

JOB SHOP PRODUCTION PLANNING & CONTROL - CASE STUDY
(AECI Modderfontein - Central Workshops)

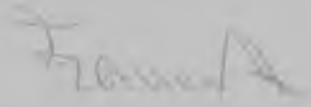
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A Dissertation Submitted to the Faculty of Engineering
University of the Witwatersrand, Johannesburg
for the Degree of Master of Science

Johannesburg 1982

DECLARATION

I declare that this dissertation is my own unaided work.
It is being submitted for the degree of Master of Science in the University
of the Witwatersrand, Johannesburg, South Africa. It has not been submitted
before for any degree or examination in any other University.



AHARON FRANCO

30th day of JUNE 1982

ABSTRACT

A scheduling approach for job-shop or made-to-order production has been studied extensively over the last 20 years in connection with computerized systems for Production Planning & Control.

The purpose of the major part of this text is to "sell" the idea of a Real Queue approach for ordinary jobs computerized scheduling systems, and a Manual Planning system for emergency and short jobs, by means of capacity allocated to this purpose.

Most of the systems employed to-day by various production companies, are "packages" sold to them by large Computerized Data Processing companies and were tailored to suit them, based on the available modular software systems. with no significant differences between one or the other. Whereas, the computer used in production planning improved control over orders, reduced the clerical work concerned and provided quick and efficient tools for decision making, less success was achieved in production management regarding meeting of definite promised delivery dates, as a result of emergency and short jobs entering the system and requiring immediate production processing. This can be attributed to the people using the system, but to a large extent, it is attributable to the approach of scheduling in most cases. Nevertheless, attempts were made to construct suitable programmes, but only by a few companies, employing in-house programmers and systems personnel for their own purposes.

As competition between manufacturers is extremely high at present, the meeting of promised delivery dates for all kinds of jobs is becoming more and more important. This requires having confident scheduling and determining of delivery dates systems, which can be constructed only after carrying out a careful and in-depth study of the system concerned.

The study given here, reflects the various stages taken when tackling a problem like this. It has been carried out in three major stages: Overall study of all management aspects of the workshops, the existing planning system and the experiments in implementation of another approach to scheduling.

The study used quantitative methods, data, tables and graphs, illustrating the various stages of the project and the text consists of 5 parts:

- PART A : Overall Management Study
- PART B : "CAPOSS" - The existing planning & scheduling system
- PART C : Implementation and experiments for determining the best solution for the system
- PART D : Final Results and Comparisons
- PART E : Production Planning & Control - Literature Survey

The text was written in this way, to enable students, system analysts, Industrial Engineers and Production Management personnel to use the various parts of the text for their individual practice and purposes, when dealing with production planning systems in general, and job shop production planning systems in particular.

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PREFACE

This text, which is my dissertation for the degree of Master of Science in Engineering, studies the correct perception for job shop production Planning and Scheduling.

It represents the results of a project which was carried out in the Central Workshops of AECI, Modderfontein, where, in October 1980, I was appointed to the position of Workshops Planning & Control Engineer. This appointment was as a result of overall management re-organization at the workshops, in order to improve the Engineering & Maintenance services given by the workshops to the various plants at the factory.

The re-organization was carried out shortly after the introduction of IBM'S planning & scheduling system, known as "CAPOSS", had failed. The "CAPOSS" system was thought to be the correct solution for improving services given by the workshops.

Since I graduated as an Industrial Engineer from the "Technion" - Israel Institute of Technology in 1975, I have dealt mainly with various types of Production Planning & Control systems. I found this an opportunity to express my experience and knowledge in this field, through this project for the benefit of Industrial and System Engineers, Production Management personnel and students.

I wish to acknowledge the consultation and tuition given to me by Professor R.T. Jamieson of the University of the Witwatersrand, Johannesburg, South Africa, in carrying out this project and in writing this text, and to thank Mr J. Becheano of the Witwatersrand University for his valuable suggestions.

Special appreciation is due to Mrs Elizabeth McFarlane of AECI, Modderfontein, South Africa for her excellent typing.

A. FRANCO

JOB SHOP PRODUCTION PLANNING & CONTROL - CASE STUDY
(AECI Modderfontein - Central Workshops)

Part A

Overall Management Study of Central Workshop and General Recommendations

Part A

C O N T E N T S

PREFACE

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2. SUMMARY AND CONCLUSIONS
3. RECOMMENDATIONS
4. FINDINGS
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 - 4.3. Key Objective
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2. List of pertinent Information/Findings/Recommendations over last 2 years
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 - 3a Planning & Control responsible to Manager Industrial Engineering
 - 3b Planning & Control Section responsible to Workshops Manager
4. Key performance areas
5. Proposed organization structure of Planning & Control Section (Functional only)
6. Proposed individual incentive bonus schemes for CWS artisans

P R E F A C E

This report is the first in a series of reports concerning my project for a MSc degree.

The report covers the general findings and recommendations of an overall Management Study of central workshops at AECI Modderfontein. This study was carried out over a period of 1½ months (1.10.1981 to 15.11 1981) and consists of general guidelines for commencing the implementation of recommendations in various areas and aspects of the workshop management.

As the investigation included all possible subjects and issues of production and management in the workshops, the recommendations cover all aspects of management and do not concentrate on any particular subject in detail.

This will be done in the next stages, which will concentrate more on the production, and planning & control aspects of the system, with minor ramifications to all the other aspects, such as personnel, training, estimating, quality control and procedures.

A. FRANCO

1. INTRODUCTION

A survey of the Central Workshops (CWS) was carried out in two stages:

1st October - 25th October followed by an interim report
and 26th October - 15th November

This report covers the total survey period and includes a programme of actions designed to correct the weaknesses found.

Object of Survey

The object of the survey was to investigate the causes of low Workshops efficiency, the reasons for the poor planning & control system, to recommend the actions necessary to enable the Workshops to function efficiently, and to implement the recommendations throughout all the management aspects of the shop: Production, Planning & Control, Estimating, Quality Assurance and Personnel.

2. SUMMARY AND CONCLUSIONS

During the past seven years, numerous reports on various aspects of the Workshops have been prepared and circulated.

The overall problem is that the Central Workshops is not providing a satisfactory service to the Factory in terms of delivery, quality and cost.

As a generalisation, this is true, although the degree varies from shop to shop.

Many of the previous reports have concentrated on the systems and procedures in use in the Workshops, such as estimating and planning. One of the many solutions was the introduction of a computerised Planning & Control system, which however, only aggravated the situation. Whilst it is true that there is scope for improvement in these areas, they are not the primary cause of the problems.

The key problem is one of management and control. With a more dynamic management, the problems which now exist in almost every aspect of the operation, would

a) not have arisen

or

b) have been corrected at an early stage

Oblique references to the management problem have been made in various reports (Appendix 1), but in general, the solutions proposed previously have concentrated on systems and procedures.

The primary conclusion therefore, is that the Factory Workshops Management should be strongly management and results orientated, and be able to motivate the personnel to provide the service for which the workshops exist.

2.1. Key Objective

The key objective proposed for CWS is as follows:

To provide an engineering maintenance service to the Factory by providing central manufacturing, repair and maintenance facilities to undertake emergency, priority and routine work, in order to achieve:

- a) Quality of service : delivery dates are met with 95% effectiveness
of product : as specified
- b) Cost on average, to be less than outside contractors
- c) Quantity of service to the Factory:
 - i) 100% for services which are not available from outside sources.
 - ii) X% by value of the routine services which can be provided (technically) either internally or externally.
 - iii) Y% by value of peak load service requirements during shutdowns.

NOTE: (ii) and (iii) percentages to be established after investigating and quantifying total Factory demand and workshop capacity.

3. RECOMMENDATIONS

3.1. Management and Organisation Structure

- 3.1.1. That the position of Production Engineer be introduced.
- 3.1.2. That the position of Planning & Control Engineer be introduced.
- 3.1.3. That the organisation structure be as shown in Appendix 3 (2 phases: (1) Planning & Control on behalf of the Manager of Industrial Engineering (2) on behalf of Workshops Manager)
- 3.1.4. That Job Specifications and Man Specifications be prepared for all staff positions.
- 3.1.5. That the key performance areas shown in Appendix 4 be adopted.

3.2. Planning and Production Control

- 3.2.1. That the Planning Section be organised as shown in Appendix 5.
- 3.2.2. That CAPOSS be retained and it's effectiveness, planning approach and procedures be reviewed as and when management changes take place.
- 3.2.3. That the Factory Workshops Manager holds daily meetings with the Planning Engineer and Production Engineer to:
 - a) Check achievement vs plan
 - b) Check reasons for non-achievement
 - c) Institute corrective action
 - d) Implement corporate management strategy
- 3.2.4. That strict discipline in the use and application of CAPOSS procedures be enforced.
- 3.2.5. That management, planning, estimating, Q.C., supervisors and men be re-trained in the practical use of CAPOSS. (The need for system discipline; the procedures; the procedures for accommodating emergency work; the method of loading only X% to allow for low efficiency, emergency work, capacities control etc)
- 3.2.6. That a practical CAPOSS user's manual be prepared which details:
 - a) The routine procedures to operate the system.
 - b) The control information provided by the system, it's interpretation and the control action options..
- 3.2.7. That a "total Factory demand versus workshop capacity" investigation be carried out to quantify the capacity problem.
- 3.2.8. That, in the short term, CWS input should be limited to CWS capacity in diminishing priority sequence.
- 3.2.9. That a "Turnaround Time Analysis Due Date - Report" be used as a measure of achievement of customer satisfaction.
- 3.2.10. That a "'Turnaround Time Analysis First Calculated Finish Date-Report" be used as a measure of planning and control efficiency.

3.3. Estimating

- 3.3.1. That the estimating function retains line responsibility to the Industrial Engineering Group, with staff responsibility to the Central Workshops Management.

- 3.3.2. That estimator selection and training programmes be reviewed to ensure a high standard of estimating.
- 3.3.3. That all basic and reference data be checked to ensure it's continued validity to the equipment, machines and methods currently in use.
- 3.3.4. That all repeat job standard times be checked to ensure their validity.
- 3.3.5. That repeat jobs be filed in such a way as to make retrieval quick and that repeat jobs always receive the same standard time per piece on each occasion. Set-up times should be shown separately.
- 3.3.6. That Route Cards give more detail of the job method used when estimating (to guide inexperienced Artisans).
- 3.3.7. That Route Cards show the set-up time and time per piece as well as the job time.
- 3.3.8. That Refresher Courses be carried out for all estimators (to re-establish departmental policies and estimating standards).
- 3.3.9. That an estimator record sheet be introduced, showing the work done by each estimator.
- 3.3.10. That a system of regular independent audits of sampled jobs be introduced, to check accuracy of estimates.
- 3.3.11. That provision be made for the estimation of additional and extra work on a job and for speedy attention to "tight time" appeals, whilst the job is still in progress.
- 3.3.12. That the time for estimating any single normal job will not exceed three days and, preferably, will be done within 24 hours. Emergency work should be estimated whilst the job is in progress.

3.4. Pay and Incentive Bonus

- 3.4.1. A clearly defined remuneration policy should be adopted in order to achieve the following objectives:
 - i) To attract personnel of the right calibre.
 - ii) To encourage them to achieve their job objectives.
 - iii) To reward them in accordance with the value of their contribution.
 - iv) To prevent loss of morale through dissatisfaction with pay levels.
 - v) To encourage them to stay with the Company.
 - vi) To achieve these aims at minimum cost.

- 3.4.2. That hourly rates for artisans be maintained in the upper quartile of competitors' rates. The employer sample used in the periodic surveys (by The Factory Industrial Relations Officer) should consist primarily of those employers who attract our employees.
- 3.4.3. That a merit grading scheme for artisans be introduced which rewards the man for the quality and range of his skills within his trade.
- 3.4.4. That the long service award scheme be retained, but that it be based on a percentage of the basic rate so that its value remains significant (in relation to basic wages).
- 3.4.5. That an individual incentive bonus scheme be introduced throughout the workshops, in place of the present group scheme. (See Appendix 6).

3.5. Recruitment and Training

- 3.5.1. That apprentices be recruited and trained on two bases:
 - a) Those with matric who are potential supervisors, technicians, etc.
 - b) Those with lower academic achievements who have practical aptitudes and who are likely to remain operators, artisans or journeymen for a considerable time.
- 3.5.2. That the apprentice complement be maintained at a ratio of 1 to 2,5 artisans (establishment).
- 3.5.3. That recruitment and retention of skilled journeymen be intensified. A more attractive cash remuneration would assist. (See recommendations 3 and 4).
- 3.5.4.
 - i) That recruitment of ICI workshops artisans in the UK be carried out in order to alleviate the present shortage of artisans. (Maintain pension schemes, etc)
 - ii) That recruitment from the Mediterranean countries (Spain, Italy, Greece) be carried out, as people from these countries tend to stay a long time in South Africa.

4. FINDINGS

4.1. Management

- 4.1.1. The present workshops management lacks the drive and motivation to bring the workshops under control. Most of the reports issued during the last few years have not been acted upon effectively. Many of the problems specified in the M&IE report MMS/P/76/16 issued in 1976 are still existing.

This lack of drive at the top has permeated all the way down to the shop floor, with the result that there is a general feeling of apathy in the whole workshops. Investigations are carried out, but nothing ever changes. Systems designed to assist Management, are not adhered to and produce results which are meaningless. Consequently, the systems fall into disrepute and are blamed for all the problems.

- 4.1.2. If the figures of the Production Manager, No. 4 Ammonia Plant are to be believed (and there is no reason to doubt them), then out of a total of R484 000 worth of work, which could have been done by CWS, R380 000 (78,3%) was put out to outside firms. This is a serious indictment on the workshops ability to provide an adequate service to the plants.

The lack of clear objectives for the CWS, not only with regard to quantity, delivery, quality and cost, but also it's capacity in relation to total demand has aggravated this situation, but one would expect competent management to insist on these being established, in order to measure performance. Forward capacity planning is a management function.

- 4.1.3. A vacuum exists between the Workshops Manager and the Foremen. It is not considered practical for the Workshops Manager to supervise all the Foremen adequately and carry out his other management duties and responsibilities.

The management and technical abilities of some of the Foremen are suspect, but until such times as these abilities are tested under proper supervision, it is not possible to state categorically, who these Foremen are and how far they are capable of doing their job.

In order to improve the management structure, the position of Production Engineer should be introduced. When established, this could be used as a training position for a graduate Mechanical or Industrial Engineer, after the incumbent has been in the position for at least 2 years.

- 4.1.4. It is believed that the present Planning and Control Superintendent has an excellent grasp of the mechanics of CAPOSS, but lacks the managerial experience to act on the information which is available.

He also lacks disciplinary control over his staff, which results in a lack of clear objectives on the part of his staff and a degree of sloppiness in the execution of their duties.

It is recommended that an Industrial Engineer be appointed to this position, to provide the necessary managerial and systems expertise.

4.2. Organisation

- 4.2.1. The proposed organisation structure is shown in Appendix 2.

The main change is in the introduction of the positions of Production Engineer and Planning & Control Engineer.

Both the estimating and quality control sections should remain responsible to their respective departmental heads in order to retain impartiality. The proposed introduction of individual incentive bonus schemes makes this particularly important, especially in the case of the estimating section.

- 4.2.2. The proposed organisation for the Planning and Production Control section is shown in Appendix 5. The section is divided into 3 major units:

- i) Planning, Scheduling, Material Procurement
- ii) Progress and Control
- iii) Administrative Convenience

If, as we believe is desirable, the CWS is geared to handle a far greater proportion of the total Factory requirements, then all work should be channelled through the CWS and the decision as to whether the work is sub-contracted or not should be a workshops decision, based on capability, delivery and price. In this case, the section would need to be expanded to deal with subcontract work. The present Spares Co-ordinator would also naturally fall into this area.

