels of the bill of material (BOM). Manufacturing orders are then routed through the factory to generate work-to-lists and capacity loading. Purchase orders may be placed and tracked. Materials and manufacturing order movements are recorded and the plan at each level is kept valid by feedback of information and management action.

5.3.3 *Application areas*

MRP II packages have been used successfully in a very broad range of manufacturing businesses, ranging from pure process type, through high volume repetitive to job shop and design-to-order businesses. The standard core system modules are listed in annex B. They may be supplemented to suit particular environments. Each module should have alternative options that enable it to be used effectively in virtually any market or manufacturing style.

5.3.4 *Possible problems*

Despite its widespread acceptance as the standard approach to planning and control of manufacturing, alarmingly few of the implementations realize their full potential to help the company achieve its strategic objectives and some do not even repay their investment. It is therefore important to examine carefully the problem areas and reason for failure to ensure that mistakes are not repeated and that an implementation produces maximum benefits. Some common difficulties are as follows:

a) *Capacity control*. Because the standard 'back schedule to infinite capacity' assumption is used by MRP II systems, users may be tempted to overload the factory. This should be avoided by proper use of the master production schedule (MPS)/rough-cut-capacity planning (RCCP) modules which plan resources in the longer term and validate forecast input and order intake. Short term contention may still occur, but can be reduced by use of capacity requirements planning (CRP) to smooth the load or to re-route problem orders.

b) *Data accuracy*. The most common cause of poor performance is that the data in the system are insufficiently accurate to persuade users to believe in what they see presented on the visual display unit (VDU). An audit of stock balances, routeings and live orders should be carried out before the system is introduced and corrective action programmes put in hand. The main system should not be run until the following minimum standards are attained:

- inventory accuracy > 95 %;
- BOM accuracy > 98 %
- routeing accuracy > 98 %.

c) *Overdue orders*. Any order not completed on time is deemed to be overdue. Such orders fall into backlog on the resource and capacity plans. As a result the priority of orders becomes confused, particularly when some overdues are no longer live (if, for example, the vendor considers 90 % is completed or the shop-floor have scrapped the last 5 %). Overdue orders should be checked regularly, and if live, re-dated to a real future date that is achievable.

d) *Expediting*. Some expediting will always be needed in the real world to maintain delivery schedules. However, many companies expedite for the wrong reasons (e.g. the operator to select the easy orders, the foreman to keep his men busy, the manager to achieve high shop efficiency, directors to meet non-business objectives). The only valid expediting is that necessary to maintain the work-to-list priorities; all others should be strongly discouraged.

e) *Complexity.* A full function MRP II system offers a staggering number of options and parameters. It can also encourage design engineers to input an as-designed BOM rather than the as-produced. Likewise planning engineers may over-complicate the routeings. All elements of added complexity require extra feedback and maintenance activity. Often this is not worthwhile and is not done satisfactorily, thus bringing the system into disrepute. Users should aim for the simplest solution that meets their needs.

f) *Function frequency.* The major functions, e.g. reviewing the MPS, running MRP and revising the work-to-lists, should be done at a frequency to suit the business. Typically this means MPS review monthly, MRP nightly and work-to-list hourly or in real time. Fast moving environments may need MPS and MRP more frequently. Users and systems operators should be educated to understand and plan how to meet the necessary frequency.

5.4 Finite capacity scheduling application packages

5.4.1 *General*

Applications for finite capacity planning are usually provided as complete packages running on a personal computer or workstation that interlinks to manufacturing control and shop-floor data collection systems. Use of a personal computer provides the highly interactive, graphical environment which the scheduling/planning function requires.

5.4.2 *Major functions*

These applications enable users to control, on a minute-by-minute basis, the allocation of jobs and operators to machines, thereby permitting a plan of short term workshop activity to be created. Users maintain a database of individual resources, resource groupings and characteristics, shift patterns and non-worked days. The package produces a schedule that may be passed back to the production control system and/or issued in the form of work-to-lists, to machine operators on shop supervision. The main functions of the scheduler are:

a) an electronic planning board using a computer graphics system;

b) an ability to communicate with other computer systems;

c) a database to store shift patterns, resource data, etc.;

d) an ability to schedule operations automatically to pre-defined criteria;

e) an ability to manipulate the plan manually.

5.4.3 *Application areas*

This type of package is suitable for companies in a wide range of manufacturing environments, including jobbing, process industry, batch and mass production. However, different suppliers' packages are focused on different industries and this will be reflected in the facilities offered.

5.4.4 *Possible problems*

The following aspects of MRP II application packages may cause problems.

a) *Flexibility.* The scheduling package should be capable of dealing with the special constraints of the company's method of operation.

b) *Accuracy.* The scheduling package should be capable of reflecting the true position of shop-floor operations. The scheduler needs accurate, up-to-date information to make valid decisions on job allocation. These data are best obtained from a shop-floor data collection or machine monitoring system.

c) *Horizons.* The horizon for a finite scheduling package should be relatively short, say one week. Extended horizons make it very difficult to synchronize material supplies. The schedule will also tend to become unstable.

6 Bespoke systems

6.1 General

Companies often find that the standard packages available do not fully meet the full range of functions they believe they require. If this is so they should decide whether to compromise on their needs, tailor the package or build their own bespoke system. The decision has major implications in terms of cost, time and usability and should therefore be taken after careful consideration of all the facts and by using specialist outside skills to supplement in-company knowledge where necessary.

