BRITISH STANDARD

BS 5192 :
Part 2 : 1993

Guide to production control

Part 2. Production programming

BSI
STANDARDS

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Quality, Management and Statistics Standards Policy Committee (QMS/-) to Technical Committee QMS/33, upon which the following bodies were represented:

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)
University of Bradford
University of Manchester (Institute of Science and Technology)

This British Standard, having been prepared under the direction of the Quality, Management and Statistics Standards Policy Committee, was published under the authority of the Standards Board and comes into effect on 15 March 1993

The following BSI references relate to the work on this standard:
Committee reference QMS/33
Draft for comment 90/97361 DC

ISBN 0 580 21493 1

Amendments issued since publication

Amd. No.	Date	Text affected

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: 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, 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.

Introduction

This Part of BS 5192 deals with the creation and maintenance of production programmes and their relationship to other plans in the business and to the resources required to implement them. Realistic production programmes are essential to ensure achievement of the organization's manufacturing objectives. For the different stages of production control see figure 1.

1 Scope

This Part of BS 5192 gives guidance on production programming and its relationship to corporate and business programmes and planning techniques such as master production schedules and capacity planning.

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 and BS 5191 : 1975 apply, together with those given in BS 5192 : Part 1 : 1993.

4 Production programming

4.1 Relationship between production programmes and other plans

As explained in BS 5192 : Part 1, in most businesses there is a hierarchy of plans, the following being typical examples.

a) *Corporate plan* sets out the strategic direction of the business over a period of 2 years to 5 or more years.

b) *Business plan* covers a shorter timescale, usually 1 to 2 years, and lays down in more detail budgets for each of the operating functions of the business together with non-financial objectives.

c) *Production plan* is a statement of the products to be made and the plant and manpower required to make them in order to achieve the manufacturing objectives contained in the corporate and business plans. It usually covers a similar timescale to the business plan, though the timescale may be considerably longer if major developments in plant are planned. The planned production may be stated in broad terms of value, mass, volume or product groups, depending on the nature of the product and how much information is available about future demand.

d) *Master production schedule* (MPS) is the programme that drives the business in the short term. It is a statement, not a forecast, of the products to be made, and when and in what quantities they are to be made. The time span of a master production schedule depends on the lead time of the products and should be at least as long as the lead time of any item in the schedule. Typically, the master production schedule covers a 6 month to 12 month rolling period with monthly or weekly reviews.

There is a two-way link between the master production schedule and sales and financial plans in order to obtain a consensus about what constitutes a realistic and achievable plan. The master production schedule is also the input to systems for planning and ordering purchased and manufactured parts, e.g. material requirements planning (MRP).

Each level of planning is dependent on the one above, and decisions made at higher levels will limit the flexibility of plans at lower levels. The degree of flexibility will depend upon the nature of the manufacturing process. For example, the output of an assembly shop employing simple tools and semi-skilled labour will not be constrained to the same extent as that of a process plant which uses unique equipment requiring several years to commission.

4.2 Other planning techniques

In addition to, or in conjunction with, master production scheduling, a number of other techniques are employed to plan manufacture. Their application depends upon the nature of the manufacturing process.

a) *Assembly schedules* are used to instruct an assembly shop what products are to be assembled daily or weekly (see **5.5**).

b) *Machine programmes.* In factories that manufacture products from high cost plant such as large presses or moulding machines, programmes are in many instances maintained for individual machines or groups of machines.

c) *Linear programming* is a mathematical technique used in some process industries to plan the optimum mix of products through the plant, for example, steel rolling mills.

d) *Project networking techniques* are suitable for managing projects, that is planned undertakings that have definable starts and definable completions. The technique is usually applied to large complex projects involving multidisciplinary teams, for example, the design, planning and setting-up activities needed for the 'first-off' of a new product or the development and manufacture of a large item of capital equipment. For further information, see BS 6046 : Parts 1 to 4 and BS 4335.

Terms such as program evaluation and review technique (PERT), critical path analysis (CPA), critical path method (CPM), precedence method and several others refer to versions of project networking techniques, but the terms are not synonymous.

e) *Bar charts* are a well known method for controlling planned activities, but their drawback, especially at the planning stage, of not showing explicitly the links between activities limits their usefulness. This can be overcome by the use of time-based networks (linked bar charts); see BS 6046 : Part 1.