In all cases, the prime objective is to provide the various areas of the factory with the service they require, including service out-of-hours, whether this be provided by the CWS facilities or sub-contractors.

- 4.2.3. One of the Workshops Manager's responsibilities is to ensure that all departments contributing to the successful functioning of the workshops, operate as a team with a common objective.

- 4.2.4. It is desirable that an Industrial Engineer be placed in CWS. He would be responsible to the Workshops Manager and have functional links with the Industrial Engineering Group. It is recommended that he be responsible for the Production Planning and Control Section. During the initial upgrading phase, it is recommended that this section be directly responsible to the Industrial Engineering Group. (See Appendix 3A).

- 4.2.5. A Personnel Officer is shown on the organisation structure chart. We believe that closer liaison with personnel will prove beneficial in the future, as the shortage of artisans worsens.

4.3. Key Objectives

This is a complex subject and the resulting objective(s) will depend, to some extent, on Company policy.

Results from the recent Key Objective questionnaire which was circulated to the various Plant Engineers, range from:

- a) Providing a 100% service to the Factory, to
- b) Leasing CWS premises to an outside firm.

The true objective lies somewhere in between, and will probably vary with circumstances, both internal and external.

Part of the in-depth study of the planning section will consist of establishing the key objectives of the workshops.

4.3.1. The assistance required by the plants from other sources falls into four broad categories:

- a) Extra services during shutdown (high peak load).
- b) Services from specialist outside companies, which are technically not available at the Factory.
- c) Services from within the Factory which are not available outside, and which, due to Company policy, are available only from the CWS (mainly jobs for explosives plants).

CWS provides a percentage of category (a). It also provides a service in respect of categories (c) and (d).

The total Factory requirement in respect of these services is not known, but there are indications from Ammonia 4, that it exceeds the present workshops capacity by 300%. Allowing even for the workshops inefficiencies, it is still probably 200% of capacity. If one considers each shop in isolation, it is probable that the situation in respect of machinery and fitting is considerably worse.

A demand versus capacity investigation is required to quantify the problem.

4.3.2. Assuming that demand exceeds capacity by 300%, then the CWS can accept only 25% of the total Factory demand, if delivery dates are to be met. Also, if incoming emergency work equals the workshops capacity, then no other work can be accepted.

4.3.3. Assuming that:

- a) The work load is restricted to the capacity of the CWS,
- b) delivery dates are being met,
- c) improved internal efficiency is resulting in greater cost competitiveness.

then the following questions arise:

"Should the CWS be expanded to cope with a greater proportion of the total work load?"

"What is the desirable balance between keeping the work inside the Company and maintaining a healthy infrastructure?"

4.3.4. It is misleading to take a "free enterprise" approach when evaluating the CWS against outside contractors. CWS management does not have entrepreneurial freedom that outside companies have.

- a) The overheads structure is outside the control of the workshops management and is probably much greater than many of the outside companies.
- b) The freedom to select only the profitable jobs does not exist.
- c) The personal profit motivation which exists in many outside companies does not apply.
- d) The freedom to manoeuvre on rates of pay does not exist.
- e) The freedom to fire unsatisfactory employees does not exist (leading to carrying of "passengers")
- f) The standard of quality expected from the workshops tends to be higher than that which is acceptable from outside contractors.
- g) CWS is subject to all the procedural policies of a large Company, e.g. buying procedures, safety, labour agreements, pay policies, training, accounting, etc which are usually short circuited or non-existent in outside companies. These blunt the competitive spirit and produce slower responses. Changes become difficult and slow.

4.3.5. The CWS is essentially a service to the whole Factory and it's effectiveness should be judged on the contribution it makes to the wider context of Factory efficiency rather than the narrow view of departmental efficiency, or of cost comparisons of isolated jobs.

4.3.6. At present, the CWS is not providing a satisfactory service. This is perceived by the customers as being primarily a problem of poor delivery, with quality and cost respectively, being relatively minor problems.

The primary cause of this problem is that the volume of work accepted by the workshops, in relation to the shop capacity at present efficiency levels, is unknown. This is as a result of an inefficient planning & control section and not having the planning system geared to give this data.

4.3.7. In the immediate future, the workshops should therefore:

- a) Improve delivery performance by limiting the volume of work accepted. (Emergency work receiving top priority, etc).
- b) Improve internal efficiencies to maximise the effective shop capacity with existing resources.
- c) Establish reports which will give an indication on demand versus capacity.

4.3.8. The Key Objective should be:

To provide an engineering service to the Factory by providing central manufacturing, repair and maintenance facilities to undertake emergency, ordinary and spares work to achieve:

- a) Quality
 - i) of service : delivery dates are met with 95% effectiveness
 - ii) of product : as specified
- b) Cost is at least 10% (average) less than outside contractors.
- c) Quantity of service to the Factory:
 - i) 100% for services which are not available from outside sources.
 - ii) X% by value of the routine services which can be provided (technically) either internally or externally.
 - iii) Y% by value of peak load requirements during shutdowns.

Note: (ii) and (iii) percentages to be established after investigating and quantifying total Factory demand and workshops capacity.

4.4. Production Planning and Control

4.4.1. It is suspected that:

There are fundamental faults in the introduction of CAPOSS as a planning system. These will be clarified in the implementation stage of the project.

Generally, system discipline in both the planning section and the shop floor, is extremely poor.

The management control facilities and information provided by the system are not being used, i.e. interpreted and acted upon.

The normal day-to-day problems encountered in the use of any system are not rectified and the same problems re-occur.

There seems to be a misunderstanding on the part of customers and the planning section, that CAPOSS is causing delayed delivery, when in fact, it is all the other problems mentioned which prevents the function from being controlled and effective.

4.4.2. Planning personnel need job specifications detailing their function and responsibilities.

4.4.3. There are 25 people in the planning section, of whom, 6 are there for administrative convenience. (PIMS Co-ordinator, handyman and 3 boys). This number is thought to be higher than necessary and it is considered advisable to investigate the possibility of reducing this number during the rectification of the application of the system.

Another feature of the personnel in this section, is the number who were posted for health reasons rather than suitability.

4.4.4. As stated before, this section should be fundamentally re-organised.

4.5. Estimating

4.5.1. The present situation in the estimating section is typical of a department which has been neglected over a number of years. The standard of estimating has dropped over the years, possibly as a result of the low status accorded to Productivity Services by the Company.

If, as recommended, an individual incentive bonus scheme is re-introduced, then the standard will have to improve if the Company is to retain control and obtain value for money. The selection and training of estimators must be of a high standard and their operating procedures and policies clearly defined and maintained. A "Refresher Course" for estimators is recommended.

4.5.2. In an incentive scheme context, it is important that the estimating section retains line authority with the Industrial Engineering Group rather than the operating department, so that the inevitable pressures to loosen standards can be resisted successfully.

- 4.5.3. In order to avoid delays between the receipt of an engineering works order into the workshops and entering that order into the planning system, it is recommended that a target maximum of 2 days be allowed for estimating normal jobs.
- 4.5.4. An attempt to measure estimator output should be made and standards applied. This has been successfully applied in other locations, normally in the form of "standard hours estimated per estimator hour". Different standards apply according to whether the work is a one-off job, repeat job, volume job, etc.
- 4.5.5. Estimator liaison with the shop floor and supervision should be improved. This will prove essential under incentive conditions, where speedy estimation of additional work, extra work and emergency jobs will be necessary.
- 4.5.6. Route cards require more details of the job method which the estimator assumed when preparing the time estimate. This will enable the artisan to see which method relates to the time allowed.

Much of the disrepute now attached to some of the estimated times arises because the artisans use different methods to those used by the estimator.

- 4.5.7. There is a considerable amount of work to be done by the Industrial Engineering Group to upgrade the estimating section.
- 4.5.8. The remuneration of estimators should be upgraded to such an extent that high quality personnel will be attracted. The total maintenance function is estimate driven. High standard estimates are of utmost importance for successful operation.

4.6. Labour Recruitment and Training

- 4.6.1. Labour turnover is particularly high in the machine and fitting shops, and there is great difficulty in recruiting replacements.

The allowed and actual machine shop establishment is as follows:

	<u>Allowed</u>	<u>Actual</u>
Skilled employees	24	18 (3 ex-apprentices)
Adult trainees	8	6
Contractors	-	2
Apprentices	<u>10</u>	<u>11</u>
	44	37

The recruitment problem also applies to Factory Made Spares (Isando Plant).

In the short term, the only real solution is to pay competitive rates of pay. The Factory Industrial Relations Officer carries out a periodic survey of the rates paid by outside companies, as a result of which, AECI rates are adjusted to match the upper quartile. It is recommended that the sample firms comprise those companies who are attracting our employees. These will tend to be smaller companies.

In view of the recession in the UK, a further possibility is the recruitment of ICI Workshops artisans who would retain pension rights and service benefits.

Another possibility is the recruitment of artisans from the Mediterranean countries such as Spain, Italy Greece etc, as these artisans are work-orientated and tend to stay longer in South Africa because of the better economic climate. Successful recruitment of these artisans would require basic changes to the Company housing and transportation schemes, as these people tend to live in Johannesburg, in flats rather than houses.

It is further recommended that a merit grading scheme be introduced to reward those with above average skills.

The present incentive scheme does not produce the desired motivation. It is a group scheme, calculated monthly and paid one month in arrears. The bonus earnings are low and not directly related to an individual effort. It is recommended that an individual incentive scheme be introduced which pays 33.1/3% of the basic rate for 100% operator performance. This should be calculated and published weekly and paid with the current months salary. The scheme would be straight proportional, to produce a strong incentive. The standard introductory procedures should be followed i.e. discussion with employees, documentation, agreements, learning periods etc.

It is important to recognise that cash remuneration is the most important factor of the pay package, in the present shortage of skilled labour situation.

4.6.2. In the long term, the solution to recruitment lies in training, both Black and White. This is expensive and wastage is high, but the larger companies have a responsibility which extends beyond the factory boundaries. It requires very special procedures and programmes for recruitment and training, but it is inevitable as a result of the economic development of this country.

The ratio of apprentices in training to artisan establishment should be around 1:2,5 (average). At the present time, the mix of trades being geared to turnover patterns.

Attractive wage rates will continue to be important in the long term.

4.6.3. Current apprenticeship selection and training is biased towards academic development. Whilst this type of apprentice is necessary, the main objective of an apprenticeship should be to produce an artisan who is skilled at and proud of his trade and who will remain at that trade for a long period. The training of apprentices who then go on to be draughtsman and estimators is not increasing the reservoir of skills available. There is a need for apprentices with practical aptitudes and lower academic abilities.

APPENDICES

1. EXTRACTS FROM PREVIOUS CWS INVESTIGATIONS
2. LIST OF PERTINENT INFORMATION/FINDINGS/RECOMMENDATIONS OVER
LAST 2 YEARS
3. PROPOSED ORGANISATION STRUCTURE OF PLANNING & CONTROL SECTION
 - 3A : Planning & Control Section responsible to
Manager Industrial Engineering
 - 3B : Planning & Control Section responsible to
Workshops Manager
4. KEY PERFORMANCE AREAS
5. PROPOSED ORGANISATION STRUCTURE OF PLANNING SECTION (FUNCTIONAL ONLY)
6. PROPOSED INDIVIDUAL INCENTIVE BONUS SCHEME FOR CWS ARTISANS

EXTRACTS FROM PREVIOUS CENTRAL WORKSHOPS INVESTIGATIONS

1. Report A by Maintenance and Industrial Engineering Department.
Undated:

Conclusion: "The only value a survey done by a consultant might have is the impartiality of his findings where they concern management."

2. Report B by Maintenance and Industrial Engineering Department.
Undated:

Para 3c. Motivation:

" The shop floor is not motivated and perhaps this lack of motivation extends further up the management structure."

Para 4a. Set standards:

" Standards of performance should be established from top management down."

Para 4d. Corrective Action:

" This aspect is adequately covered in the opening remarks on the absence of a formalised corrective action plan. Also there is a distinct lack of discipline in the areas of the operation where I have been involved. This last section can well be covered with an Incentive Bonus scheme as far as shop floor personnel is concerned. This is not a panacea because the need for control also exists at a higher level than shop floor. A new bonus scheme will thus perforce be frustrated should the other elements that are lacking not be corrected."

Recommendations:

" Some staff changes may be necessary in order to invigorate the situation."

3. Memorandum, Maintenance and Industrial Engineering Department, 26.03.1980.
(by B. Mills - the founder of the system)

Introduction, Para 2:

" The problems that exist cannot be isolated to the change in operating venues (of FMS) but to the manner in which the whole of the "CAPOSS" system is operated. Basically there are no fundamental differences in the problems to those that existed 9 months ago. The solution to them is people action, strong controls with good follow up procedures and a stable operating system."

Conclusion:

" Whatever system is employed to control the throughput of work, it is essential that the disciplines imposed by the system must be implemented and maintained at all times and not just paid lip service."

OTHER REFERENCES

1. PSD Project MMS/P/76/16:
"Interim report on investigation into Central Workshops Planning", 1976
by I. Krigel/L.L. Sella
2. Report A
"List of pertinent information/findings/recommendations over last 2
years" See Appendix 2.
3. Personnel Department:
"Report on bonus scheme in Central Machine Shop" by T.G. Jenkin 11.6.80
4. Memo
"Investigation into problems between Spares Production and Modderfontein
Workshop" by B. Mills 26.3.80

MAINTENANCE AND INDUSTRIAL
ENGINEERING DEPARTMENT

REPORT A

LIST OF PERTINENT INFORMATION/FINDINGS/RECOMMENDATIONS
OVER LAST 2 YEARS

DATE	REF	WHO	TO WHOM	INFO/FINDING/RECOMMENDATIONS
25/10/78	1	J.A. Newberry	Chief Eng.	a) Clean out and revamp estimate filing system. b) Microfilm estimates.
Feb. '79	3	A.H. Caldwell	?	a) New base rates for bonus scheme is required. b) Restructure schemes to utilise PIMS figures.
21/5/79	4	F.M. Jay	Chief Eng.	a) Review machine shop time standards. b) Resolve computer problems with bonus schemes. c) Recording of waiting time and UCW on plants to be re-organised. d) Utilise surplus journeyman on other work.
25/5/79	5	F.M. Jay	W.A. Logeman FTSM ACE(M) FWE SPE	a) Check time queried by HEKRO II BRUNSWICK (Ref. 3b). i) Times correct ii) Transcription errors b) Will issue method sheets if workshop management agrees.
1/6/79	6	H. Flein	Chief Eng.	PCI sheet identifying probable causes as i) Incorrect performance measurement ii) Low working rate iii) Use of incorrect methods iv) Unrecorded delays or waiting time v) Increase in quality standard
1/6/79	7	Meeting	FWE	a) Institute a proficiency increment.
20/6/79	8	F.M. Jay	FTSM	i) Modderfontein schemes are tight ii) This contributes to high turnover iii) Machineshop standards should be loosened iv) Cost of administering scheme is 12 man days per month instead of 4 because of poor system v) Computer Bureau has not resolved all the problems with the system