The standard package option is always the fastest and cheapest and will generally provide many of the core functions. As a rule of thumb it is recommended that if a significant proportion of the functions are present then tailoring is the best solution. However, if several essential functions are absent, then bespoke system development is indicated.

6.2 Full system development

This solution will take time (one to three years) and a considerable degree of user involvement and will be expensive. It will consist of a phased development covering the following typical stages.

a) *Computer systems design*, converting the functional requirements specification into database and system specifications covering reports, screens, file updates and data maintenance.

b) *Technical specification*, based on the computer system design, making a decision on the technical environment in which the programs will run (database, development language, on-line teleprocessing, networking etc.).

c) *Program and system test*, converting the computer system design into a computer program based on decisions made in the technical specification and testing individual modules.

d) *User acceptance test*, testing the whole system with real data.

e) *Installation*, loading the programs and live data, initializing the system, training users, running parallel and going live.

f) *Evaluation*, comparing results with those required and tuning both the technical and functional performance.

g) *Maintenance*, changing functionality to meet new needs.

A major requirement for the successful outcome from the development is strong, final result orientated, project management to control budgets, timescales and user expectation.

6.3 Tailoring standard packages

Most companies will have their own needs for the form of the data presented on a VDU or report and in the way they want it laid out. For instance:

- company specific headings, titles and field names may be required;
- some companies may wish to have a field such as cost displayed, others may not;
- dates may be required in one of many formats;
- the result of calculations on database information may be displayed together with the user field name.

Changes of these types may be accomplished by the following different methods:

a) *Source code amendment*. This type of change may be made by the user only if the source code is available and the user is skilled in the programming techniques and language used. This is the subject of bespoke amendments and is not usually termed tailoring. It should not be attempted without careful system planning and control (see **9.5**).

b) *Fourth generation language (4GL)*. 4GLs are becoming increasingly user friendly and can provide a very high degree of screen and report output in the format required by the user. However the ease and flexibility of use are very dependent both on the 4GL and on the database structure of the main production control software. A high level of user training may be required to use the advanced tailoring available. New applications developed with 4GLs are likely to need full bespoke system management techniques.

c) *Screen/report generator*. Many manufacturing planning and control packages include a facility for amendment of the screens and reports of the standard system. The flexibility will depend on the particular package and should be checked by users for the presence of functions to achieve the degree of tailoring they require. They may be used by company staff trained by the software vendor but changes should be documented and monitored by the system department.

6.4 Advantages and disadvantages of bespoke systems

The obvious advantage of a bespoke system is that it should deliver exactly what the user needs to do the job. The obvious disadvantage is that it takes time, people and money. A bespoke system can be justified if it does provide the correct solution. Experience shows that there are many pitfalls and that many bespoke systems fail to provide the answer to real problems of the company and overrun on time and cost. Examples of the hazards include the following:

a) incorrect understanding of the real problems;

b) computerizing old procedures, not new needs;

c) trying to automate human judgement functions;

d) not subdividing activities sufficiently to enable them to be controlled;

e) under-resourcing the project (in volume and quality);

f) changing requirements after FRS;

g) allowing timescales and budgets to slip without investigation and corrective action;

h) poor documentation;

i) incomplete testing;

j) inadequate user education and training;

k) lack of qualitative and quantitative evaluation;

l) poor modification control;

m) lack of senior management commitment.

Nevertheless, bespoke projects that are well managed can provide outstanding benefits providing the critical factors of time, cost and effectiveness are uppermost in the project manager's mind.

7 System selection and justification

7.1 General

Assuming the feasibility study has recommended the use of a computerized production control system, the system required should now be found and the business case approved.

7.2 Software evaluation

The FRS will be used as the evaluation yardstick for software. Because the FRS will be long and complex, a checklist of all the features in priority sequence should be created and agreed. This list should have cut-off lines drawn through it between the essential functions, the desirable functions, and the attractive features. As a starting point this one page list can be used to begin the elimination process. However, since functional requirements are only one of three major selection criteria, the checklist should be a composite of the specifications from the FRS, hardware and software requirements identified in **4.6** and **4.7** (including the communication issues) and the cost/return-on-investment specifications. Therefore, if MRP II is an essential requirement for the functionality, but the total system cost has to be under £250 000 and be on an open operating system (and these are also essentials) the requirements of the FRS are considerably limited by the other two requirements. A consolidated requirements list like this can be generated by the company through its own resources or produced on the company's behalf by a third party professional consultancy team.

After the initial elimination list has been produced the products to be evaluated should be found. For production control software the problem will be one of choosing from a large list of options. Sources of information on software availability can be obtained directly from the major hardware vendors, from the major software houses and from trade shows.

Once a short list of software has been agreed it is now time to inspect each in detail against the original and full functional specification. Final selection will then be based on further additional criteria such as the following:

a) feature availability;

b) fit to specification;

c) consultancy and training availability;

d) maintenance cost and availability;

e) software stability and availability;

f) ability to communicate with other systems;

g) ability to expand;

h) ongoing commitment from vendor for development;

i) ease of use;

j) response time;

k) similarity to present system;

l) price.

7.3 Hardware evaluation

Further qualification of the system will relate to the following:

a) hardware resilience;

b) modern architecture;

c) number of concurrent terminals supported;

d) sufficient main store for the number of parts and structures being commonly used;

e) fast search capabilities;

f) sufficient mass storage;

g) stage of its product life cycle.