4.3 Criteria for successful planning

Successful planning depends on following a number of criteria.

a) Clear and rapid communication is essential through all levels of the planning process. This means communicating instructions downwards and reporting back results upwards in a closed loop (see figure 2). Feedback of information is essential if the plan is not to lose contact with reality.

b) Plans should be realistic and capable of being achieved in the time and with the resources available. A plan that is not realistic and has no chance of being achieved should be revised, otherwise the planning process loses credibility.

c) A plan should have clearly defined cut-off points after which it should become firm. Changes reached after a cut-off point should as far as possible be avoided as they will either result in non-achievement of the plan or achievement at increased cost.

d) The time span or planning horizon should be not less than the longest lead time of any item in the plan. A planning horizon that is too short will result in non-achievement or achievement at increased cost. On the other hand, a plan should not be frozen or firmed up sooner than necessary, since the shorter the time between plan and execution, the more accurate the plan is likely to be.

5 Master production schedule (MPS)

5.1 Operation

The master production schedule is the build plan of products or groups of products required to meet market demand, constrained within the limits of production resources. The master production schedule is derived from the sales plan but the two may not necessarily be identical. Seasonal sales or the need to smooth under- or over-capacity may result in differences between the MPS and the sales plan. Although a master production schedule may be based on a forecast, it is not a forecast but a statement of what is to be produced over a certain period of time. The schedule provides the input to other systems for planning material provisioning, internal manufacture and short term capacity requirements.

5.2 Relationship with other functions

The master production schedule is a rolling programme that is updated at regular intervals, usually monthly, and agreed by the various functions of the business, e.g. production, sales, engineering, distribution and finance. To ensure its acceptance by all parties, it should be signed off by the chief executive. The master production schedule drives the business in the sense that it determines what will be available for sale, what is to be manufactured and purchased, and the resultant cash flow projections.

5.3 Input to the MPS

5.3.1 *General*

In order to prepare a master production schedule, the scheduler needs to have information about the following:

a) sales demand, either in the form of a forecast, or, if the business makes to customers' orders, actual orders received;

b) lead time to procure material and manufacture the products;

c) available major plant and other resource capacity including the capacity of any associated activities such as design customization and laboratory testing that may be relevant;

d) major products and bills of material.

5.3.2 *Sales demand*

Sales demand may be expressed in many forms, for example as individual products, families or groups of products, modules or part completed items, or in terms of mass, size or value.