DATE	REF	WHO	TO WHOM	INFC/FINDING/RECOMMENDATIONS
1/10/79	9	F.M. Jay	Chief Eng.	i) Times are reasonable in general ii) Problem with times is not generally because of estimate problems but poor supervision iii) Observed unproductive time was more than 1½ hours per day after activity sampling. iv) A formal action plan needs to be drawn up.
27/2/80	10	H. Klein	F.M. Jay	a) Reasons for losses in bonus scheme <u>MACHINE SHOP</u> i) Waiting time not booked separate ii) Paid absenteeism booked as time taken iii) Poor performance iv) Extra work done and not claimed v) Jobs to be repeated (scrap) vi) Poor planning/grouping of jobs vii) High % idle time viii) Poor supervision - no experience ix) No motivation by supervision x) High overtime hours at low performance xi) High scrap costs <u>WELDERS</u> i) High waiting time ii) Complaint too high iii) Waiting time during week and overtime after hours iv) Supervision reluctant to use schemes v) High training time - coding
12/3/80	11	H. Klein	QCE	i) Meeting between QCE and some journeymen ii) Complaints about times and procedures iii) Estimators not represented
13/3/80	12	H. Klein	F. Jay	i) Journeymen book non-existing time ii) Matter reported to F&E iii) FWE discussed matter with leading hand and requested a correction iv) Leading hand did not correct matter but "did another fiddle".
6/5/80	13	Meeting	FWE, SPE QCE, J.J. Watkins	i) Times allowed are not booked leading to losses in bonus scheme ii) Waiting time is caused by non-availability of electricians. iii) No action was minuted to discuss this with electrical section iv) Times are not adequate

DATE	REF	WHO	TO WHOM	INFO/FINDING/RECOMMENDATIONS
26/3/80	14	B. Mills	I. Krige cc. MIEM ACE(M) FWE SPE J. Watkins	i) Shopfloor supervision do not have worklists ii) Lack of action on known problem jobs iii) Scrap/ rework system ineffective iv) Work is not inspected in sequence v) Problems with materials because of poor control in planning vi) Work performed out of sequence vii) Relationship problem
23/4/80	15	SPE	I.A. Krige FWE J. Watkins	i) Incoming orders not grouped ii) This causes inefficiency
11/6/80	16	G. Jenkin	CE ACE(M) FWE FTSM FPM	i) Times, relationships, structure pay rates, induction, paperwork estimate data system, supervision cause problems ii) Ignorance of procedures by journey men iii) Communication gap
30/6/80	17	FWE	ACE(M)	i) Most jobs are late ii) Farm more work outside iii) Reduce incoming work load
July '80	18	SPE	MIEM	i) Emergencies loaded on Isando cause late deliveries ii) Documentation, material jigs and jobs not tied up
July '80	19	IAK	-	1) Personal observation of worklists showed a distinct lack of working to the schedule. No. of times scheduled were fairly high in most cases.

CONCLUSIONS

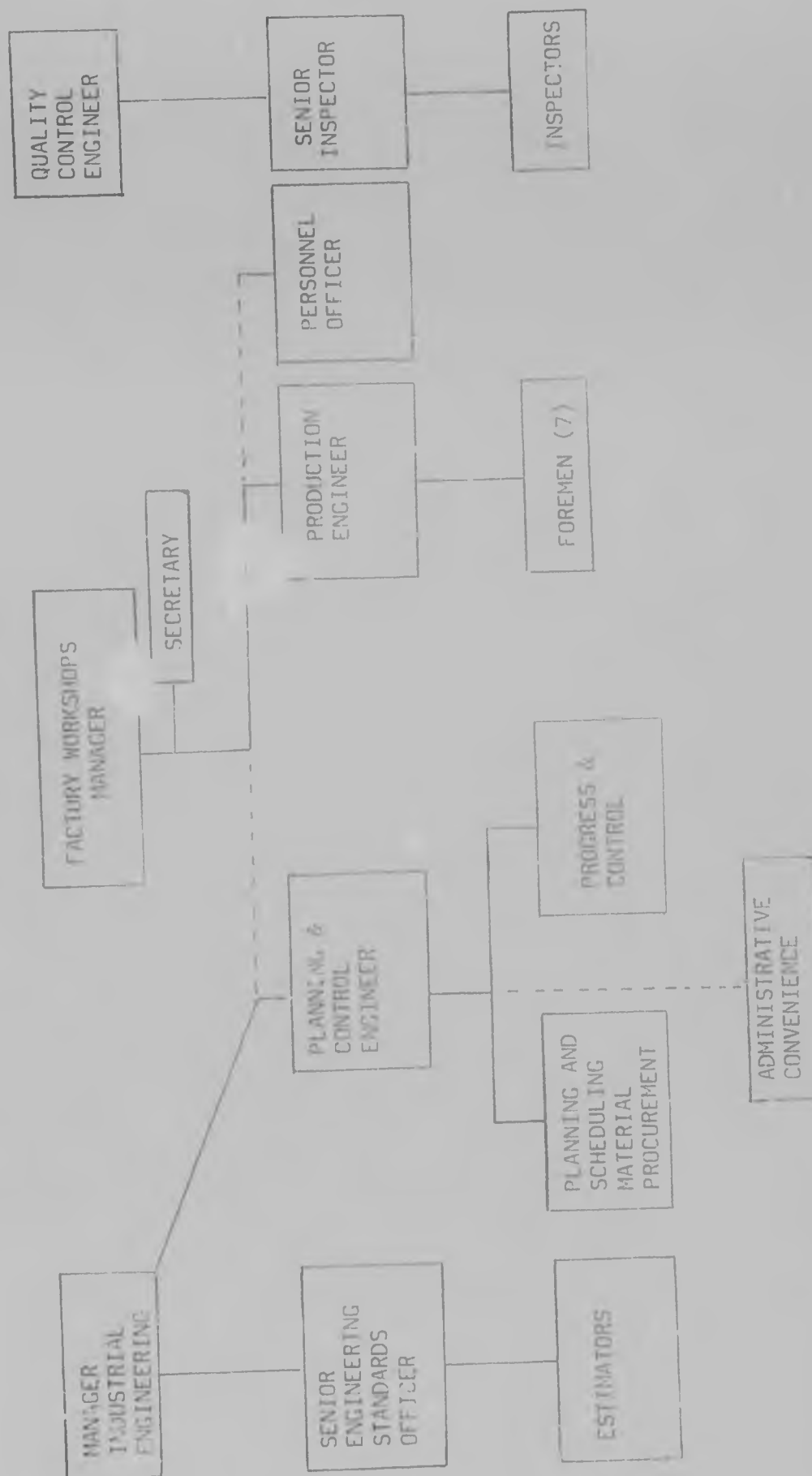
From the above it can be clearly seen that:-

- 1) A large number of problems have been identified during the last 2 years.
- 2) I have found no evidence of a formal concerted plan for corrective action.
- 3) With all the problems already identified and not solved a productivity survey by a consultant will not be of much benefit except for (4) below.
- 4) The only value a survey done by a consultant might have is the impartiality of his findings where they concern management.

RECOMMENDATIONS

- 1) That a committee chaired by the Chief Engineer and consisting of workshop management, Industrial Engineering and Industrial Relations be formed.
- 2) This committee should survey the existing data concerning problems in the workshops. The information still pertinent should be extracted and additional information gained where necessary.
- 3) A rational formal concerted plan to overcome the problem should be formulated. This plan should have specific objectives, spell out accountabilities and responsibilities clearly and have an action programme tied to a specified time scale.

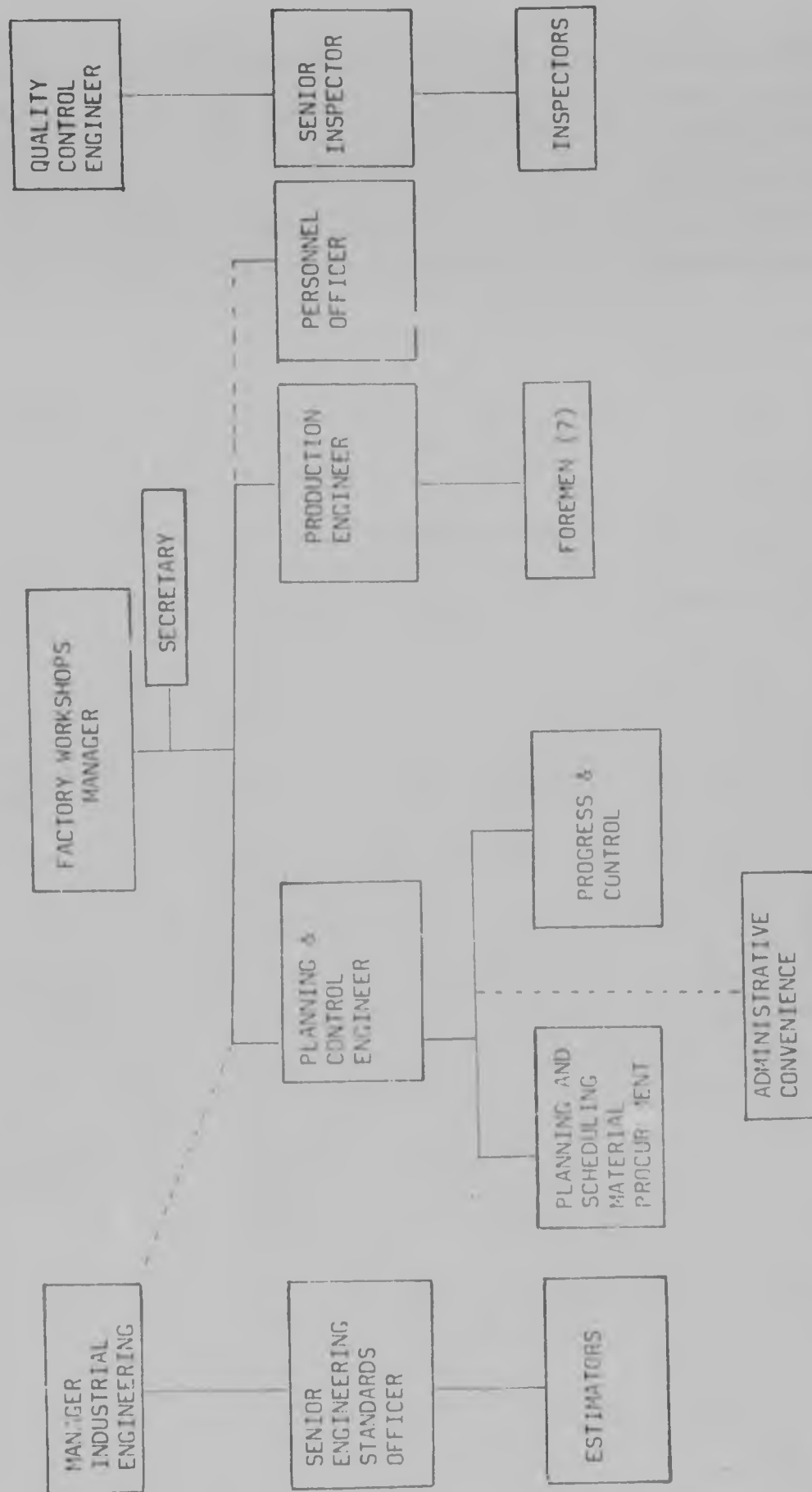
PROPOSED WORKSHOPS ORGANISATION STRUCTURE



PHASE 3

Planning & Control Section
responsible to Manager Industrial
Engineering.

PROPOSED WORKSHOP'S ORGANISATION STRUCTURE



PHASE 2

Planning & Control Section
responsible to Manager Factory
Workshops.

KEY PERFORMANCE AREAS

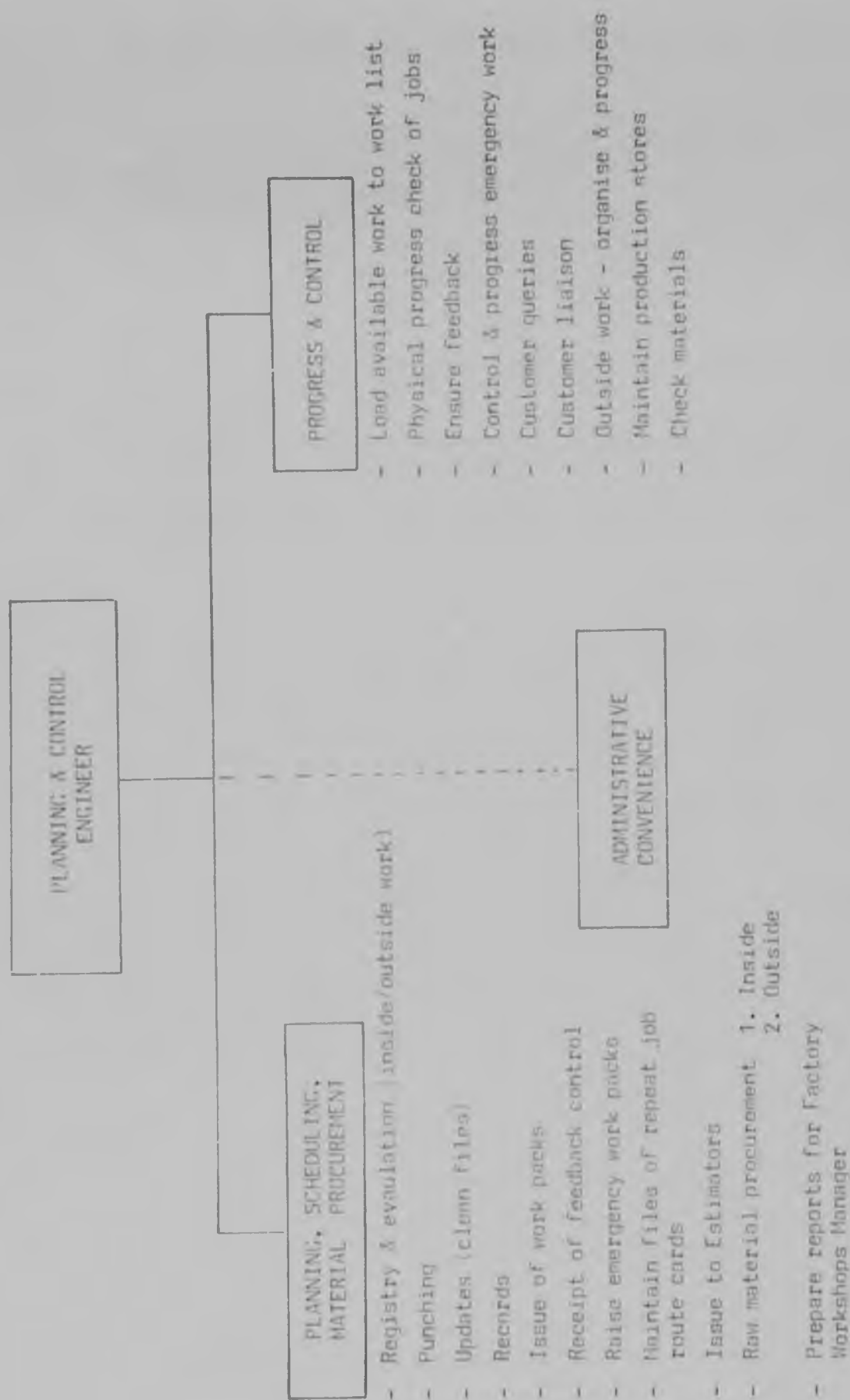
JOB	END RESULTS TO BE ACHIEVED	YARDSTICK
Leading Hand	1. The correct jobs are completed by the appropriate equipment & men in the section. 2. Correct quality. 3. Satisfactory time taken on each job. 4. Adequate manpower utilisation.	100% achievement of daily production programme and all emergency jobs issued by Planning to be started. Scrap rate < 5% for section. Operator performance : 100% Dept performance : 95% for section.
Foreman	1. The starting and completion of all emergency jobs received from Planning & Control. 2. Department production targets achieved each day. 3. Department manpower utilisation. 4. Average of operators output 5. Quality	- 0 % emergency jobs not started. - 95% emergency jobs completed within 24 hours. 100% achievement of department daily production programme. Dept programme: 95% for Dept Average O.P. : 100% for Dept Dept scrap rate < 5%
Production Engineer	1. Satisfactory delivery performance of the total workshops as planned. 2. Emergency jobs processed without delay. 3. Control production costs (directs) (to be defined more closely)	95% of ordinary jobs delivered within ± 3 days of due date (excluding emergencies) 95% emergency jobs completed within 48 hours < R X per Std. hour
Planning & Control Engineer	1. Convert customer requirements into practical, achievable daily production plans. 2. Control workshops input to the capacity available	- 0% jobs lost - < 5% jobs with CFD* in ± 5 days excess of FCFD** LSD load % not be exceed 130% in any work centre.
Factory Workshops Manager	1. Ensure that the resources are available to enable CWS to achieve the key objective. 2. Ensure that the key objective is achieved. 3. Ensure that within the constraints of (2), the workshops Total Resource Productivity is optimised. 4. Carry out corporate strategy: Evaluate trends, prepare forecasts, review key objectives, prepare plans, evaluate, implement.	