7.4 Communication aspects

The functional specification will have indicated the other application areas of the business with which the production control system has to communicate and how the communication should take place, i.e. manual, batch interface or on-line. Batch and on-line facilities for communication with other hardware and software implies the need for local area networks utilizing the most prominent of the emerging standards. Communication between different vendors' hardware using third party software is often difficult and, therefore, expensive. If communication (especially on-line) is or will be important to the installation, compatible hardware and software should be chosen at the beginning where possible, to avoid major expense.

7.5 Justification

In order to justify the cost of any system, the present costs should be known, quantified and documented. Projections on cost savings from that point can then be made and verified when the time comes. One of the biggest mistakes made in the cost justification process is to fail to quantify the present costs. These costs should be identified in measurable terms and the same measures applied after implementation. Additionally, the benefits of the new system should be expressed in measurable terms which implies that before any implementation takes place it should be known what the benefits ought to be and how to measure them.

8 Implementation

8.1 General

There are two phases in implementation. The first is the installation phase comprising the installation of hardware, software, communications and the accomplishment of basic training to allow the new system to be certified ready for use. The second and far more difficult phase is the assimilation of the new system into the daily use and routine so that it becomes a valuable, effective and successful business investment. Planning for installation only will not provide the full benefit identified in the justification exercise. It should therefore be planned as the first step or major task in the overall implementation of the business system. Taking this long term view keeps the installation phase in context, shows its relationship to future implementation activities and helps to prevent the loss of key people to the project at the finish of installation.

However, the installation has to be successful and be seen to be successful to allow full implementation to take place. The installation step is described in detail in **8.2** to **8.5**.

8.2 Strategic approach

There are generally three ways to install the software system.

a) *Parallel run*. This technique is used when an existing system is being replaced. The new and old systems are run in parallel during a specified change-over period to gain experience and confidence in the new system before the old one is removed. The drawback to this procedure is the problem of trying to keep two systems exactly aligned. If one is out of phase with the other then there is always the problem of which one is current and which one should be used. This can be twice the work for all people involved, both end users and data processing personnel.

b) *Step-by-step*. This technique is used when portions of the business can be moved across to the new system one part at a time. An example might be the installation of a central sales order processing system to replace a conglomeration of five or six different systems used at various factory locations. By moving the low volume sites across first and gaining confidence and experience, the large volume sites can convert later after greater knowledge and skill has been acquired. Also, since each site is being moved across sequentially by the same data processing team, both the end users and installation team can pace themselves to allow for unanticipated problems and learning curve.

c) *Big bang*. This technique is used when space and cost are paramount. The old system is removed and the new system installed and commissioned over a weekend, holiday or shut down period. It is usually a high risk plan because failure of the new system to perform to the set standards directly impacts the business since there is no fall-back capability available. However, this may be the only alternative for new factories or green field sites.

8.3 Project team

The project team should be managed by a dedicated manager from the production control function. His mission is to first establish the installation objectives in measurable terms, get proper project planning in place, agree proper resourcing, get an installation budget, establish the training requirement and training schedule, get all these points agreed by senior management, and then review progress and take appropriate action where necessary.

To assist in this task the project manager will need project team members from several areas of the business as follows:

a) end users of the production control department;

b) production control middle management;

c) data processing staff and middle management;

d) liaison members from sales/marketing, finance, manufacturing, distribution, and engineering;

e) in-house or third party education and training instructors;

f) quality control;

g) technical authors;

h) software/hardware vendor project manager.

8.4 Project control

The objectives, timescales and costs for the installation have to be agreed with senior management at the outset. This requires the following items:

- an objectives sheet set out in measurable terms which will be used as benchmarks in the final audit;
- a budget for internal and external costs;
- a fully documented project plan showing all the activities required and their dependencies, the timeframe and resourcing (by name) for each activity and an achievable end date.

Once these plans are agreed it is the job of the project manager to manage the installation on a daily basis, with total dedication to the task by having all other responsibilities removed and reallocated to others. Without this level of commitment the project will not be seen to be important and will consequently not achieve its objectives. Project management requires periodic reviews at the working level, middle management level and senior management level. These reviews need to include the vendor project manager and all actions should be minuted and followed up.

8.5 Education and training

One of the major activities to be identified and accomplished during installation is the training of all those involved. This should take place at three levels and the appropriate time, follow-up and budget should be allocated. The three levels are as follows:

a) *End user.* This is where practical training of all end users takes place. It should contain an introduction from their senior management, an overview of the total implementation plan and objectives showing benefits, as well as extensive hands-on training sessions where all objections are handled, negative reactions neutralized and a clear understanding of the system gained.

b) *Middle management.* The emphasis here is on how the system works in support of their individual management tasks. It is both a selling and learning course with the emphasis on functional capability showing new/better techniques for doing the job.

c) *Senior management.* This should be a short sharp selling course on how the system fits in and supports the other business systems, what the major benefits are, the return on investment expected and a demonstration of its major or most competitive functions.

9 Ongoing operation of computer aided production management (CAPM)

9.1 General

A well planned and executed implementation should mean that after project completion the new system will operate as planned for several months without adjustment. However, managers will be aware that business conditions change rapidly as well as staff, products and processes. It is therefore vital that all aspects of the computer aided production management (CAPM) systems are regularly reviewed to ensure that they are continuing to meet the top level objectives of the business, that forthcoming threats and opportunities are identified and that the appropriate actions are taken to minimize risk and maximize benefit.