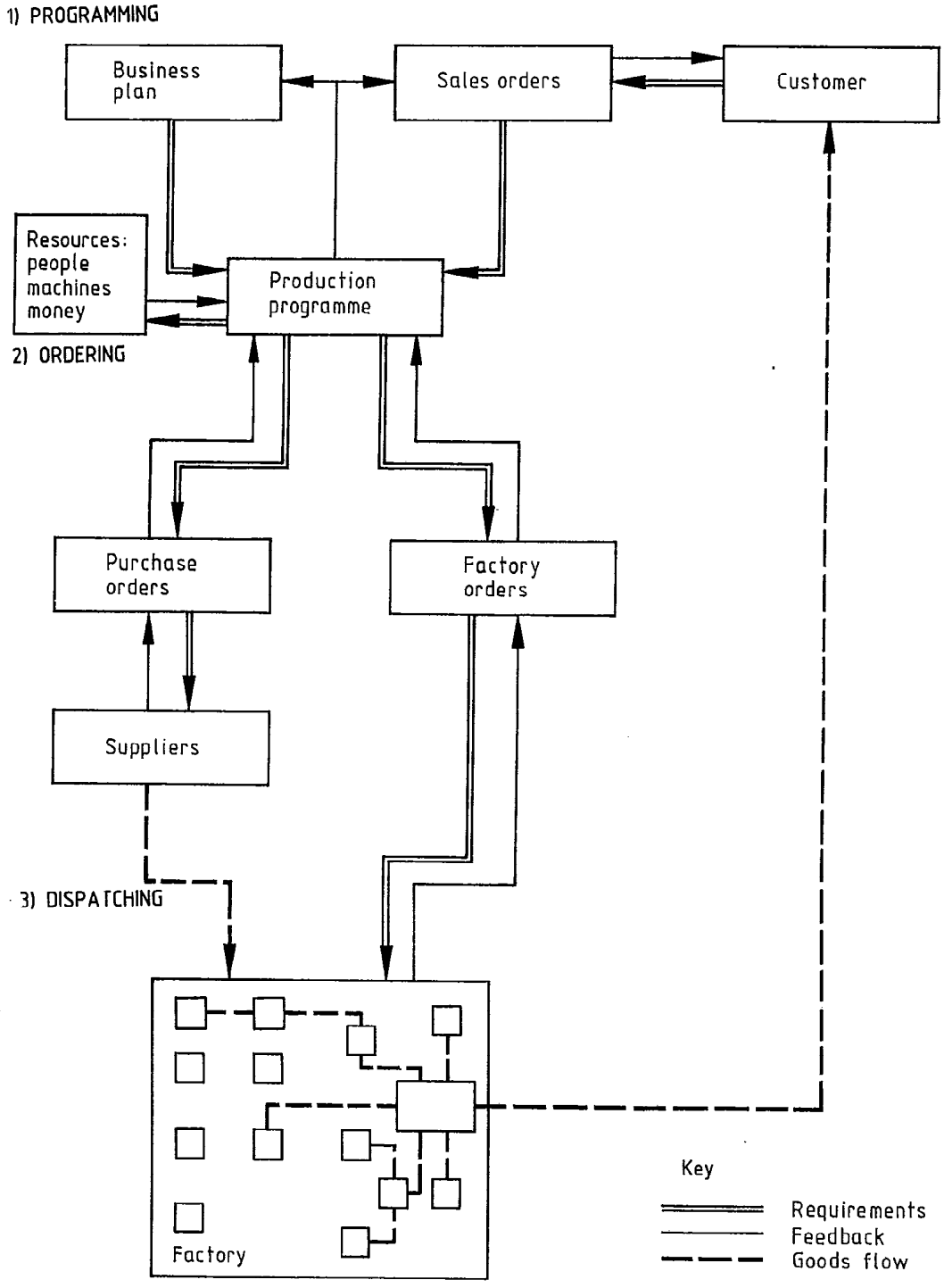

Figure 1. Stages of production control

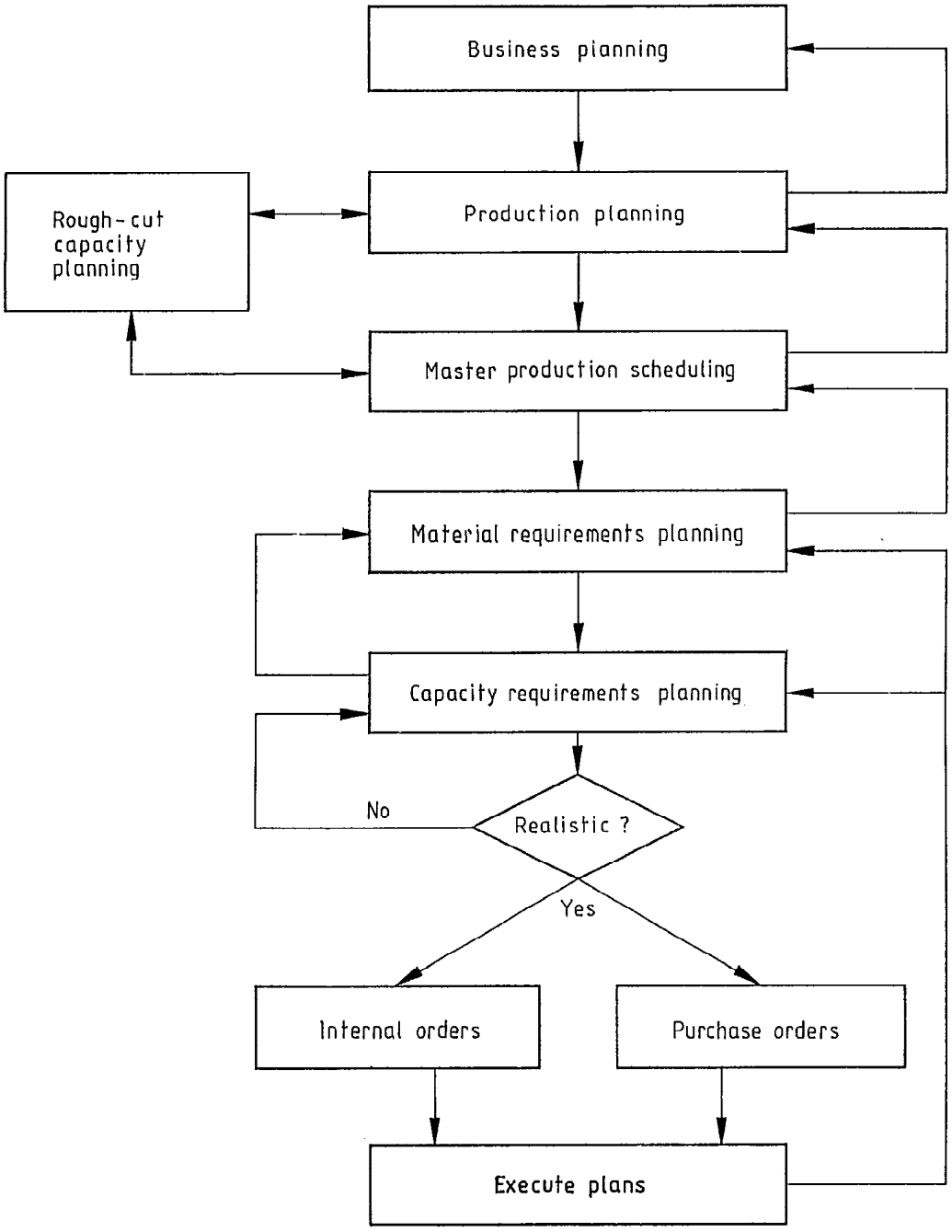

Figure 2. Closed loop system

A sales department often has difficulty in forecasting sales of individual products, especially in industries in which there are a large number of end products such as pharmaceuticals. In these circumstances it is sometimes possible to forecast sales of product families and to create a bill of material for the family. The master production schedule will then comprise planned manufacture of the product families, and only at the final build stage will individual products be scheduled.

In industries with a large range of customer options, such as the motor industry, the sales forecast is pitched at a level below the end product, e.g. engines of a particular size or number of automatic and manual transmissions, etc. The product is designed in the form of modules which can be assembled to provide a wide variety of options, each module having its own bill of material. The content of the master production schedule consists of plans for manufacturing the modules.

In some industries, forecast by mass or volume is used as the input to the master production schedule. In such cases the main purpose of the master production schedule may be to plan forward capacity requirements, rather than material requirements.

In industries that have a spares and service demand or produce by-products at lower levels in the manufacturing process, forecasts will be required for these items. The items should be planned as independent demand at the level in the bill of material where they occur so that they are provisioned along with dependent requirements from higher levels.

In practice it is likely that the quality of information will vary according to the customer and hence the MPS will be based on a mixture of customer firm orders, customer forecasts and in-company forecasts derived from past performance.

To aid the master scheduler these will ideally all be displayed on a VDU and there should be a routine within the computer system to select data to be used based on priority rules (for example, customer forecast supersedes market forecasts), summarizing at different levels, i.e. product code, product group, etc.