* CFD - Current Finish Date

** FCFD - First Calculated Finish Date

PROPOSED ORGANISATION STRUCTURE OF PLANNING SECTION

(Functional Only)



PROPOSED INDIVIDUAL INCENTIVE BONUS SCHEME FOR CWS ARTISANS

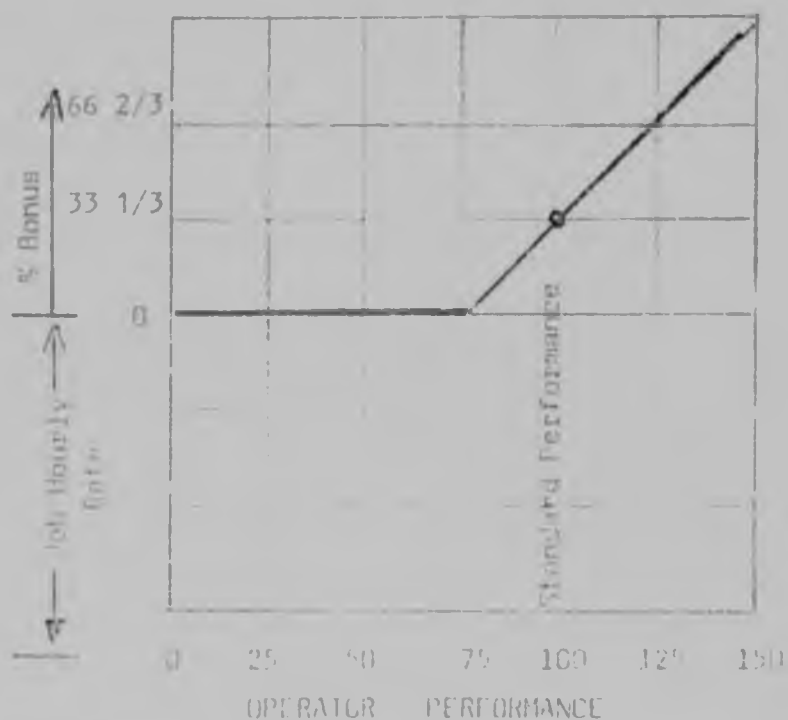
The scheme proposed for the CWS is the standard straight proportional scheme based upon operator performance. It would be an individual scheme.

$$\text{Operator Performance} = \frac{\text{Standard time for measured work}}{\text{Time taken (excluding diverted time and waiting time)}} \times 100$$

It is recommended that bonus calculations be based upon the Average Operator Performance for a week rather than on a job by job basis.

An average operator performance of 100 (i.e. Standard Performance) will result in bonus percentage of 33 1/3 % of the artisan hourly rate.

An average operator performance of 75 is the threshold performance and is 0 % bonus.



The main principle only is detailed here. A fully detailed set of conditions under which the scheme will operate will require to be drawn up.

JOB SHOP PRODUCTION PLANNING & CONTROL - CASE STUDY
(AECI Modderfontein - Central Workshops)

Part B

"CAPOSS" - Philosophy, Features, Areas of Application, Inputs,
Reports and Frequencies, Procedures and General Description

Part B

C O N T E N T S

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3. Route Card Input
4. Printed Output
5.
 - a. Input coding note for additions
 - b. Input coding note for cancellations and change
6. Processing Description
7. Programming System

PREFACE

This report is a 2nd in a sequence of reports for the MSc degree project of the author.

The report describes in brief the I.B.M. Capacity Planning Operation Sequencing System ("CAPOSS"), its main philosophy, its features and its functions.

It contains descriptions of; the areas of application, the Inputs and the reports produced.

The major part of this report is a summary based on my experience as a user of the system and as such I tried to give an overall picture from the view point of the system's suitability to a practical Production Planning and Control situation.

The theoretical part of this report has been extracted from the IBM Manual For Programme Product (GH 12-5105-1).

A. FRANCO

1. INTRODUCTION TO CAPOSS

In the past scheduling programmes were used mainly in manufacturing areas. Because of the new features, solutions are also available to the process industry including the mining basic metals, chemical and petroleum industries as well as the paper, rubber, ceramics, glass, textile and footwear industries whenever the production involves limited quantities for a definable order. This is in contrast to complete flow production.

In manufacturing, the lateness is very often detected too late to avoid delay therefore a much better solution is to control the complete flow of an order, beginning with the customer inquiry. Manufacturing itself then is a part of the overall production cycle and can be controlled using realistic end dates.

CAPOSS can be installed for the overall control of all projects within a company and then can be used in more detail to schedule the job shop, as well as all activities for a single project in a department e.g. design, or development of new products.

CAPOSS uses general principles and as such can be used for any kind of scheduling control.

CAPOSS can be used to determine the load profile for an order or typical product by scheduling all individual activities. This can serve as a model for overall planning.

As this type of programme can be used efficiently for make to order manufacturing the system was adopted as planning and control system for the Central Workshop of AECI Modderfontein.

By introducing this system the idea was to achieve the following advantages :-

- Quick reaction to changed requirements
- Production of a daily scheduling reflecting the actual conditions as reported by feedback from the shop floor
- Control over capacity requirements
- More realistic start and end dates for activities
- Furnishing of operation dispatch lists considering the interactions between all activities and orders
- Processing of a large amount of data which can't be treated manually with the same frequency.

The answer, if all these advantages have been achieved, and the reasons for not achieving, in the case of AECI Modderfontein Workshops will be given in Part C of this project.

2. PURPOSE AND OBJECTIVES OF SCHEDULING

2.1 General

The Major scheduling objectives of CAPOSS are to assist in :-

- (i) Meeting target dates
- (ii) Reducing the lead time of a project or order, which normally results in a reduction of the capital invested in work in process
- (iii) Keeping resources fully occupied
- (iv) Performing capacity requirements planning
- (v) Providing management with an up to date and realistic solution.

The above objectives have different priorities in different environments and the first four of them are conflicting objectives. CAPOSS attempts to find the best compromise between all extremes.

Schematically, objectives in scheduling are looked at as follows :-

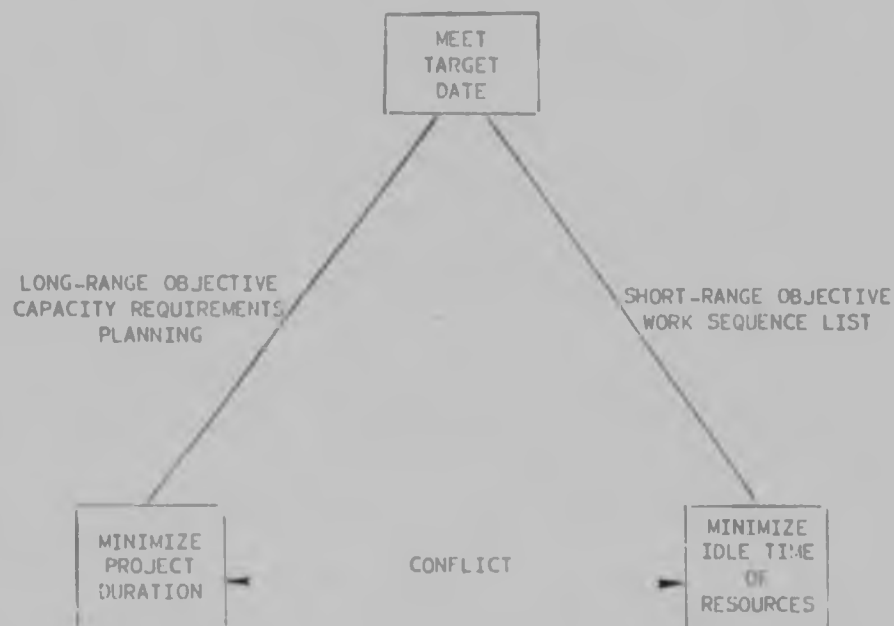


Figure 1 Objectives of Scheduling

A simplification of the above theoretical figure to the day to day management view of the Workshops is shown in figure 2.

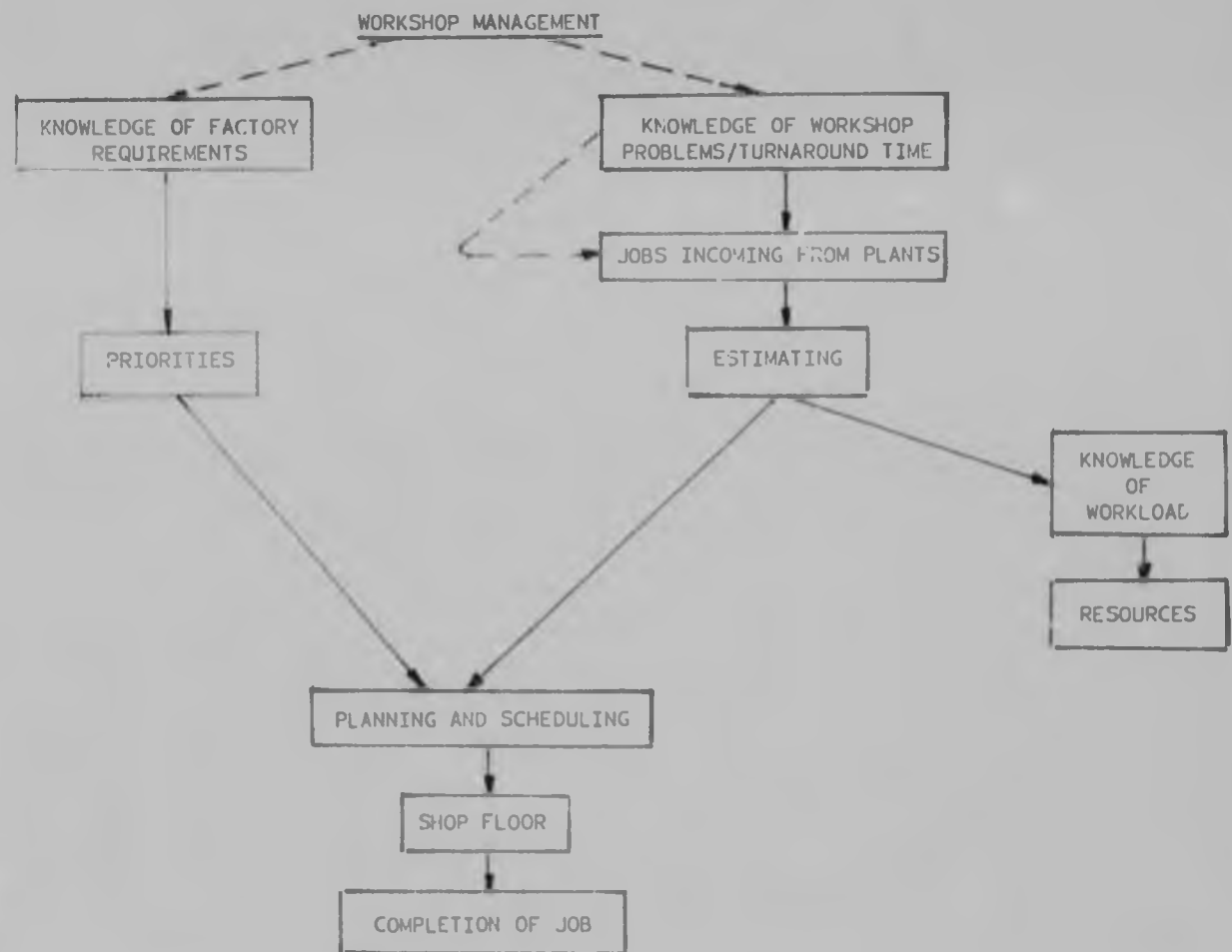


Figure 2 Day to day management view of workshop

2.2 Solution

The approach taken in the CAPOSS system to answer the above questions is to divide the problem into three areas and to apply different solutions to each. This allows the use of different levels of control which increase, with respect to individual orders, as the time approaches to execute or manufacture them.

CAPOSS contain the following types of scheduling :-

- Capacity requirements planning - (long range scheduling)
- Completion time estimating - (middle range scheduling)
- Operation sequencing - (short range scheduling)

These are illustrated in figure 3.

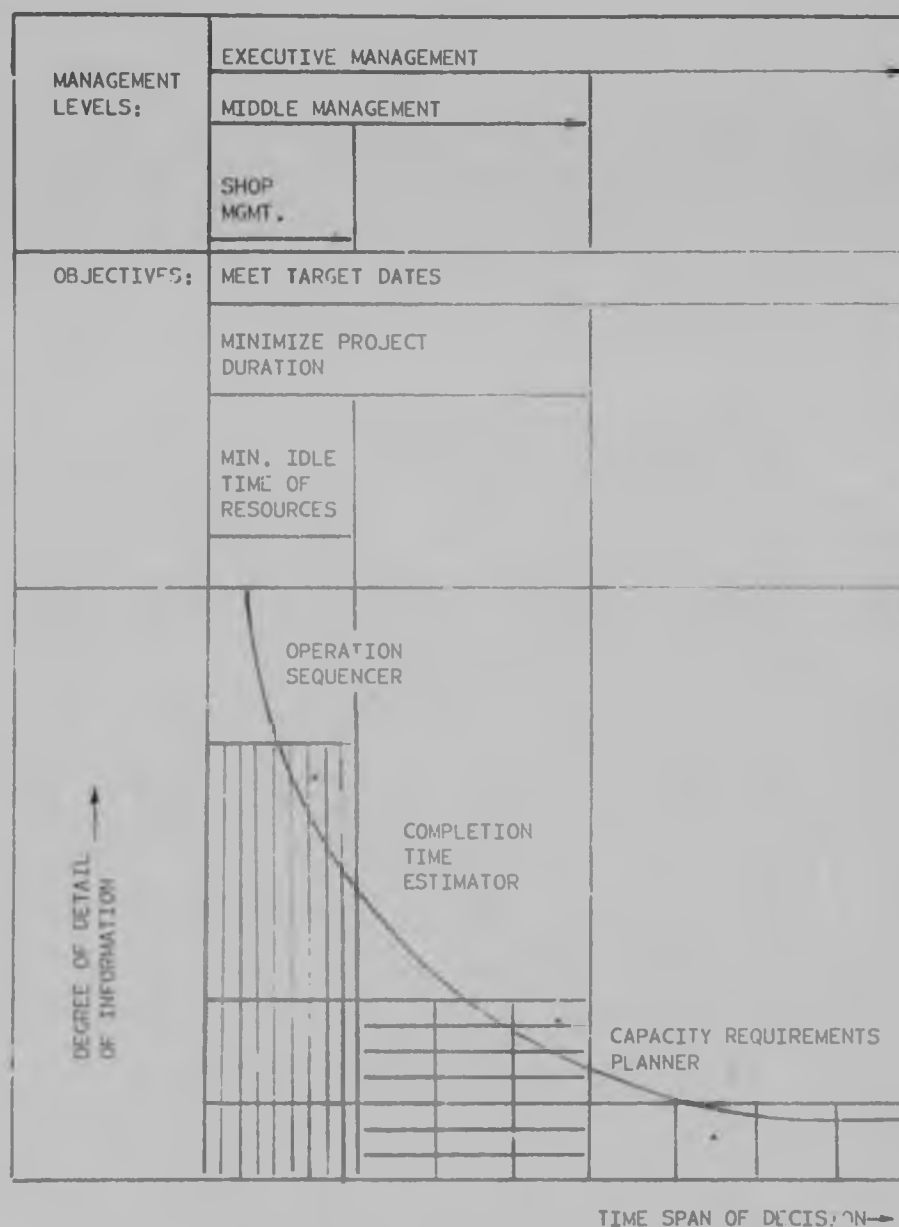


Figure 3 Information and scheduling

The 3 types of Scheduling produce the most important reports for control :-

- (i) Capacity requirements planning report
- (ii) Detailed output from operation sequencing and completion time estimating (Daily work list).