Because of the integrated nature of computer systems, each item of data in the system is used by several departments and is open to enquiry by all. It is recommended therefore that at some operational meeting (typically the master schedule meeting, where most departments will be involved in agreeing the manufacturing contract for the coming periods), there should be a review of the top level business measures, that might include the following:

a) customer due-date performance (percentage of complete orders shipped within one day, early or late of plan);

b) percentage of warranty claims;

c) stock turns;

d) percentage of waste in factory (including yield, scrap, obsolescence, rework);

e) profit against plan.

Forthcoming challenges might include the following:

1) introduction of a new product;

2) introduction of a new machine or process;

3) major swing in product mix;

4) recruitment of a new staff member who will be a key user of the system;

5) promotion of existing staff to positions where they will use new functions of the system;

6) planned software improvements;

7) planned hardware changes;

8) possible power cuts.

Any of these or similar types of potential problems or any significant deviation from the performance indicators should have a plan of action agreed as a matter of priority.

There are a number of issues which affect the ongoing operation of any system. These will be examined in detail in **9.2** to **9.7**.

9.2 User implications

9.2.1 *General*

CAPM systems are people-driven decision systems, supported by computer based information processing facilities. The ultimate factory-of-the-future operated entirely by computer and robot is a concept that is much talked of but has not yet been achieved in any but the simplest forms. Some of the most vital ingredients in the ongoing success of a total system are therefore the commitment and retraining of staff and their preparedness for continuous improvements towards just-in-time (JIT) manufacturing.

9.2.2 ***User commitment***

During implementation user commitment will have been a major task for the company management. The project communication links should be maintained, the focus being changed from the completion of activities to the attainment of business objectives. These should be the top level company objectives, not the local objectives. The latter are likely to achieve false local optima only, e.g. local productivity bonuses tend to generate output, not saleable throughput from the factory and measuring buyers by price variance leads to cheap buying but poor quality and delivery performance.

These high level measures are less directly affected by individual effort, more by teamwork. The communication programme should therefore aim to generate the motivation to work as a team and create the understanding that the team is only as strong as its weakest link.

If a bonus scheme is thought necessary then it should be linked into a high level measure, ideally annual profits. However, the communication programme should then spend more effort to create an understanding of the other market and financial factors that can have a major impact on the profit figure.

The commitment demonstrated by the senior managers is critical. Nothing will destroy a well planned and implemented production control system faster than a manager who wilfully ignores one of the policy rules that he has agreed. The master schedule establishes all other schedules in the factory and if a customer is so important that an order has to be pushed through, then top management should be seen to agree the new master schedule and the consequences on all other orders in the system.

9.2.3 ***User retraining***

Education and training are stressed as major success indicators in clause **8**. It is therefore important that any new person coming into the company should be educated and trained to a similar standard.

For people who are moved within the company the need for education and retraining is less obvious and more frequently omitted. It is important to realize that such a person's attitudes to his new role may have been formed before the introduction of the new system and that he will require the same education and training as any other new person to enable him to work with the team.

As in clause **8**, it is again important to stress the difference between education and training.

a) Education involves generating awareness of the underlying principles that drive the system, understanding of the key policies which staff need to observe to run the system successfully and commitment to use the information to make decisions to maximize the company's benefit;

b) Training involves instructing users of the system to follow the standard operating procedures and on the actions necessary when problems arise.

The other key aspect of user retraining is that systems do not stand still; they evolve and develop. Changes and additions will be made to the computer and manual parts of the system. Likewise there will be changes in the company targets. For any major or minor change it is vital to educate and retrain the users directly involved and to ensure that other staff are kept informed. Examples of such change might be linking the sales order processing system with the manufacturing system or using an MRP II implementation as the start of a JIT continuous improvement programme.

9.3 Computer operations

Depending on the size of the system and its complexity, the operation of the system on a daily basis will require anything from minimal attention, i.e. start up and shut down, to dedicated data processing professionals devoted to the smooth operation of the whole information technology environment.

For fault free operation, care has to be taken to have the correct levels of experienced personnel available especially during periods outside normal hours, i.e. nights and weekends. Such personnel should initially be trained by the hardware vendor as part of the installation project to ensure the adherence to good practice, especially in the areas of security, backup, archiving and maintenance. Alternatively there are firms that offer a computer operation service.

9.4 Hardware maintenance

Hardware maintenance is usually contractually agreed with the vendor and provides for periodic preventative maintenance, optional advice, guidance and upgrade service, plus breakdown call-out service. The maintenance may be provided directly by the vendor or through an authorized third party.