It is important also that when items are despatched or cancelled, there is a procedure within the sales order processing system for reducing commitment and for handling overdue commitments so that when the MPS is reviewed, the most relevant and up-to-date requirement information is available.

5.3.3 *Lead time*

Figure 3 shows an example of a purchase and manufacturing lead time for a product. A master production schedule that covers a time span less than the minimum lead time will mean either that the schedule is non-viable or that panic measures have to be taken to achieve the plan. Such measures often increase cost, e.g. air freighting components, splitting batches. In industries in which the products are made from common materials it is sometimes possible to firm up the MPS in stages, e.g. stage 1 material supply, stage 2 component manufacture, stage 3 final assembly.

5.3.4 *Capacity*

In preparing the master production schedule, account should be taken of the available capacity. In factories that are engaged purely on assembly or on a single process this may be a fairly simple matter of calculating the daily output from the line or process.

However, for many industries capacity planning is more complex, involving many processes and many components and sub-assemblies. A technique called rough cut capacity planning can be used in order to ascertain quickly whether or not the MPS is viable. This is a crude form of capacity planning that generally ignores work-in-progress and concentrates on key or critical resources. To aid the scheduler, a capacity bill of material is sometimes produced for each product that shows the capacity on key resources that the product will use.

5.3.5 *Products and bills of material*

As explained in the preceding sections, the scheduler needs to have a thorough understanding of the families, the products and the way that bills of material are structured in order to decide the best method of creating and maintaining the master production schedule.

5.4 Types of master production schedule

5.4.1 *Format*

The format of the master production schedule varies according to the type of business as explained in **5.4.2** to **5.4.4**.

5.4.2 *Make-to-stock*

Businesses that have to meet customer demand in less time than is needed to manufacture the product need to make for stock. Orders are in this case fulfilled by drawing from stock of finished products. Typically, businesses making simple commodities, such as electric plugs, paints and so forth, come within this category.