These reports are discussed in detail in item 7.1 - Printed Output.

3. PLANNING A JOB

3.1 General

In many jobs, multi-trade work is required. Jobs are hence split into the relevant parts, each requiring a different resource. Each part is given an estimated duration and the parts are put into the correct processing sequence.

In CAPOSS terminology: An order is made up of a sequence of operations, each requiring a certain duration at a specified work centre.

The order is given a priority and due date. If unable to start immediately it can be given an early begin date.

3.2 Scheduling techniques

The scheduling solutions for the 3 ranges of planning use different techniques and are designed to satisfy the different levels of accuracy required.

The types of loader are :-

- Bucket loader
- Horizontal loader
- Vertical loader

3.2.1 Bucket loader

The Bucket loader is used in the Capacity Requirements Planner and considers the capacities of a work centre. It assumes that all machines in the work centre are equal in performance and the work centre capacity is the total of the individual machine capacities.

The tasks of this type of loading are :-

- (i) To compute the expected earliest and latest start dates for each operation in the order file.
- (ii) To load operations to work centres in a given time.
- (iii) To level loads where possible.
- (iv) To plot out graph load for each work-centre.

The resulting load profile is normally very irregular as shown in figure 4.

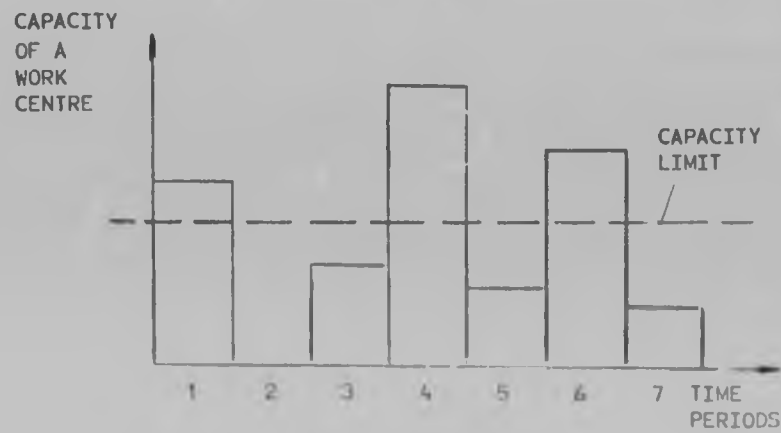


Figure 4 Capacity Requirements

The bucket loader smooths out the irregularities and produces a load that is consistent with the capacity available. This is known as load leveling (Task (iii)) and is shown in figure 5.

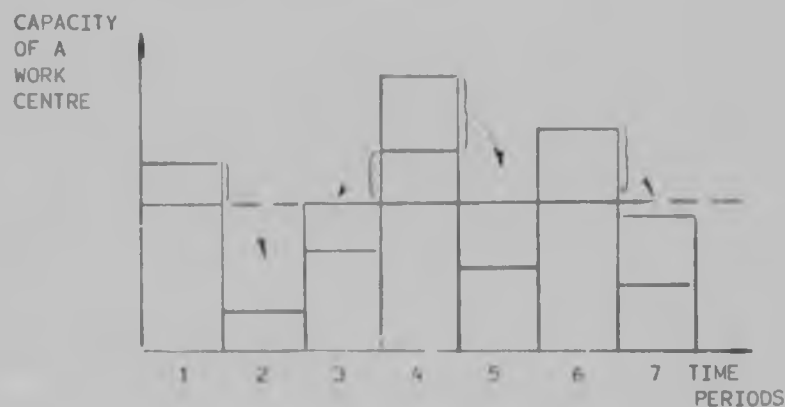


Figure 5 Load Leveling

The Graph (Task (iv)) shows capacity requirements for each work centre if every due date is to be met.

As mentioned earlier it is for use by Senior Management to decide on future machine/manpower levels required and/or contracting out.

It gives global view and does not consider individual order.

5.2.2 Horizontal loader

The horizontal loader considers each individual order and generally it does the following :-

- (i) Loads orders in priority sequence.
- (ii) Each order has its operations loaded in sequence to the appropriate work centre.
- (iii) The work is loaded to the daily capacity of the work centre.

By means of the α it shows the possible completion date of each order (with given capacities) if work is done in priority sequence - thus highlights jobs which are unlikely to be completed by due date and shows work centre loading/bottleneck.

The results produced by such a horizontal loader are sensibly accurate when considered over a medium time range and are for use by middle level Management to consider action to relieve the medium range problems i.e. certain orders should be contracted out.

3.2.2.1 Order Priority

The sequential priority of order is a function of 5 weighting elements (x_1, x_2, x_3, x_4, x_5) and Scheduling Status x_6 .

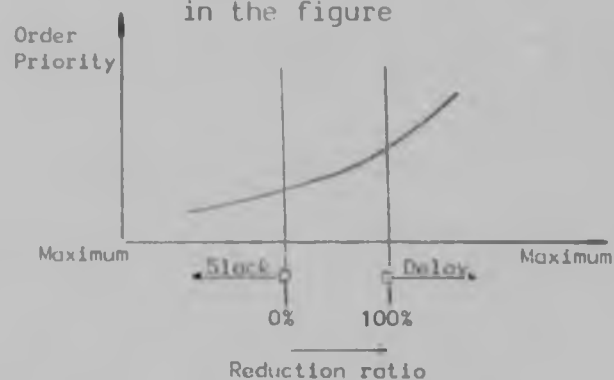
The Variables

$$\text{Order Priority} = y = x_1 + x_2 + x_3 + x_4 + x_5 + x_6$$

x_1 - Delay : The amount of time an order will be finished after due date = CURRENT FINISH DATE - First Calculated Finish Date.

x_2 - Slack : The amount of time between the earliest begin date and the start date of an order that still allows the order to be finished on time.

x_3 - Reduction ratio : The percentage between a slack of zero and a delay of zero as shown in the figure



x_4 - External Priority : From 1 to 9. Given by customer and translated internally to various weights.

x_5 - Capital cost : The greater the cost of the order, the greater the weight given.

x_6 - Scheduling status : Order already scheduled = 12
Order waiting on queue = 0

The present values of the variables are as follows :-

x1 - Delay		x2 - Stock		x3 - Reduction Ratio	x4 - Priority		x5 - Capital Cost	x6 - Schedule Status	
Days	x1=	Days	x2=	x3=30%**	Ext.	x4=		Start	Queue
0-5	1	0-20	Not		1	1	Not imple- mented*	12	0
5-10	2	20-30	imple-		2	1			
10-20	3	30-40	mented*		3	2			
20-40	4	40-50			4	3			
40-70	5	50-60			5	3			
70-110	6	60-70			6	12			
110-160	7	70-80			7	13			
160-220	8	80-90			8	13			
220+	9	90+			9	17			

- * - Recommended as not practical for use by the I.B.M. experts
 ** - Value recommended by the I.B.M. expert

3.2.2.2 Summary

In middle term planning, management has two tools to make its decision. The capacity requirements planning graphs highlight the capacity problems that can be expected to exist while the Completion Time Estimator phase shows which orders are affected. The two sets of results interact in as much as the capacity requirements are respected the delays resulting from the above will be reduced.

3.2.3 Vertical Loader

The above discussed scheduling techniques provide management with the information required for capacity planning. They do not provide the control function required by shop management to produce workable sequence of work for the shop to follow.

The purpose of a vertical loader is to analyse the results of the horizontal loader and produce a workable sequence of day to day work.

The main characteristics of the vertical loader are :-

- Considers each single machine in a work centre
- Considers all operations on their calculated operation priority (Not on the order priority)
- Loads highest priority operation to relevant work centre. Puts next operation into appropriate queue.
- Loads all work centres in this way on a time interval (say 1 hour) then loads for 2nd interval etc
- Takes into consideration similar work, etc, if specified.

The vertical loader gives shop floor Management the "best" work sequence for each machine today - considering capacity, jobs already started etc.

3.2.3.1 Operation Priority

Operation Priority is determined by means of a function consisting of 6 Variables which can be divided into 3 groups.

The function

OPERATION PRIORITY = R = /xx/yyy/z/

group 1 - xx

- If operation is in process xx : 99
- Partial Feedback > xx - 99
- Forced by user can give 90+ parameter
0 TO 9 xx = 90-99
- System gives 70 + ORDER
PRIORITY
- Successive operation xx = 60
- If delay > certain amount and it falls
into the future it gets 40 + ORDER
PRIORITY
- If nothing like this happens to the
operation it groups the operations to
3 groups : 30, 20, 10

group 2 - yyy

DUE DATE - LATEST START DATE + 800

group 3 - z

THE SHORTEST OPERATION DURATION

3.2.4 Summary

In the previous items I tried to explain the philosophy of priorities which the CAPOSS is based on through the application of the scheduling techniques.

Actually, the most important reports don't include the same data with regard to priorities.

The order file which gives the list of orders and operations as per schedule highlight only the external priority given by the customer.

The daily work list which is the operations sequencing of the vertical loader gives the order priority (Horizontal loader) and the first group (xx) of the operation priority (Vertical loader). An utmost important factor in the application of this philosophy is the control over inputs such as External Priorities, and Due Dates given by customers and the control over capacity requirement by management. This will be discussed in Part C of this project.

4. PREREQUISITES

4.1 Description of Data

Within the programme, each record must have a unique identity. This is achieved by the hierarchy of identification as shown in figure 6.

The complete identification sequence is the project number, order number, operation and alternate operation numbers.

The length and format of each number is specified by the user as they exist in his environment (Workshop's description of data - See Appendix 1).

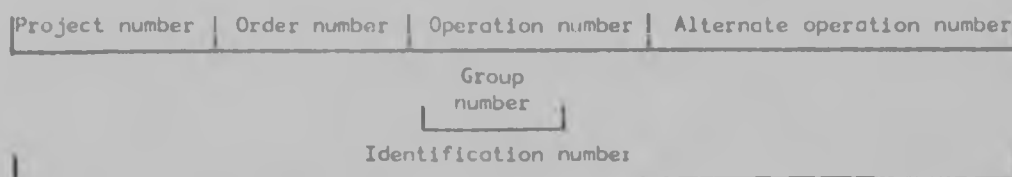


Figure 6 Identification number

In our particular case the identification number is as follows :-

4.1.1 Area

This number defined the plant or department from which the order is initiated.

4.1.2 Order Number

This number defines the customer order, a work order, a project, a network, etc.

4.1.3 CAPOSS Number

This number defined the sequential number of order in the planning system. All plant queries and correspondence about orders with planning is done through this identification number.

4.1.4 Group Number

Orders can be grouped together by defining the leftmost digits of the CAPOSS number as group number.

The group could be sub-assembly, an assembly, or any convenient group of orders. The group can be used to specify interrelationships of associated orders with other orders.

4.1.5 Operation number

This is the serial number of the routing operation, and unless specified by an alternate routing it defines the sequence of manufacturing.

4.1.6 Alternate Operation Number

This number identifies a substitute routing and can be one of the following :-

Single connection

Single connection forms a path between operation and primary operation as shown in figure 7. The primary operation is performed after completion of the secondary.

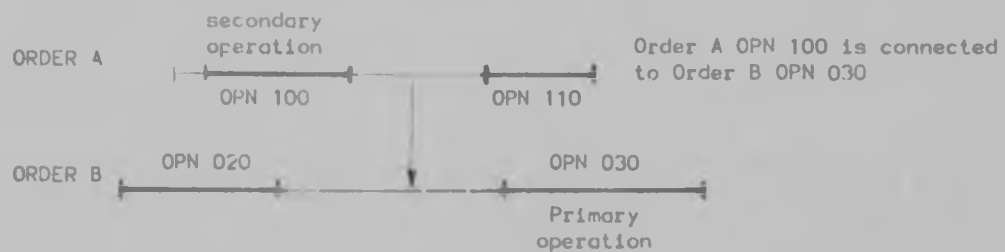


Figure 7 Single connection

Group connection

Group connections are a shortened method of defining a number of single connections from a common group of orders (i.e. common group number) to a single primary order.

A group connection can exist only from the last operation of each order in the group as shown in figure 8.

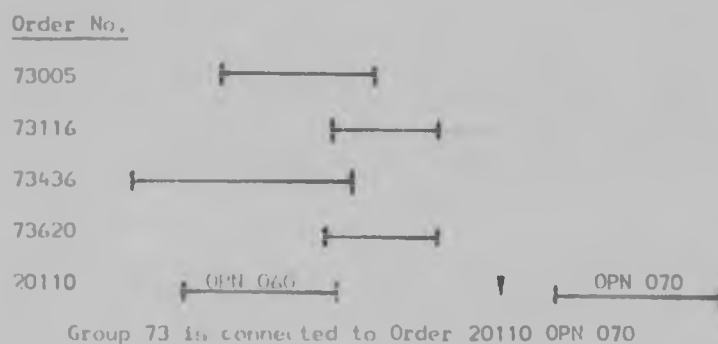


Figure 8 Group connection

4.2 Work centres

4.2.1 General description

Each operation or material requires a work centre. The work centre is described in sufficient detail to allow the determination of inter operation times, institute times and cost calculations. Capacity details are given, including shift starts, and number of shifts, to perform loading to finite capacity.

The description of Work centre may include : men or machines of equivalent performance, a single person or a machine, an assembly department, a storage area, an external supplier, etc.

A Work centre can be referred to as finite capacity if its capacity has physical limitations or as infinite capacity. an example for infinite capacity is "problem solver" work centre.

4.2.2 Sub-groups

Sometimes work can be done only on specific machines within a work centre because of different skill classifications, special fixtures, tolerance ranges, etc. In these cases work centres can be divided into "sub-groups" and loading will be done on sub-groups capable of doing the work.

4.2.3 Single machines

If applicable, different capacities and capacity changes can be specified for single machines.

4.2.4 Alternate Work centres

If a bottleneck occurs at a work centre and an alternate routing is not available the alternate work centres define possible substitutes for the prime work centre.

4.3 Shop Calendar

All date computations and specifications are made in working days. To achieve this and show the results effectively it is necessary to be able to reference each working day. The shop calendar which is used in Central Workshop's is shown in Appendix 2 of this report.