9.5 Software maintenance

The arrangements for the maintenance of software are similar to those for the maintenance of hardware with the added complication of support for modifications if they have been applied. Maintenance of application software is an important consideration for all user companies for three main reasons.

a) It should be appreciated that in any software of significant complexity there are likely to be logical inconsistencies (bugs). Despite exhaustive testing procedures some will be undiscovered and may cause erroneous results or even system failure (crash).

b) Most vendors provide a general purpose software product with a range of inquiry and reporting capabilities. If, from this selection of screens and reports, the specific information needed for the business is not available or awkwardly presented, the decision may be made to modify the screens and reports to suit. Usually no extension to the normal maintenance agreement is needed in this case since only the output format is altered. Furthermore, as operating experience grows, the software vendor is likely to develop additional features and improved routines that will speed up processing and provide extra functions. New peripherals, communications or hardware requirements may also cause software modifications.

c) As business requirements or trade regulations change a user may find that extra functions are required and may decide for these or other reasons to modify the source code, either using his own resources, those of the vendor or those of a third party. The extent to which this complicates support depends on whether the changes are driven by a single user or many users (a user group). When many users request an enhancement a software vendor will often develop the new facilities required. However, when the changes are driven by one user only maintenance will have to be carefully negotiated with the vendor since changes to the source code can render the software unusable or unsupportable if poorly done. Unless the changes can be covered by a bespoke enhancement arrangement, the vendor will only support the standard source code and let the user worry about supporting the changes. If the changes are extensive the vendor may no longer support any of the product except by such a special arrangement. In those cases, usually the party that undertook the modifications will also support them as part of the arrangement. Customizing, as it is called, should be done with reasonable advice and guidance from the owner of the software to allow the modifications to be easily included in any future upgrades of the software, the operating system, or the database management system.

It follows from items a) to c) that the agreement for software maintenance should be formal and contractual. It should normally be with the original vendor, but in some cases it can be with a reputable software house that is allowed access to the source code. User maintenance is not recommended without careful consideration of all the implications (it is estimated that 80 % of data processing budgets are spent on maintenance).

Software maintenance agreements typically cost 10 % to 15 % of the software purchase price per annum. For this a user might expect the following services:

1) a bug fixing service;

2) a help desk for user application queries;

3) hotline support for operating problems;

4) free version updates with appropriate documentation;

5) membership of a user group.

The help desk and hotline services are normally during office hours and 24 h service would be an extra charge. A number of consultancy days per year may also be included, but are normally charged as extra.

The vendor's version update policy should be clearly stated. Updates should be at regular but infrequent intervals, perhaps every 6, 9 or 12 months. They should be announced beforehand with an indication of the new features and functionality, so that users can prepare for implementation. Old versions will not normally be supported for more than a few months after the new version is shipped.

9.6 Contingency planning

In particularly sensitive environments the best way to have 100 % reliability is to run a duplicate backup system. Since this level of expense and contingency is not always necessary, normal planning calls for the following action:

a) backup copies of all work taken on a periodic basis depending on volume of work but usually at least once a day;

b) backup stored in a safe fireproof place usually outside the computer centre area and preferably in a security vault;

c) emergency computer usage agreement with the vendor or other suitable third party using the same equipment and configuration.

9.7 Security

All of the procedures described for contingency planning in **9.6** are also appropriate for the prevention of accidental loss of information. However, where deliberate tampering or possible theft of information is to be prevented, additional measures need to be taken.

The possible tampering and theft by outsiders can be minimized by careful application of the security measures built into the computer operating system. If this is a requirement for the business when choosing the system it should be included in the list of essential requirements when evaluating the software and operating system. The security features operate in two ways: first by setting functional parameters which only allow certain terminals to access certain information (e.g. only the personnel department can access salary information) and/or by setting certain terminals to respond only to queries and not allow input of data to prevent tampering; secondly, the operating system can be set to allow access only by authorized individuals through the use of a password. This password when typed in will not appear on the screen to prevent unauthorized people seeing it and it should be periodically and conscientiously changed and protected.

10 Future trends

10.1 Computer integrated manufacturing (CIM) and the information systems strategy

In **4.1** it is stated that the strategies that have to be in place, agreed and understood to drive a successful business are the marketing strategy, the business strategy and the information technology strategy. The evolution of the information technology strategy that is taking place for manufacturing companies today is an extension of the management information system (MIS) concept to include computer integrated manufacturing (CIM). The implementation of CIM cannot be done completely without the proper links into the other business functions such as finance, sales/marketing, customer service, research and development and commercial/legal systems. Furthermore, there is a need to provide management level summarized and graphically displayed information to all senior management utilizing the same man/machine interface (MMI) capability. The trend is, therefore, for CIM to link together databases of information where each is servicing a major business discipline and utilize office systems to provide across the company MIS or senior management extracts from these communicating databases.

The major stumbling blocks to the straightforward implementation of these concepts are as follows:

a) lack of agreed communication standards;

b) lack of non-keyboard oriented input/communication with the computer systems.

As the pressure for reduced manufacturing development-to-delivery lead time, better quality and greater flexibility in product configuration continues to increase these barriers will be overcome.

10.2 Hardware and network developments

All signs in the industry point to computer hardware that will be smaller, cheaper, faster, and better. The implication for the user is that capacity becomes less and less of a problem as the size and price come down and the reliability goes up. Also, cheaper and faster computers will start to be used in what were previously areas of marginal or very small return on investment simply because the cost has dropped.

Probably the most significant trend in this scenario is distributed processing: the move away from large centralized databases on mainframes to distributed or departmental systems where all the business systems of the department are co-located on a departmental machine. The departmental applications then share data between departments using distributed databases interfaced to a network. There will be, therefore, duplicate information in the various departments that is kept up to date and managed by a network community management system that incorporates full security/access control mechanisms for proper data protection.

It will be important in this environment to make sure that old and new systems can coexist and communicate in this network and that system exchanges and replacement will be transparent to the network and end users. To allow this to happen and in effect to have seamless connectivity between departments a new type of data integration should evolve. This process is known as the conceptual interface, where it is the business process, not the data, which is being networked. The process involves the interface and exchange of logically dependent rather than physically dependent information. The result should be an evolution of hardware and community management systems that can coexist with existing computer hardware and software developments and take advantage of new developments by non-disruptively introducing them into the network.