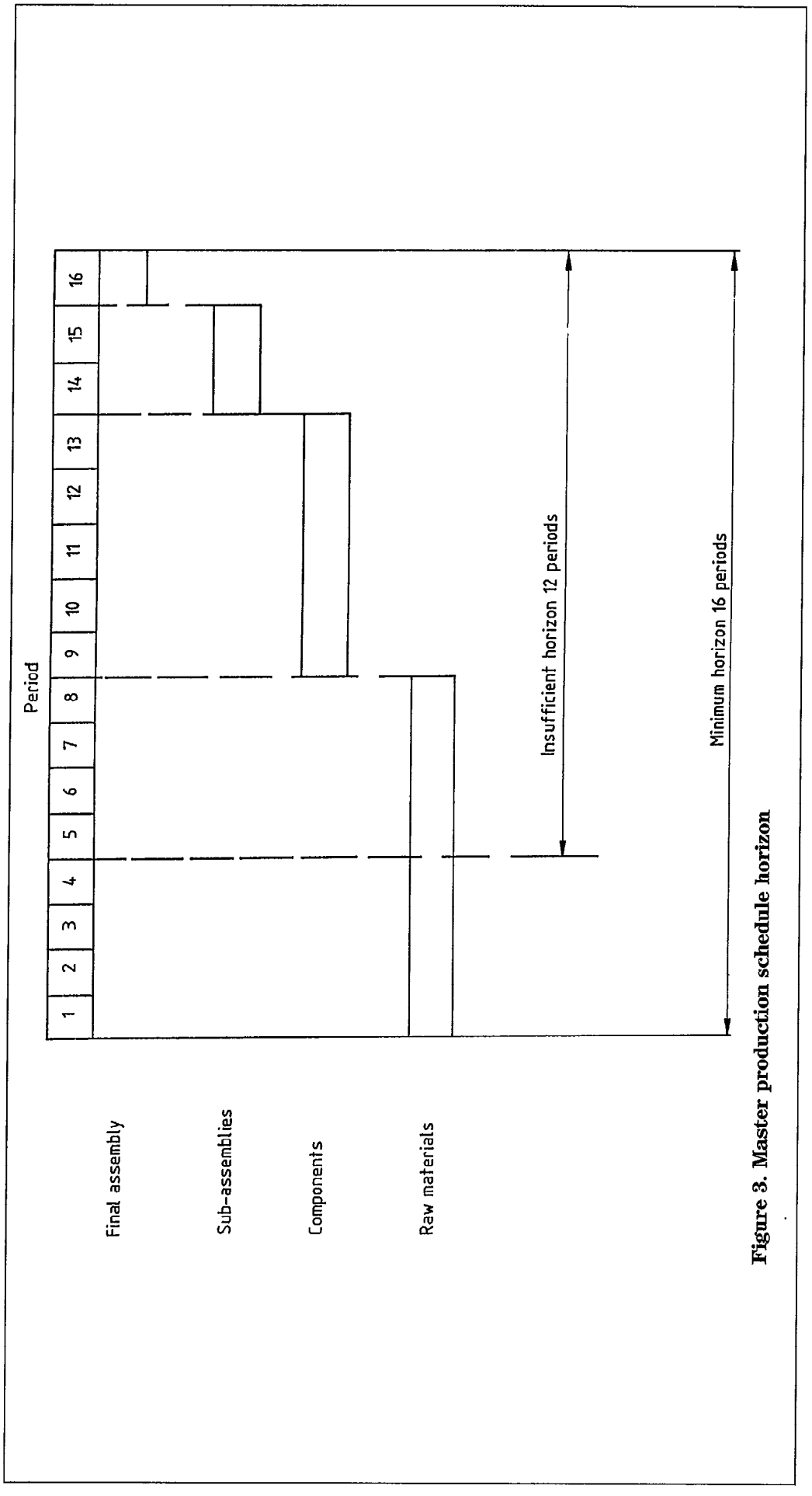

Figure 3. Master production schedule horizon

The master production schedule has therefore to be based on a forecast of demand. An example of a master production schedule in a make-to-stock situation is shown in figure 4.

5.4.3 *Make-to-order*

Some businesses do not begin to manufacture until they receive an order from a customer. Often, the project has to be designed to meet the customer's unique requirements, for example special purpose machinery, and, therefore, the master production schedule should also include schedules for the design and engineering departments. Long lead times are a characteristic of this kind of business. They involve the whole manufacturing cycle from design, through supply of material to component manufacture, assembly and test. Figure 5 shows an example of a make-to-order master production schedule.