The calendar uses 4 digit numbers : The first digit shows the last digit of the calendar year. The remaining 3 digits are used for consecutive numbering of working days.

5. FEATURES OF CAPOSS

5.1 Operation splitting

Simultaneous processing of an operation on several machines may be required, the objective being to reduce the throughput time of the operation. This action is known as operation splitting.

The user can indicate which operations are to be split and can define his own limit to the maximum number of splits possible.

The different options for splitting operations can be specified :-

- Quantity to be split
- Run time is to be split
- More than one single machine is to be assigned to each piece.

5.2 Lot splitting

Sometimes it is necessary to split an order into 2 lots to achieve a fast throughput of a limited portion of the order. The remaining portion follows at normal speed. Lot splitting can be achieved during shop floor feed back.

5.3 Overlapping

It may be desired to process two consecutive operations in parallel with each other. This is the case when the run time is long and it is practical to start the succeeding operation before the preceding operation has completed the planned quantity. The result can be a considerable saving in throughput time. The conditions for overlapping are illustrated in figure 9.

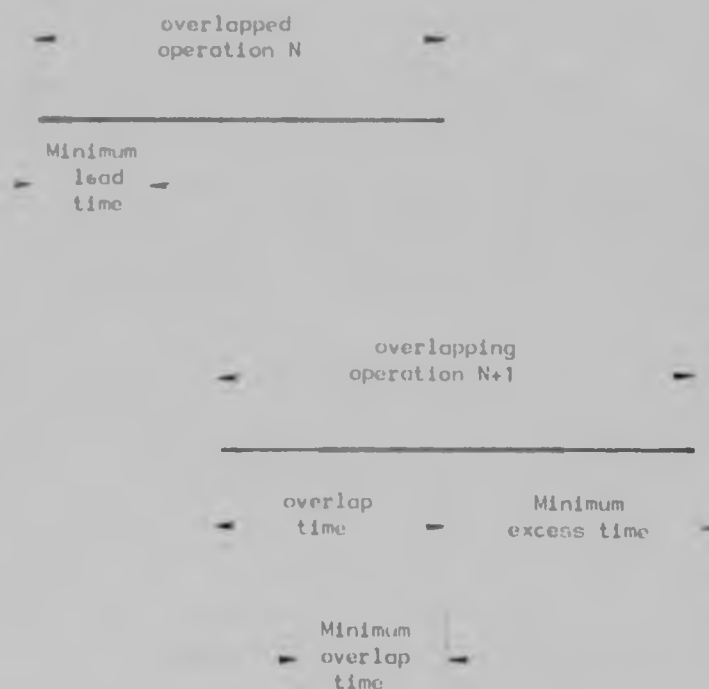


Figure 9 Conditions for overlapping

5.3 Overlapping to avoid delay

The user can ask for additional overlapping to be automatically applied. The overlap occurs where possible, between the operation in which the delay was detected and the following operation.

5.4 Related Facilities

A problem that often arises in the manufacturing is that more than one facility must be available at the same time to work together on a common operation. This may be men and machines or tools and machines.

Two different kinds of relationships within an order must be distinguished:

- i) **Forced parallel operation** : This relationship requires the facilities to be available at the start of the run time.

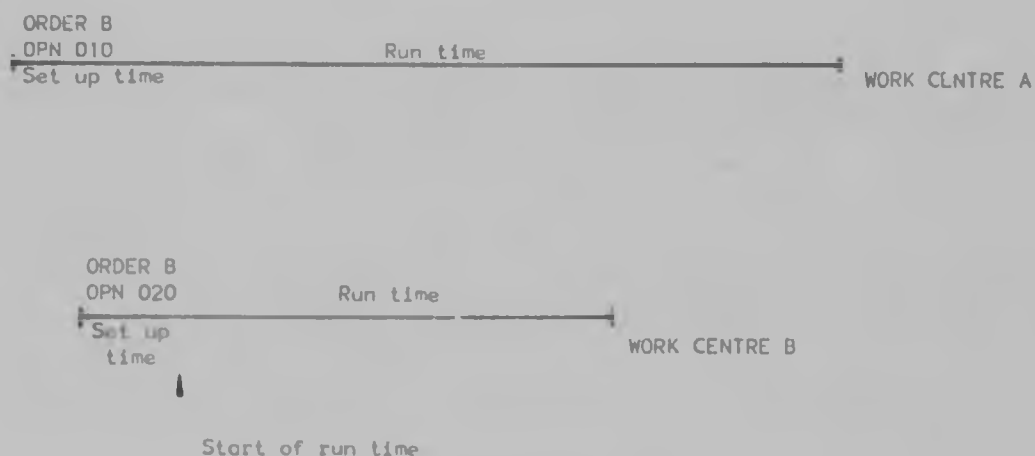


Figure 10 Forced Parallel operation

- ii) **Forced overlap** : Both facilities may have different run times, but the shorter run time must not exceed the range of the longer run time.

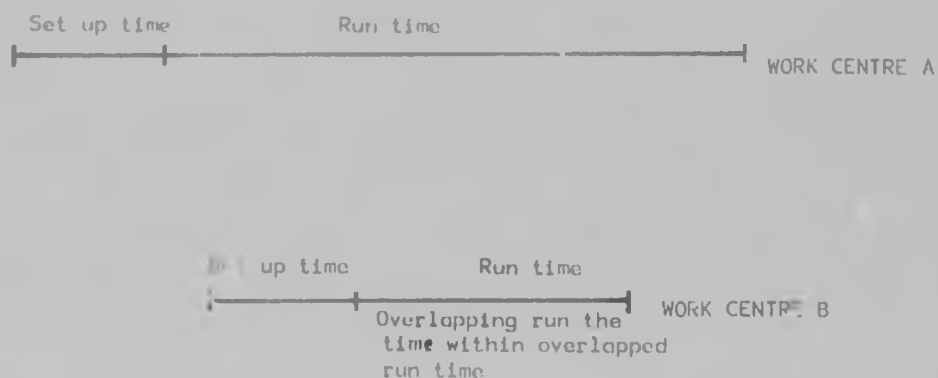


Figure 11 Forced overlap

5.5 Operation Grouping

Sometimes there is the need to group operations to take full advantage of their similarity.

The reasons for grouping are economic, technical or a combination of the two.

Grouping is achieved by CAPOSS regardless of which type of grouping the user requires.

5.6 Alternate Possibilities

A scheduling system must be capable of handling alternatives. Two possibilities are allowed.

- i) Substitution of an operation by an alternate operation or routing.
- ii) Off-loading of operations from a work centre onto an alternate work centre with capacity available.

5.7 Overtime

Decision on applying of overtime in case of overloading situations are furnished to the programme as permanent capacity changes or via the work centre file.

5.8 Statistics

The statistics information is computed from the scheduling data. All order data can be saved on a separate file and will be available to user programme.

The following three categories of statistics are maintained :-

- Statistics on times and quantities
- Statistics on costs and
- Statistics on number of operations.

5.9 Priorities and loading Procedures

As discussed on item 3.

5.10 Urgent orders and changes

The user can supply input data for new orders into the short range scheduling cycle.

In doing so he may want to make sure that the new order is available for processing immediately or to pull an order early which already exists in the long range scheduling.

Changes are accepted via shop floor feedback. They can include changes to the number of pieces of an order, new due dates, and insertion of operation in an order.

5.11 Pull early procedure

If there is a waiting time as a result of shortage of work, by means of pulling early operations are being done earlier and as a result better utilization of resources and elimination of waiting time accordingly is achieved.

5.12 Costing

Can be used for the order priority calculation. Cost factory is a function of : Materials, labour, overheads, Piosurcharges and cost method.

5.13 Materials

The programme considers materials availability on scheduling the operations and highlights delays due to the non-availability of materials to be prepared/procured from outside.

6. INPUT

6.1 User input

Order data furnished to the programme can be given by card, tape or disk.

At present, in AECI order data is given by cards.

The input is mostly derived from two sources :-

- i) Production control which specifies order quantities and required dates according to customer orders or forecast requirements.
- ii) Engineering control (Estimating) which maintains manufacture routing information.

Either or both of these areas are prepared as input on a ROUT CARD (ROUT CARD input See Appendix 3)

6.2 Main content of ROUT CARD

The data derived from the rout card is being punched into 4 main types of cards.

CARD	DATA		Originated by
	Use as it originated	Inserted by planning	
CW-52 ORDER CARD	Identification data Area code, order no, Caposs no, item code, description, initials and quantity	Due date, early be- gin date Caposs priority	Plants, other customers
CW-52 OPERATION CARD	Identification data Operation no, work centre, group code, description, quantity standard time, in- spection, PL Men, Assistant	Delay before opera- tion, alternate work centre	Estimating section
CW-42 MATERIALS REQUIRED	Identification data (DUP) Operation no, work centre no, stores code no, description status, quantity stores location	-	Estimating section
	If outside order	Purchase requisition no, delivery date, quantity, cost centre	Planning section
CW-72 OPERATION CONNECTION	Identification data (DUP) Operation no, primary area, primary work order no, primary Caposs no, primary operation no.	-	Estimating section

The input data of the rout card is being used to produce the following records :-

- Project record
- Group record
- Order record
- Material record
- Operation record
- Alternate operation record and
- Connection record.

Where the supplied data is not available, estimated values are used. By making use of these values a rapid implementation of the programme can be achieved and a complete schedule can be produced even though some values may not be known accurately.

6.3 Specification of work centres

The description of work centres is given in fixed format cards and stored on disk. The information required can be grouped into four types as follows :-

- i) Constant data for the work centre such as factors for computing inter-operation times, substitute times, cost, etc.
- ii) Alternate work centres for main work centre.
- iii) Details of single machines/men within the work centre; individed capacities, capacity changes and belonging to a sub-group within the work centre.

CAPOSS provides for the allocation of an operation to a particular single machine or sub-group. Thus, a work centre can be divided into a work centre sub-group, but this is not being used by Central Workshops.

6.4 Parameters

Parameters are stored more than once with different values. This allows the user to decide which variation of the parameters is required for a specific execution without having to refurnish the parameters that have changed since the last execution. An example would be a request for a full schedule report on a monthly basis but a report on exceptional items once a week.

7. SYSTEM OUT-PUT

The output of the scheduling system can be divided into two groups as follows :-

- i) Printed output, which includes all planning and scheduling reports for direct use by the departments involved.
- ii) Output files, some of which contain intermediate information or are part of the complete scheduling cycle and are permanent.

7.1 Printed Output

The printing of output data follows the same pattern as that for input. Data required for printing is set up in the fixed format output area.

All output reports can be written to the printer or on tape or disk where they are available for further processing. Appendix no. 4 is a file consisting of all possible printed output. In the following items detailed explanation on content is given only for the daily operation worker list report, capacity requirement report and the order file report as they represent all the data of the outputs.

7.1.1 Daily operation work list

Example of the report is shown in figure 12. The report is daily and consists of 3 parts :-

i) Work centre data

Period number	: consecutive days
Starting date	: The date referred to the period
Available capacity	: The net hours available at the stated period
Planned time	: As above (not used)
Set up times	: Where applicable
% Set up times	: To be reduced from the available capacity
Idle hours	: As a result of not having work available
% Idle hours	: Only for indication
Load chart	: Derived from the above values
W/C efficiency	: Average efficiency at the W/C
Capacity status	: FINITE/INFINITE
Shift length	: Number of working hours per shift
Operation grouping	: (Not used)
Schedule type	: Early start date/Latest start date
Balanced capacity key	: Leveling by scheduling
Maximum idle time	: Gaps in scheduling
Statistics	: Average waiting time of job in the W/C to be loaded under 4 groups of order priority.

ii) Operations list data

Urgent type	: Orders external priority
Area code	: }
Order number	: Identification numbers
CAPOSS number	: }
Operation number	: As per routing
Group	: Of operations
Description	: Of the operation
Quantity	: As required
Bin number	: The location of material for the operation in the binning room
Delay hours	: Delay before operation as stated on the rout card
Times scheduled	: The number of time operation appeared on the top of the list and has not been done for some reasons
Req/Load	: Automatic loading (Priority 9)
Stores purchase no	: Outside order
CSD	: Calculated starting date
Assistant	: Assistance from other work centre
From Work centre	: Previous work centre from where the job should come
From CFD	: The current finish date at the previous work centre
Inspection	: If required after completing the operation
To Work centre	: The next work centre to which the job should be moved
To CSD	: The current starting date of the next work centre
PLND Men	: Number of men required for the operation at the present work centre
Standard time	: The time required to complete the operation
Priority	: Order Priority/Operation Priority

iii) Work centre queue : Data

Operation waiting in the queue for the next 2 days.
The format data is of the same structure as of ii).

7.1.2 Capacity Requirement - Planning Report

The report is weekly and gives the long term loading situation for every work centre as stated before it is used by high level management.

The total period range can be pre-determined and divided into a number of sub-periods with various lengths. An example of the report is shown in figure 13.

The following data is given in this report :-

Period	: Sub-period number
Starting date	: Of the Sub-period
Available hours	: The available hours in the sub-period
ESD hours	: Production hours required for operation if scheduling is based on earliest starting date
LDS hours	: Production hours required for operation if scheduling is based on latest starting date
ALT hours	: Latest start date load in hours offloaded to or from this work centre when considering alternate work centre
LSD load	: Load graph based on latest start date with indication from 0% of loading to 200%
Surplus hours	: Surplus hours in the sub-period to be utilized if working only on 100% on overload situations
Extra	
Normal	: Waiting time as a result of unavailability of work
Unavoid overload	: Overload hours in the subperiods if all due dates are to be met (graph)
Period hours	: Overload hours in the subperiod assuming present capacity limits
Cumulative hours	: Cumulative overload hours assuming present capacity limits
Sequential overload	: Not used.

IHM CAPACITY PLANNING AND OPERATION SEQUENCING SYSTEM									
CAPACITY REQUIREMENTS PLANNING REPORT FOR WORK CENTER 504 N/C DRILL MACH									
VERSION 01 MCD 04. 55-2 KEY DATE 1083 21-04-81 PAGE 23									
CAPACITY REQUIREMENTS PLANNING REPORT FOR WORK CENTER 504 N/C DRILL MACH									
NUMBER OF SINGLE MACHINES 1 ALTERNATE MC LOG'S									
PER STRT PER AVAIL	DATE	LEN	MRS	FSD	LSD	ALT	0	100	200
1	1083	5	6	279	254	100	100	100	100
2	1088	5	60	59	67	100	100	100	100
3	1093	5	60	7	13	100	100	100	100
4	1098	5	60	-	5	100	100	100	100
5	1103	10	120	0	0	100	100	100	100
6	1113	10	120	0	0	100	100	100	100
7	1123	10	120	0	0	100	100	100	100
8	1133	10	120	0	0	100	100	100	100
9	1143	10	120	0	0	100	100	100	100
10	1153	10	120	0	0	100	100	100	100
TOTALS	AD	960	384	342	617	201	201	201	201
CAPACITY REQUIREMENTS PLANNING REPORT FOR WORK CENTER 504 N/C DRILL MACH									
NUMBER OF SINGLE MACHINES 3 ALTERNATE MC LOG'S									
PER STRT PER AVAIL	DATE	LEN	MRS	FSD	LSD	ALT	0	100	200
1	1083	5	150	344	272	100	100	100	100
2	1088	5	150	257	111	100	100	100	100
3	1093	5	150	194	65	100	100	100	100
4	1098	5	150	143	43	100	100	100	100
5	1103	10	300	265	142	100	100	100	100
6	1113	10	300	0	6	100	100	100	100
7	1123	10	300	0	2	100	100	100	100
8	1133	10	300	0	36	100	100	100	100
9	1143	10	300	24	138	100	100	100	100
10	1153	10	300	0	100	100	100	100	100
TOTALS	AD	2400	1236	865	1065	1137	72	72	72

Figure 13 Capacity requirement - planning report

7.1.3 Order File ("Bible")

This is a detailed working report which includes all the orders in the system and is given once a week.