Currently the biggest obstacle to communication between old and new systems is the lack of agreed communications standards. Users will soon want to share not only data between business units but also voice, text, image and potentially full motion video displays. Standards have not yet been established or agreed to allow this to happen. At present the Open Systems Interconnect (OSI) Standard is being defined by the International Organization for Standardization (ISO). Since it is vendor independent, the seven layer model of the OSI is popular, but even this requires the cooperation and agreement of vendors and users to both adhere to the standards and develop future products in line with the agreed approach. Until this happens, data processing and communications managers will have to anticipate and plan for an evolutionary move to the new services and facilities that are forthcoming.

10.3 Software developments

The facility that will enable the community management and network systems, described in **10.2**, to function will be the software environment. Software has been steadily evolving over the past 20 years from third generation to fourth generation and eventually fifth generation systems will be available. The difference between the three generations is important in understanding how the emphasis on capability has changed and also on how it will be possible for the three generations to coexist and complement each other in a future business environment.

Third generation languages like COBOL and BASIC are very powerful but require an expert to use properly and derive full benefit in large complex database developments. The emphasis in the third generation has been on producing logical algorithms of functionality.

Fourth generation languages now concentrate more on providing a sensible framework and structure for development. The emphasis has moved away from pure logical programming to ease of use and total system logic definition. The key fourth generation innovations have been as follows:

a) use of a data dictionary for defining logical relationships;

b) application tools for the rapid development of search and data manipulation capabilities;

c) report writers (report generators);

d) macro instruction writers for quick code writing of straightforward logic;

e) relational database approaches.

One imposition of the fourth generation approach has been to require full system design and definition before programming can begin. The total approach should be considered first rather than just the logic of an individual algorithm.

The fifth generation systems are likely to adopt the theme of integration and facilitation. The ability to unlock information regardless of where it resides in the network and the ability to capture and apply expertise will be paramount. The fifth generation systems will probably be knowledge based capabilities becoming the facilitating gateways to the network. They will probably provide the following attributes:

1) sensible guided access to information;

2) well developed community management;

3) conceptual interfacing by finding the data in the network that are needed and then setting up the data processing requirements for moving data about and hence communicating on a logical basis;

4) natural language questioning and touch screen input allowing non-structured access to data.

All these developments will greatly enhance the ability of extant systems and applications to work together and achieve even greater return on the present investment.

10.4 Expert systems

Expert systems that can be used for decision making in the manufacturing arena are evolving. Examples of their potential use are as follows.

a) Configuration specification for the manufacture/assembly of standard parts and components to fulfil a complex customer requirement: in essence, it will be possible to take a request for tender and produce a proposal based on standard options with lead times and costs.

b) Decision control on the shop-floor: an expert system will be available to cell controllers in an unmanned environment. If a problem occurs its symptoms could be fed automatically to an expert system to provide a solution or elevate the problem to the next level in the shop-floor control hierarchy for a similar deliberation at that level and upwards if required until a solution is found and automatic rescheduling takes place.

c) Master scheduling modeller: this will create a model for master scheduling or factory scheduling using four variables:

1) forecast;

2) actual sales;

3) actual and forecasted capacity;

4) cost.

Annex A (informative)
Development of the use of computers in production control

A.1 General

Soon after the advent of electronic computers it became apparent that they would have a potential role in production control. In common with many other applications predicted at that time there were many obstacles to be overcome before most ideas became practical. In particular it can be seen with hindsight that workers were over-optimistic about the data processing capacity and reliability of the early computers, tried to apply erroneous theoretical logic in some areas, did not involve users and failed to identify that the real benefits would come from integration of the information held within the system.

It is therefore useful to look briefly at the history of the development of computers so that we may understand where certain ideas and concepts have come from and avoid repeating the early errors.

A.2 Computers as calculators

A.2.1 *Mathematics laboratories*

The early valve based computers, which were able to perform mathematical calculations rapidly albeit with very small core memory and limited input/output devices, were chiefly used in mathematics laboratories.

A.2.2 *Operational research (OR)*

With the advent of transistors, larger memories, card input, magnetic tape input and output plus slow line printers, the processing of small volumes of data became possible.

At this time operational research (OR) activities were focused on the problems of production and had developed formulae to express economic order quantity (EOQ). They had also identified forecasting tools based on history that predicted future trends and seasonality.

In addition, they were able to estimate the likelihood of deviation from forecast by calculating standard deviation or mean absolute deviation (MAD). This led to the concept of customer service levels which could be maintained by holding safety stock (SS) to guard against unexpected demand.

The new computers made these calculations easy and fast to perform and before long it was common to find factories with manual reorder point (ROP) logic systems based on EOQ, SS and lead time calculated by computer on a periodic basis.

At the same time Forrester [1] was using computers to carry out time series evaluation or simulations of the likely effect of interdependency. These showed that the dynamics of the situation would not lead to the optimum use of stock as predicted by the OR workers. This work was largely ignored and production control departments were thus busy launching economic orders at the reorder point and even more busy expediting the shortages of stock in order to complete jobs.

A.3 Computers as batch processors

A.3.1 *Inventory recording by batch updates*

With the development of larger memory computers that could store information on random access disc packs it became possible to maintain the stock level by a series of daily or weekly batch updates of the movements of parts into and out of store.