Few businesses can function on a purely make-to-order basis, since customers generally find the long lead times unacceptable. Many industries therefore operate on a combination of make-to-stock and complete-to-order.

5.4.4 *Make-to-stock and complete-to-order*

There are several ways in which the lead time between receipt of a customer's order and delivery can be compressed. Designs may be standardized or products designed in modular form with variants so that only a minimum amount of design effort is required to customize the product. The business may hold stocks of raw material, particularly those with long lead times. Manufacture may proceed against a forecast of demand up to some incomplete stage such as components or sub-assemblies, so that completion of the end product only occurs when the customer order is placed.

Product A

Lead time 3 periods

	Opening free stock	Periods 1	2	3	4	5	6	7	8
Forecast		10	10	15	15	15	15	20	20
Scheduled receipts			40						
Projected available	10	0	30	15	0	-15	-30	-50	-70
Planned order receipts						40		40	
Planned order release			40		40				

Figure 4. MPS make-to-stock

Product B

Lead time 6 periods

	Periods 1	2	3	4	5	6	7	8
Customer order due	3	4	5	3	3	2	3	2
Scheduled receipts	7		8		5			
Planned order receipts							5	
Planned order release	5							

Figure 5. MPS make-to-order

Figure 6 shows an example of a master production schedule in a make-to-stock or complete-to-order situation. Note that the schedule is driven by the forecast, not customer's orders, the assumption being that the forecast demand will be fulfilled. The schedule also shows, period by period, how much projected product is uncommitted by orders. It, therefore, acts as a guide to the scheduler and to the sales department of what is available to sell in each period.

Products that are designed as modules that can be put together in a number of ways to produce a large variety of end products are a feature of this type of business. The motor industry is perhaps the most notable example, with its combination of body styles and colours, engine sizes, accessories and so on. Although the possible number of end item combinations can run into many thousands, the number of items in the master production schedule can be kept to a comparatively small and manageable number.

5.5 Assembly schedule

In many industries that make to a partial stage of completion and only carry out final assembly on receipt of a customer's order, the assembly schedule is the document that instructs the assembly department what to produce. The schedule typically covers a period of 1 week. It is important to note that the assembly schedule is subject to the constraints of higher level plans, and, therefore, the assembly schedule is usually a derivative of the master production schedule.

6 Capacity planning

6.1 Objective of capacity planning

The objective of capacity planning is to ensure that sufficient manufacturing resources are available to fulfil the objectives expressed in the organization's corporate and business plans. Resources are both manpower and plant. If design and development is involved, as, for example, with customized products, it is the responsibility of the design or engineering function to plan the necessary resources.

6.2 Definition of production capacity

Production capacity is the amount of resource available for loading work after deducting all non-productive time such as planned maintenance, holidays and rest periods, allowances for plant breakdown, for sickness and absenteeism, etc. Machine set-up time may be included or excluded from capacity, according to whether it is treated as a planned activity or not. Activities that form a vital part of the production process, such as testing, should be included in capacity planning.

6.3 Long and short term capacity planning

Capacity plans may be divided into long term and short term. Long term plans cover the acquisition or disposal of manufacturing plant and buildings and the recruitment and training of the workforce. Long term capacity plans form part of the production plan referred to in **6.1**, and are often based on a sales forecast expressed in broad terms, perhaps product groups or volume.

Module 'X'

	Back orders	Periods							
		1	2	3	4	5	6	7	8
Forecast		10	10	15	15	15	15	20	20
Customer orders	1	9	8	8	6	4	2		
Scheduled receipts		10	10	15	15	15	15	20	20
Uncommitted (available to sell)			2	7	9	11	13	20	20

Figure 6. MPS make-to stock/complete-to-order

Short term capacity planning generally aims to fine-tune the capacity to ensure that it is capable of dealing with the load imposed by the short term production programme arising from the master production schedule. Capacity may be fine-tuned by overtime working, or shift working or subcontracting. Occasionally it may be possible to increase capacity by introducing new plant at short notice. Methods improvement should also be considered as another possible way of increasing capacity from the same resources (see BS 3375 Parts 1 to 4).