As the system uses the same order file layout through all stages of the programme on common phase can print the order information at any stage in the programme.

The report could be summarised for different point selection such as for work centre, project or period. An example of the report is shown in figure 14.

The report gives the following data :

Area	:	
Order number	:	
Caposs number	:	As on the Daily operations
Operation number	:	work list
Group code	:	
Description	:	
Registration date	:	The date the order was registered in planning (before) punching
Early begin date	:	As stated on the input
Due date	:	The requested delivery date by customer
FCF date	:	First calculated delivery date by the programme
CSD*	:	Current starting date (by the vertical loader)
CFD*	:	Current finish date (by the vertical loader)
Quantity	:	As required
Work centre	:	To which operation should be done
Standard hours	:	Standard hours to do the operation
Delay hours	:	Hours in which operation shall be delayed
Assistant	:	Assistant from other work centre
Originator	:	The initials of the order originator in the plant.
Complete Operation	:	Number of operation completed already
Hour	:	Number of hours completed already
Late - *	:	Indicates the operation is late
Urgent type	:	Job which shall appear on the top of the list
Priority	:	The external order priority

* - Changes every run to give higher priority job incoming to the system.

7.1.4 Summary of reports, issue frequencies and users

As stated before appendix 4 file includes all the CAI/OSS reports used by central workshop.

The following table presents the list of reports included on this file, their frequency of issue and the users of them.

Frequency	No	Description	User							Remarks
			Management	Pl. off	RR. Sup.	Foremen	Progress	Mat. co.	Mat. prep.	
Daily	-	Master file (per request)	X		X	X				Exception report (W/C, project, customer)
	1	Daily operation work list				X	X			-
	2	Material preparations							X	Materials to be prepared 10 days before CSD
	3	Binning					X		X	Location of material per order
	4	Material deletion audit list							X	Feedback for materials preparation
	5	Order deletion audit list		X	X					Completed orders
	6	Deliveries			X					Completed orders accepted by plant
	7	Messages		X						Errors to be rectified
	8	Input audit list		X						Total input
	9	Periods and shop calendar	X	X	X					See appendix no. 2
Weekly	10	Order file		X						-
	11	Capacity requirements	X							-
	12	Plant report	X						X	List of plant orders and CFD'S
	13	Outside orders						X		Orders from outside in process
	14	Stores requisitions						X	X	List of materials to be applied
	15	Spares delivery dates and load times			X				X	Input for stores inventory system
	16	Work centre loading analysis	X							Hours loaded by various customers
	17	Orders and hours remaining by plant and priority	X							-
	18	Orders and hours loaded by plant and priority	X							-
	19	Order residence time	X							For identifying old jobs
Monthly	20	Turnaround time analysis (2 reports*)	X							Jobs turnaround time per priority
	21	Work centre capacity, queue time		X	X					Statistics
	22	Cost allocation	X	X						Computer costs

* - Reports based on DUE DATES and on FCED

7.2 Output files

7.2.1 Run data files

The run data files : Parameter file, Work Centre file and Capacity Event file are created from fixed format parameter and work centre input. They contain all phase parameters and work centre data. The parameter file must be on line for all.

7.2.2 Order file

The order file contains all data derived from the input and maintained with additions, changes, cancellations, total cancellations, completions, total completions and partial completions. This file contains all information required for a complete description of the project.

The structure of the order file is shown in figure 15.

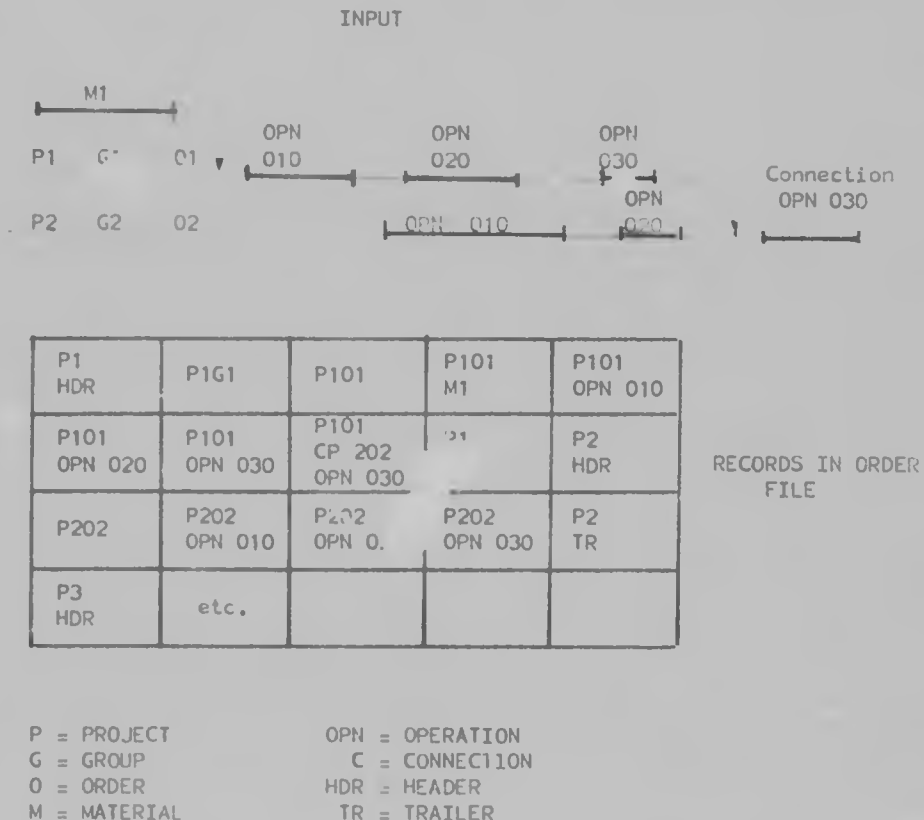


Figure 15 Layout of order file

The project trailer record is generated internally and contains statistical information for cost (if available), times and operations.

The order file is a sequential file and can therefore be stored on disk or tape. This allows the programme to process large volume order files on a machine configuration with limited storage units.

7.2.3 Subset Order File

The Subset Order File is created from the Order file using a data range. It serves as a basis for the short range scheduling (daily) where direct access processing is essential.

7.2.4 Data file

The Data file contains all input records. As unsorted Data is added to this file it must be stored before being input to the Order file creation phase.

7.2.5 Deletion file

This file includes all completion, partial completions, order deleted because of errors and the final information from the scheduling system including shop floor feedback and are then available for statistics or other purposes.

8. TRANSACTIONS AND FEEDBACK

8.1 Transactions

The system allows the existing order-dependent files to be updated to reflect the actual situation in the scheduling environment.

The following types of transactions are accepted :-

- addition
- partial completion
- cancellation
- total cancellation
- change
- completion
- total completion.

The transactions are given either by daily coding (Examples are given in Appendix 5 - Input coding note for addition, cancellation and change), or by a daily feedback card which will be described on the next item.

8.2 Feedback

8.2.1 Operations

Daily feedback on completion of operation is given by cards produced by the system as per routing. The cards are produced by the system as new order is entering to the Data file. In the rout cards the last 3 operations are always :-

<u>Operation</u>	<u>Description</u>
7777	Final inspection
8888	Plant accepted job
9999	Planning close job

Once operation 9999 is fed back, the system will close the job totally.

8.2.2 Actual Quantity completed

There is the option to use it, but as a result of practical reasons except where a scrap job is involved there is no need to work with it.

8.2.3 Actual time

The system can use actual time in order to give additional reports such as for bonus scheme, etc, but at present it is not used and the programme assumes planned time values when updating statistics of time completed.

However, where an actual quantity differs from the planned quantity the planned time will be adjusted.

8.2.4 Operation out of Sequence

Whenever operation is reported completed although the previous operations has not completed, the user can specify whether or not those previous operations are to be automatically considered as completed.

In Central Workshop's case we prefer operation to be completed one following the other for better control, but if we feedback operation 7777 - final inspection all previous operations are considered completed.

8.2.5 Partial completion

The founders of the programme found that it is impractical to report frequent partial completions for very long operations, thus, there are few possibilities to feed partial completion such as predetermined rate of production, zero quantities, etc. However, we found that partial completion is essential and does not require a large amount of daily coding, so we implemented it.

8.2.6 Capacity changes

Changes in capacity for a single machine, work centre and for the complete shop can be reported.

Obviously it is not recommended to do it frequently.

9. PROCESSING DESCRIPTION

- A copy of I.B.M.'s Manual (GH125105-1) - Processing Description is given in Appendix No. 6.
- A copy of I.B.M.'s Manual (GH125105-1) - Programming Systems is given in Appendix No. 7.

APPENDICES

1. Description of Data
2. Workshops CAPOSS Calendar
3. Rout Card Input
4. Printed Output
5.
 - a. Input coding note for addition
 - b. Input coding note for cancellation and change
6. Processing Description
7. Programming System

CW 32

ENGINEERING WORK ORDER

AREA		WORK ORDER No				CAPOSS NUMBER						PLANT ITEM CODE			
JOB TITLE															

Work Requested

DATA ON THIS PART GIVEN

By CUSTOMER

*CIRCLE WHICHEVER APPLICABLE				QUOTE (R)
Quote required*	YES	NO	Signature	
Quote accepted*	YES	NO	Signature	

PRI RITY	U	EARLY BEGIN Y D D D	DUE DATE Y D D D	FWD SCH	QUANTITY
☐	☐	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐	☐	☐ ☐ ☐ ☐

CENTRAL WORKSHOPS JOB CARD

COMMODITY OR DRAWING No		
Originator		Phone
Plant Section		Date Originated
Early Begin Date	Date required	Clearance reqd ?

PRIORITY

Production loss	☐	Planned shut-down	☐
Imminent red safety	☐	Imminent production loss	☐
Small job	☐	Planned	☐
Reason for priority			

Priority Authorisation

FOR WORKSHOP USE ONLY

CW 82 5 21 as above	Material						28
	Labour						35
	Overheads						42
	Prio surcharge						49
	TOTAL						56
	Cost Method*		1	2	3	4	5	57

DATA GIVEN BY PLANNING

CW 52	5-21 as above

OPERATION DETAILS

CARD OF
PAGE OF

OP. No.	WC No.	GP CD	BIN No	DESCRIPTION	SPEC. BY DATE	QTY.	STD. TIME	INSG P.L. Man W/C W/C ASPHALT Gravel Before OP	ESTIMATE NUMBER	INSP INT.
DATA GIVEN BY ESTIMATING										
7777				FINAL INSPECTION						
8888	P98			PLANT ACCEPT JOB						
9999	P99			PLANNING CLOSE JOB						

CHECK NUMBER OF EMPLOYEE WHO IS TO DO THE JOB:

MATERIAL REQUIREMENTS

CW 42

AREA WORK ORDER No CAPOSS NUMBER

OP No	WC No	BRISCH CODE	DESCRIPTION	STATUS	STORES PURCHASE REQ. No	DEL DATE	QTY	CCST CENTRE	Alloc No	Line No
			DATA GIVEN BY							
			ESTIMATING							

OPERATION CONNECTIONS

CARD CODE	AREA	WORK ORDER No	CAPOSS NUMBER	OP No	Primary Area	PRIMARY WORK ORDER No	PRIMARY CAPOSS NUMBER	PRIMARY OP No
CW 7 2								
CW 7 2								
CW 7 2								

QUALITY RECORD

QUALITY CONTROL ENGINEERING

OP	WC	M/C	OPER	FIRST OFF INSPECTION				PATROL INSPECTION							QTY MOVEMENT			
				ACC	REJ	SIGN	DATE	PERIOD	1st	2nd	3rd	4th	5th	6th	ORDER	PASSED	SIGND	

REJECTION INFORMATION

OP No	TIME	DATE	CAUSE OF REJECTION	CORRECTIVE ACTION	NUMBER REJECTS	REJECTION REWORK	REWORK INSPECTION		
							ACC	REJ	SIGND

"First off MUST be approved by Quality Control before starting production."

AECI/M/ENG/L223b-7807

CENTRAL WORKSHOPS SHOP CALENDAR

CAPOSS SHOP CALENDAR 1981

DAY	JAN		FEB		MARCH		APRIL		MAY		JUNE		JULY		AUG		SEPT		OCT		NOV		DEC	
	D	A	D	SHOP	D	SHOP	D	SHOP	D	SHOP	D	SHOP	D	SHOP	D	SHOP	D	SHOP	D	SHOP	D	SHOP	D	SHOP
M			2	1022	2	1042					1	PH			3	1148			2	1212				
T			3	23	3	42					2	1104			4	149	1	1189		3	213	1	1233	
W			4	24	4	44	1	1064			3	105	1	1125	5	150	2	170		4	214	2	234	
T	1	PH	5	25	5	45	2	65			4	108	2	126	6	151	3	171	1	1100	5	215	3	235
F	2	1001	6	26	6	46	3	66	1	1084	5	107	3	127	7	152	4	172	2	191	6	216	4	236
M	8	1002	9	1027	8	1047	6	1067	4	1085	8	1108	6	1128	10	1153	7	PH	5	1192	8	1217	7	1237
T	9	03	10	28	10	48	7	68	5	84	9	109	7	129	11	154	8	1173	9	193	9	218	8	238
W	7	04	11	29	11	49	8	69	6	87	10	110	8	130	12	155	9	174	7	194	11	219	9	239
T	8	05	12	30	12	50	9	70	7	88	11	111	9	131	13	156	10	175	8	195	12	220	10	240
F	9	06	13	31	13	51	10	71	8	89	12	112	10	132	14	157	11	176	9	196	13	221	11	241
M	12	1007	16	1032	16	1052	13	1072	11	1090	13	1113	13	1133	17	1158	14	1177	12	1197	16	1222	14	1242
T	13	08	17	33	17	53	14	73	12	91	16	114	14	134	18	159	15	178	13	198	17	223	15	243
W	14	09	18	34	18	54	15	74	13	92	17	115	15	135	19	160	16	179	14	199	18	224	16	PH
T	15	10	19	35	19	55	16	75	14	93	18	116	16	136	20	161	17	180	15	200	19	225	17	244
F	16	11	20	36	20	56	17	PH	15	94	19	117	17	137	21	162	18	181	16	201	20	226	18	245
M	19	1012	21	1017	23	1057	20	PH	18	1095	22	1118	20	1138	24	1163	21	1182	19	1202	23	1221	21	1246
T	20	13	24	38	24	58	21	1076	19	95	23	119	21	139	25	164	22	183	20	203	24	228	22	247
W	21	14	25	39	25	59	22	77	20	97	24	120	22	140	26	165	23	184	21	204	25	229	23	248
T	22	15	26	40	26	60	23	78	21	98	25	121	23	141	27	166	24	185	22	205	26	230	24	249
F	23	16	27	41	27	61	24	79	22	99	26	122	24	142	28	167	25	186	23	206	27	231	25	PH
M	26	1017			30	1082	27	1080	25	1100	29	1123	27	1143	31	1168	28	1187	26	1207	30	1232	28	1250
T	27	18			31	63	28	81	26	101	30	124	28	144			29	188	27	208			29	251
W	28	19					29	82	27	102			29	145			30	189	28	209			30	252
T	29	20					30	83	28	PH			30	146					29	210			31	253
F	30	21						PH	103				31	147						211				