In general this was accounting department and computer systems department driven and required users to dispose of their trusty, ever accessible, card index systems, for which they had responsibility and accountability and users were instructed then to rely on periodic reports detailing order launches and stocks that were difficult to understand and reconcile. The users' reactions were mostly negative, resulting in inaccurate cut-off points, continued expediting and the establishment of three stock figures:

- a gross value maintained by accounts;
- a theoretical figure from the computer;
- a card index system of stock control maintained by the stores.

The main effect of these inventory/ROP systems was that calculations based on incorrect data and incorrect logic were performed faster. This resulted in confused and frustrated staff (who blamed the computer), together with higher stocks and poorer service levels.

A.3.2 *Net, dependent, time phased, supply and demand*

In 1969 Orlicky published his seminal work on materials requirement planning (MRP) [2]. This identified the key fault in ROP systems, namely that they did not take into account the dependent demand that exists between a product and the components that it is made of, both in the required quantity and timing. For components that were not sold outside the system it was therefore not necessary to forecast the demand. This could be accurately predicted by multiplying the component quantity per product from the bill of materials (BOM) by the forecast sale of the product and backdating its requirement by the lead time necessary to build the components into the product. These requirements for the product were, in addition, netted off against any product in stock and any product expected from a supply order already issued. This is in fact the real logic of the shortage list and it therefore offered a system that users could understand and use more effectively.

In fact, the limited computing capacity of the era meant that suggested actions could not be recalculated frequently enough to take into account changes occurring in the factory and were still bedevilled by the difficulty of maintaining a high accuracy level of stock, BOM and routeing data. Another problem was that the majority of systems were developed as bespoke systems. This slowed their introduction but also tended to incorporate false logic due to poor systems analysis, a misunderstanding of the real needs of the business or the belief that special circumstances applied for each company. One specific area of debate was the scheduling technique and capacity assumption. In a well ordered production system it seemed attractive to schedule on a finite capacity basis. However, apart from project type applications, production is not determinate, but highly variable (as is demonstrated when a manager decides to rush a particular order through quickly). These points undermine the finite capacity assumption in all but simple process applications.

A.3.3 *On-line enquiry systems*

Until this stage all usable data had to come from the computer as printed paper (printouts). As computers increased in size and power it became possible to attach visual display units (VDUs) to the host computer. This enabled stores, production, inventory, control personnel to enquire on stock and work order information. The system was still batch updated so the information was still only correct at the time of update, but because transaction history data were made available it now became feasible to maintain accurate stock data.

However, the recalculation of order dates and quantities was still a lengthy process, forcing users to rely on weekly or, more usually, monthly planning runs. In addition, applications were not usually integrated so that data input to the system was often duplicated with increased probability of error and reconciliation difficulties. System power also limited the number of terminals that could be attached, thus restricting the accessibility of information.

Nevertheless, there were many successful MRP implementations, particularly where stable forecasts or order patterns made resource management easy to tackle.

A.4 Computers as on-line information systems

A.4.1 *On-line teleprocessing and net change planning*

With regular order of magnitude improvements in the size of computer memory, the speed of processing and the amount of secondary disc storage available, it became possible to cater for on-line transaction processing. This feature meant that at last users could have their card index information available on demand. Many of the reasons for inaccurate stock balances had thus been eliminated and, with their increasing number of terminals connected to the system, other departments shared that up-to-date accurate information. This policing effect could now encourage the maintenance of data accuracy.

The software development of net change planning has significantly reduced the suggested action output. Previously it was necessary to regenerate action messages for every part. Now it is possible to replan only those parts where a change has occurred in the supply, demand or static data. This not only reduces output but also processing time so that overnight net change calculations are now a realistic opportunity for all well sized and operated systems.

A.4.2 *Modular system integration*

Increasingly it has become accepted that management and control of production can be thought of as a number of standard modules. A list of the main modules might include the following:

a) engineering data (formulations or recipes);

b) inventory control;

c) MRP;

d) purchase order control;

e) works order control;

f) capacity control;

g) master scheduling;

h) resource requirement planning;

i) cost control.

Most manufacturing companies aim to encompass these facilities within their manufacturing resource planning (MRP II) system, the key concept behind this system being the rapid feedback of changes and problems to ensure the maintenance of accurate data and a valid set of priorities. More and more companies are now prepared to buy standard packages that provide the major functions and where necessary incorporate specific needs of their business by tailoring the standard programming code. Frequently it is only necessary to make the input and output suit their users needs.

The reliability and speed of modern computers and software means that at last users can pursue their different activities on the basis of a common set of accurate figures and valid priorities upon which they can make sound decisions. They are controlling the system, rather than being controlled by it.

A.4.3 ***Further integration***

Naturally some businesses have found it necessary to integrate in other directions. Computer systems can now offer a wealth of optional extras such as the following:

a) distributed processing for multi-site operations;

b) automated shop-floor data collection;

c) repetitive or rate based planning for companies in high volume non-batch processing frequently found in just-in-time (JIT) volume manufacture;

d) computer aided design (CAD), computer aided manufacturing (CAM), computer aided process planning (CAPP) can now be linked and feed the main part, (BOM), routeings and tool information needed to plan new or modified parts and products;

e) electronic data interchange (EDI) with suppliers and customers;

f) materials handling through automated guided vehicles (AGV) and automatic storage and retrieval systems (AS/RS).