6.4 Capacity planning techniques

6.4.1 *Simple techniques*

In industries where manufacture consists of a few operations or processes, and where the products have few components or levels in the bill of material, capacity may be measured in terms of units of output, such as the number of products per day off an assembly line, or in standard hours, or by mass or size, e.g. metres per hour from an extrusion machine, or in some other convenient unit. In such industries, ensuring that the master production schedule is realistic in terms of available capacity is a relatively simple matter of scheduling the work load on the assembly line or process.

In many industries, however, manufacturing control is more complex, involving many operations on many products, each having several levels in the bill of material. In these industries more sophisticated techniques are needed to plan and control capacity.

6.4.2 *Capacity requirements planning (CRP)*

Capacity requirements planning uses a similar methodology to material requirements planning (MRP). Starting with the due completion date in the master production schedule, CRP back schedules through each level in the bill of material and through successive operations, and, applying lead time and batching policies set by management, calculates the start and finishing dates and the loads on each works centre for the manufactured parts.

NOTE. A works centre is any convenient grouping of people by skill or machines by characteristics for the purpose of planning and control.

CRP calculates the load profile, and hence the capacity required, on each work centre, based on the latest possible start and finish dates for each operation, in order to achieve the output in the master production schedule. It provides the basic information for the capacity planning and loading techniques described in **6.4.3** and **6.4.4**.

6.4.3 *Infinite capacity planning and loading*

This technique assumes that there are no constraints on capacity and that capacity can be expanded to meet any demand made upon it from the planned load (see figure 7). As such a condition very rarely occurs in practice, it is often necessary to reschedule the plan should load exceed capacity. To minimize the need for rescheduling, which can be a time consuming and difficult exercise, the master production schedule should first be roughly balanced with capacity using a technique such as rough cut capacity planning described in **5.3.4**. Small short term overloads can then usually be managed by short term expedients such as overtime working and subcontracting and by minor flexibility in the programme. Under these conditions, infinite capacity planning and loading is a valid and worthwhile technique.

6.4.4 *Finite capacity planning and loading*

In this technique, as its name suggests, capacity is assumed to be fixed, and overloads should be rescheduled to fill any troughs that occur in the forward production plan (see figure 8). Such rescheduling can become quite complex and generally requires the use of a computer since any alteration in the load profile in one work centre may involve rescheduling the load profiles in other work centres downstream from it. Deferral of work into later time periods can result in orders becoming overdue unless there are floats or buffers between the various manufacturing stages to absorb the delay.

Rescheduling has to take account of the relative priorities of the jobs being rescheduled. These priorities, of which there are a variety of forms, can be both internal and external. For example, an internal priority could be based on the proportion of operating time to slack time remaining between the current date and the due completion date. External priorities are those based on the urgency of a customer's order.

The interaction of priorities in such a computer system can be very complex, and the resultant output difficult to understand. The technique has an application in industries in which accurate capacity planning is important, for example, the jobbing industry. However, many businesses prefer to use the more simple infinite capacity planning and loading technique and to smooth loads manually.

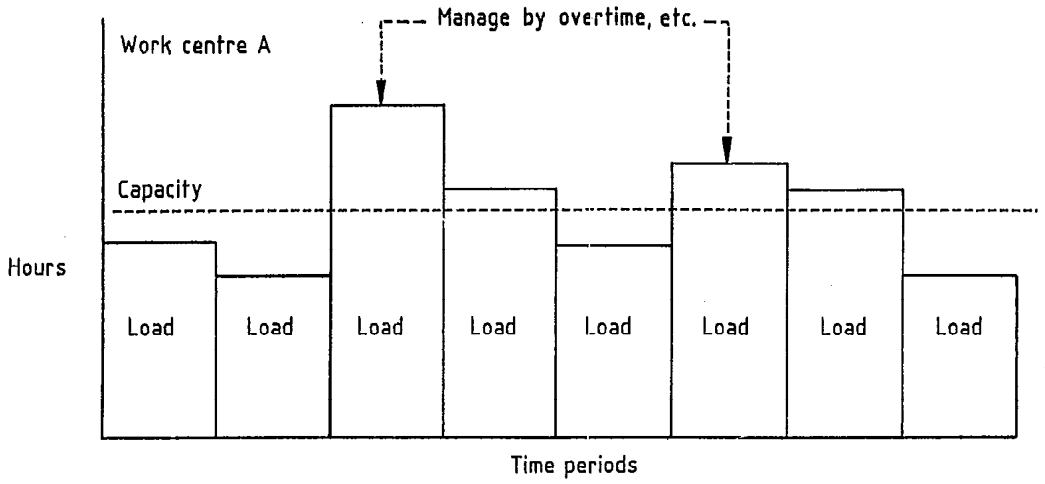

Figure 7. Infinite capacity loading

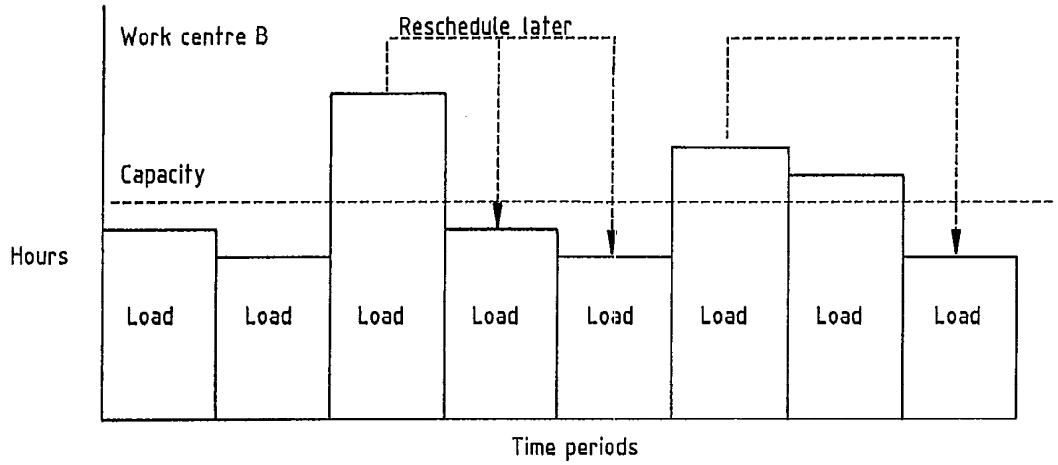

Figure 8. Finite capacity loading

List of references

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 3375 :	*Work study and organization and methods (O & M)*
BS 3375 : Part 1 : 1984	*Guide to organization study*
BS 3375 : Part 2 : 1986	*Guide to method study*
BS 3375 : Part 3 : 1985	*Guide to work measurement*
BS 3375 : Part 4 : 1985	*Guide to work performance control*
BS 4335 : 1987	*Glossary of terms used in project network techniques*
BS 5192 :	*Guide to production control*
BS 5192 : Part 3 : 1993[1)]	*Ordering methods*
BS 5192 : Part 4 : 1993[1)]	*Dispatching (shop floor control)*
BS 5192 : Part 5 : 1993[1)]	*The relationship between production control and other management functions*
BS 5192 : Part 6 : 1993[1)]	*Computer aided production control*
BS 6046 :	*Use of network techniques in project management*
BS 6046 : Part 1 : 1984	*Guide to the use of management, planning, review and reporting procedures*
BS 6046 : Part 2 : 1992	*Guide to the use of graphical and estimating techniques*
BS 6046 : Part 3 : 1992	*Guide to the use of computers*
BS 6046 : Part 4 : 1992	*Guide to resource analysis and cost control*

[1)] In preparation and referred to only in the foreword.

BSI — British Standards Institution

BSI is the independent national body responsible for preparing British Standards. It presents the UK view on standards in Europe and at the international level. It is incorporated by Royal Charter.

Contract requirements

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Revisions

British Standards are updated by amendment or revision. Users of British Standards should make sure that they possess the latest amendments or editions.

Any person who finds an inaccuracy or ambiguity while using this British Standard should notify BSI without delay so that the matter may be investigated swiftly.

BSI offers members an individual updating service called PLUS which ensures that subscribers automatically receive the latest editions of standards.

Buying British Standards

Orders for all British Standard publications should be addressed to the Sales Department at Milton Keynes.

Information on standards

BSI provides a wide range of information on national, European and international standards through its Library, the Standardline Database, the BSI Information Technology Service (BITS) and its Technical Help to Exporters Service. Contact Customer Services, Information Services Group at Milton Keynes: Tel: 0908 221166.

Subscribing members of BSI are kept up to date with standards developments and receive substantial discounts on the purchase price of standards. For details of these and other benefits contact the Manager, Membership Development at Milton Keynes: Tel: 0908 220022.

BSI
2 Park Street
London
W1A 2BS

BSI
Linford Wood
Milton Keynes
MK14 6LE

9303—6—1.2k—B

ISBN 0 580 21493 1

QMS/33