However, as each of these and many other advances become possible in a technical sense it is vital that their use provides the opportunity for a genuine improvement in business performance. In addition, it should be recognized that the totally automated factory is still a dream of the future in all but the simplest cases. The variety and speed of change together with the range of options for correcting factory plans means that people continue to be the key ingredient for a successful manufacturing organization. JIT manufacturing is tending to reduce the necessity for detailed shop-floor control. This is better left to the managers and supervisors who can quickly react to problems as they occur in the most flexible and appropriate manner, secure in the knowledge that the data they are acting on is accurate, is the same as that being used by other parts of the organization and that they understand the logic that led to any suggested actions the system may output.

The trend of modern computer aided production control systems is in fact to give people both the time and information they require to do their real jobs, i.e. maintaining the competitive manufacturing edge of the business.

Annex B (informative)

Production and inventory control software

The major package modules and software are listed in table B.1.

Modules may also be available for the following special applications:

- business planning;
- lot traceability;
- contract management;
- estimating;
- tool management;
- engineering change control;
- distribution requirement planning;
- shop floor data collection and monitoring;
- forecasting;
- CAD/CAM;
- CAPP;
- direct numerical control (DNC);
- statistical process control;
- finite capacity scheduling;
- maintenance management;
- automated warehousing;
- technical records;
- process control;
- project management;
- finite element analysis.

Other modules may be available for the following non-manufacturing activities:

- general ledger;
- sales ledger;
- purchase ledger;
- fixed assets;
- sales order planning;
- sales analysis and forecasting;
- payroll.

Table B.1 Standard modules and functions

Module	Functions
Technical data	Basic item data Bill of material structure Bill of task structure Copy product structure Item where used enquiry Technical change control Reports by single level, multi-level, summarized explosion Archive change history
Inventory control	Goods in receipt Works order material issue by item, kit, backflush Rate schedule backflush Issue to floor stock Trial kitting Subcontract material issue and receipt Works order product receipt Customer order shipment Unplanned inventory movement Multi-location stock record Transaction history ABC analysis Cyclical inventory count Stock quantity on-hand enquiry Customer stock order entry Customer special order entry Customer order enquiry Works order entry Works order shortage check Works order enquiry Supply/demand review Forecasting non-MRP items Order status listing Shortage reporting Archive transaction history 4GL report generator
Material requirements planning (MRP)	Planner action report Suggestions on screen Supply/demand review with MRP suggestions on screen Time phased pegged report Bucketed report Regenerative or net change review Parameter control of filters, horizons, run type

Table B.1 Standard modules and functions (*continued*)

Module	Functions
Manufacturing technical data	Work centre data Routeing data, primary, alternative, customized Copy routeing data Tool data Process data Process-tool link data Work centre report Work centre where used report Process where used report Routing report Process report Tool where used report
Shop floor control	Scheduled routeings maintenance Reschedule orders Scheduled routeing report Split batch maintenance Output recording by works order or rate schedule Scrap recording Rework recording Labour reporting WIP status reports Manufacturing activity reports Labour performance reports Scrap reports Archive manufacturing activity
Capacity requirements planning (CRP)	Capacity requirements summary Capacity requirements detail
Master production scheduling (MPS)	Family structure data Copy family structure data Family forecast data Explode family forecast to products Resource data Master schedule routeing data Copy master schedule routeing data Resource reports Master schedule routeing report Resource 'where used' report Master schedule item 'where used' report Master schedule family structure report Family forecast report Available to promise

Table B.1 Standard modules and functions (*concluded*)

Module	Functions
Rough-cut capacity planning (RCCP)	Resource requirements summary Resource requirements detail What if simulation Summary resource and routeing maintenance Resource requirements valuation
Cost control	Item frozen, current and new costs Work centre frozen, current and new costs Accounting cost selection codes Cost changes by material or item group Cost roll up report Cost update report Print cost sheets Inventory revaluation report Works order operation cost enquiry Works order cost enquiry Purchase invoice detail input Labour variance report Works order closeout report Purchase variance report WIP valuation report Staging valuation report Scrap valuation report
Purchasing control	Company data Buyer data Vendor data Vendor and item enquiry Purchase item master data, units of measure, references Purchase order maintenance Contract order maintenance Call-off release Print purchase orders Print contract orders Outstanding purchase order reports Purchase order enquiry: by order Purchase order enquiry: by item Purchase order enquiry: by vendor Blanket contract order review Open order report Blanket release schedule report Blanket contract expiry report Purchase order spend report Purchase order commitment report Vendor performance report Project purchase variance report Purchase item history report Complete and archive orders

List of references (see clause 2)

Normative references

BSI standards publications

BRITISH STANDARDS INSTITUTION, London

BS 3138 : 1992	*Glossary of terms used in management services*
BS 5191 : 1975	*Glossary of production planning and control terms*
BS 5192 :	*Guide to production control*
BS 5192 : Part 1 : 1993	*Introduction*

Informative references

BSI standards publications

BRITISH STANDARDS INSTITUTION, London

BS 5192 :	*Guide to production control*
BS 5192 : Part 3 : 1993	*Ordering methods*

Other references

[1] FORRESTER, J.W. *Industrial Dynamics.* Cambridge, MA: MIT Press, 1961.

[2] ORLICKY, J.A. *Material Requirements Planning.* New York: McGraw-Hill, 1975.

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