REC/M ENG/L 84 8007

CAPOSS SHOP CALENDAR 1982

DAY	JAN		FEB		MARCH		APRIL		MAY		JUNE		JULY		AUG		SEPT		OCT		NOV		DEC	
	D	A	D	SHOP	D	SHOP	D	SHOP	D	SHOP	D	SHOP	D	SHOP	D	SHOP	D	SHOP	D	SHOP	D	SHOP	D	SHOP
M																								
T																								
W																								
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F																								

REC/M ENG/L 84 8007

CW 32 EI 1744969 IRK ORDER 9Y *ADP* SINGER & GAIT
 Forward ordinator immediately MDF - NITROGEN ARD
 Area 02 H 6364 A 1231.06.5.41 16 WMSV 03-22369/145
 Drawing No
 WORK REQUESTED TITLE
 FIT MODIFIED ADG LITATOR SWAF
 21/SHOP TO MAKE UP
 Originator's Initials
 G. Richter
 Plant Section 17/4.1.4
 Date Original 27.11.81
 Date Requested 20-11-81
 YES
 Work Requested
 FIT MODIFIED ADG LITATOR SWAF
 AS PER DRAWING
 MAKE UP & REPAIR AS PER ATTACHED DRAWINGS
 DWS. NO 03-22369 1-7 EXCEPT 7
 CAPOSS PRIORITY (Tick one box)
 IMMEDIATE ACTION ☒
 URGENT REQUIREMENT ☐
 PLANNED SHUTDOWN ☐
 NORMAL WORK ☐
 S.F.'s Signature *[Signature]*

*CIRCLE WHICHEVER APPLICABLE:
 Quote required* YES NO Signature
 Quote accepted* YES NO Signature

FOR WORKSHOP USE ONLY

CW 82	Materials	28
	Labour	35
521	Overheads	42
as above	Prior surcharge	49
	TOTAL	56
	Cost Method	1 2 3 4 5 57

PRIORITY U
 EARLY BEGIN Y D D D
 DUE DATE Y D D D
 FWO SCH
 QUANTITY

CW 52 5-21 as above OPERATION DETAILS CARD 1 OF 5 PAGE OF

OP No.	WC GP No. CD	BIN No.	DESCRIPTION	SPEC BY DATE	QTY	STD TIME	ESTIMATE NUMBER	INT IN
080402			CUT 12.5 S/E 1/4" DIA	J. DR	1			
			CUT 2.54 TH S/E 1/4" DIA		1			
040402			M/K BEARING CAP AS PAR DRG PT 1		1	16	0352	
050402			M/K SINGER SEAL TO DRG PT 5		1	13	0705	
060402			M/K & GAIT BEARING CAP TO DRG PT 1		1	06	24995	
7777	108		FINAL INSPECTION	RETAIN	1	01		
8888	P98		PLAN: ACCEPT JOB					
9999	P99		PLANNING CLOSE JOB					

CHECK NUMBER OF EMPLOYEE WHO IS TO DO THE JOB:

MATERIAL REQUIREMENTS

CW42

10

147597

125125501

OP. No.	WC No.	DESCRIPTION		STATUS	STORES PURCHASE REQ. No.		DEL. DATE	QTY.	COST CENTRE	CAPOSS NUMBER	
		BRISCH CODE									
014		12541512	304 5/5 PLY 122x122 J6					1			
024		12541512	304 5/5 PLY 230x230 J6					1			

OPERATION CONNECTIONS

CARD CODE	AREA	WORK ORDER No.	CAPOSS NUMBER	OP. No.	PRIMARY WORK ORDER No.	PRIMARY CAPOSS NUMBER	REWORK OP. No.
CW72	02	1463814	125125501	7777	1463814	125125500	0060
CW72							
CW72							

QUALITY RECORD

QUALITY CONTROL ENGINEERING

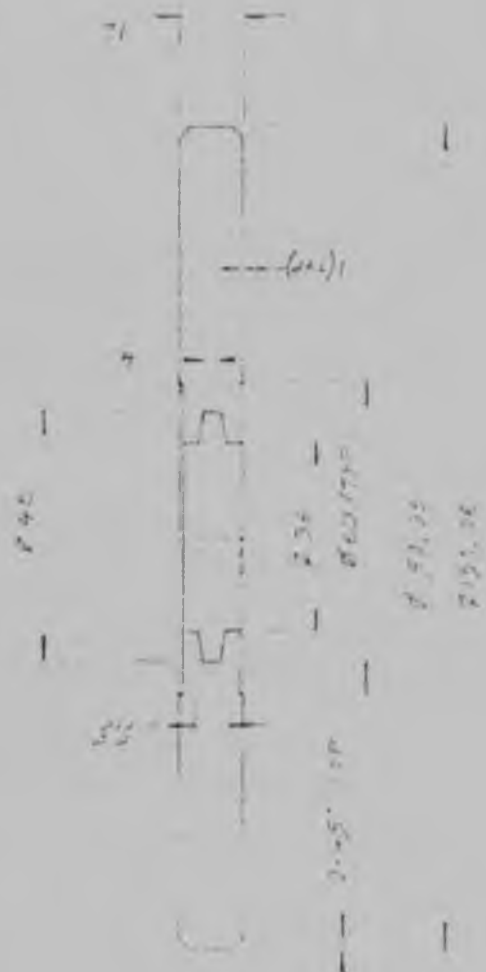
OP	WC	M/C	DREN	FIRST OFF INSPECTION				PATROL INSPECTION								QTY. MOVEMENT		
				ACC	REJ	SIGN	DATE	PERIOD	1st	2nd	3rd	4th	5th	6th	ORDER	PASSED	BY	
													</					

REJECTION INFORMATION

OP No.	TIME	DATE	CAUSE OF REJECTION	CORRECTIVE ACTION	NUMBER REJECTS	REJECTION REWORK	REWORK INSPECTION		
							ACC	REJ	SIG

RECIM ENR. L273b

"First off MUST be approved by Quality Control before starting production"



STATL B-1449 38304
112541542

32/ ALL OVER

1 OFF SKF FELT SEAL
Nº FIND

NAME, OFF

123106501

$$100\% - 10\% = 90\%$$
[illegible]

CW 32

ENGINEERING WORK ORDER

CENTRAL WORKSHOPS JOB CARD

AREA	WORK ORDER No	CAPOSS NUMBER	PLANT ITEM CODE

COMMODITY OR DRAWING No

2-B 1457/10

JOB TITLE
62241-011 P.E.T.N. PRIMING

Originator's Initials

M/C

Work Requested

POWDER CONTAINER HOLDER

Originator	Phone
Plant Section:	Date Originated
Early Begin Date	Date required
Clearance reqd.	

PRIORITY	Red safety hazard
Production loss	Planned shut-down
Imminent red safety	Imminent production loss
Small job	Planned
Reason for priority	
Priority Authorisation	

*CIRCLE WHICHEVER APPLICABLE

QUOTE (R)

Quote required* YES NO Signature

Quote accepted* YES NO Signature

PRIORITY	U	EARLY BEGIN	DUE DATE	FWD SCH	QUANTITY
		Y D D D	Y D D D		/

FOR WORKSHOP USE ONLY

CW 82	Material					28
	Labour					35
	Overheads					42
	P surcharge					49
	TOTAL					56
	Cost Method*	1	2	3	4	5

CW 52

5-21
as above

OPERATION DETAILS

CARD 3 OF 74
PAGE OF

OP. No.	WC No.	GP CD	BIN No.	DESCRIPTION	SPEC. BY DATE	QTY.	STD. TIME	PL Man	Alt. W/C	Asst	Delay Before Op	ESTIMATE NUMBER
				10mm DIA EN58E x 570 LONG		1	0.2					
				M/C RODS TO DRG & POLISH 2 OFF EACH.		4	0.4					32194
				MARK & CUT PLATE TO DRG.		1	0.6					18912 18912/1
				FILE & DRESS PLATE TO DRG MARK & DRILL SET PLATE & RODS FOR WELDING.		1	1.7					18912/2 18912/3
				WELD PLATE & RODS TO DRG.		1	0.4					13000/1
				CONSTRUCT HOLDER AS PER DRG LEVEL PLATE, DRESS WELD, FILE RADI POLISH COMPLETE. MARK, DRILL & C'S'K VERTICAL PLATE.		1	1.3					18915
				FINAL INSPECTION		1	1					
				PLANT ACCEPT JOB								
				PLANNING CLOSE JOB								

CHECK NUMBER OF EMPLOYEE WHO IS TO DO THE JOB:

AECI/M/ENG/L223a

MATERIAL REQUIREMENTS

CW 42

AREA WORK ORDER No. CAPOSS NUMBER

OP. No.	WC No.	BRISCH CODE	DESCRIPTION	STATUS	STORES/ PURCHASE REQ. No.	DEL. DATE	QTY.	COST CENTRE	Alloc. No.	Line No.
22	25 26	28 29	30 31	32 33	34 35	36 37	38 39	40 41	42 43	44 45
101	102	112	342	16	16mm DIA x 600 L					
103	102	112	541	16	43mm TH x 130 x 250					

OPERATION CONNECTIONS

CARD CODE	AREA	WORK ORDER No.	CAPOSS NUMBER	OP. No.	Primary Area	PRIMARY WORK ORDER No.	PRIMARY CAPOSS NUMBER	PRIMARY OP No.
CW 7 2								
CW 7 2								
CW 7 2								

QUALITY RECORD

QUALITY CONTROL ENGINEERING

OP	WC	M/C	OPER	FIRST OFF INSPECTION				PATROL INSPECTION						QTY. MOVEMENT			
				ACC	REJ	SIGN	DATE	PERIOD	1st	2nd	3rd	4th	5th	6th	ORDER	PASSED	S.G

REJECTION INFORMATION

OP No.	TIME	DATE	CAUSE OF REJECTION	CORRECTIVE ACTION	NUMBER REJECTS	REJECTION REWORK	REWORK INSPECTIO		
							ACC.	REJ.	SIG

AECI/M/ENG/L2236

"First off MUST be approved by Quality Control before starting production."

APPENDIX 4

CAPOSS REPORTS

Frequency	No.	Description
Daily	4.1	Daily operation work list
	4.2	Materials preparation
	4.3	Binning
	4.4	Material deletion audit list
	4.5	Order deletion audit list
	4.6	Deliveries
	4.7	Messages
	4.8	Input audit list
	4.9	Periods and shop calendar
Weekly	4.10	Order file
	4.11	Capacity requirements
	4.12	Plant report
	4.13	Outside orders
	4.14	Stores requisitions
	4.15	Spares delivery dates and lead time
	4.16	Work centre loading analysis
	4.17	Orders and hours remaining by plant and priorities
	4.18	Orders and hours loaded by plant and priorities
	4.19	Order residence time
Monthly	4.20	Turnaround time analysis
	4.21	Work centre capacity, queue time
	4.22	Cost allocation

● 7. **Website Address**

[illegible]

1. *Chlorophyll a* (Chl *a*)

1176	001144
1177	000000
1178	000030
1179	000059
1174	000130
1175	000155
1176	000000
1177	000000
1178	000000
1179	000007
1180	000007
1181	000007

1000000000

1000000000

1000000000

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1000000000

1000000000

DATE	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
1	1155	1156	1160	1161	1162	1163	1164
2	1155	1156	1160	1161	1162	1163	1164
3	1155	1156	1160	1161	1162	1163	1164
4	1155	1156	1160	1161	1162	1163	1164
5	1155	1156	1160	1161	1162	1163	1164

DATE	TIME	FROM	TO	FLY	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP	WIND	TEMP

CAPACITY REQUIREMENTS PLANNING REPORT FOR WORK CENTER 504 N/C DRILL MACH

NUMBER OF SINGLE MACHINES 1										ALTERNATE MC NO'S										
ORDER STAT PER AVAIL										SEC LOAD TYPE NO LOAD										
DATE	LEN	HRS	ESQ	LSD	ALT	0	100	200	300	SURPLUS	NOVM	EXTR	0	50	100	PER	UNAVOID	OVERLOAD	*SEC LOAD*	
			HRS	HRS	HRS					HRS	HRS	HRS				HRS	CUM	0	ESD	LSD
						(*)	(*)	(*)	(*)	(*)	(*)	(*)				(*)	(*)			
1	1083	5	60	278	258	.....	.....	.....	.....	17	120	.....	.....	.....	.....	194	194	.....	.....	0
2	1088	5	60	278	258	.....	.....	.....	.....	17	120	.....	.....	.....	.....	194	194	.....	.....	0
3	1094	5	60	278	258	.....	.....	.....	.....	17	120	.....	.....	.....	.....	194	194	.....	.....	0
4	1098	5	60	278	258	.....	.....	.....	.....	17	120	.....	.....	.....	.....	194	194	.....	.....	0
5	1103	10	120	0	0	.....	.....	.....	.....	17	120	.....	.....	.....	.....	194	194	.....	.....	0
6	1111	10	120	0	0	.....	.....	.....	.....	17	120	.....	.....	.....	.....	194	194	.....	.....	0
7	1121	10	120	0	0	.....	.....	.....	.....	17	120	.....	.....	.....	.....	194	194	.....	.....	0
8	1123	10	120	0	0	.....	.....	.....	.....	17	120	.....	.....	.....	.....	194	194	.....	.....	0
9	1143	10	120	0	0	.....	.....	.....	.....	17	120	.....	.....	.....	.....	194	194	.....	.....	0
10	1157	10	120	0	0	.....	.....	.....	.....	17	120	.....	.....	.....	.....	194	194	.....	.....	0
TOTALS			80	960	344					817	818					201				0

CAPACITY REQUIREMENTS PLANNING REPORT FOR WORK CENTER 506 G/IMO CYLIND 1

NUMBER OF SINGLE MACHINES 3										ALTERNATE MC NO'S										
PER STAT PER AVAIL										SEC LOAD TYPE NO LOAD										
DATE	LEN	HRS	ESQ	LSD	ALT	0	100	200	300	SURPLUS	NOVM	EXTR	0	50	100	PER	UNAVOID	OVERLOAD	*SEC LOAD*	
			HRS	HRS	HRS					HRS	HRS	HRS				HRS	CUM	0	ESD	LSD
						(*)	(*)	(*)	(*)	(*)	(*)	(*)				(*)	(*)			
1	1083	5	150	384	278	.....	.....	.....	.....	202	274	.....	.....	.....	.....	72	72	.....	.....	0
2	1083	5	150	384	278	.....	.....	.....	.....	202	274	.....	.....	.....	.....	72	72	.....	.....	0
3	1093	5	150	104	85	.....	.....	.....	.....	202	274	.....	.....	.....	.....	72	72	.....	.....	0
4	1084	5	150	143	43	.....	.....	.....	.....	202	274	.....	.....	.....	.....	72	72	.....	.....	0
5	1113	10	300	262	182	.....	.....	.....	.....	202	274	.....	.....	.....	.....	72	72	.....	.....	0
6	1113	10	300	0	0	.....	.....	.....	.....	202	274	.....	.....	.....	.....	72	72	.....	.....	0
7	1123	10	300	0	0	.....	.....	.....	.....	202	274	.....	.....	.....	.....	72	72	.....	.....	0
8	1133	10	300	0	0	.....	.....	.....	.....	202	274	.....	.....	.....	.....	72	72	.....	.....	0
9	1143	10	300	0	0	.....	.....	.....	.....	202	274	.....	.....	.....	.....	72	72	.....	.....	0
10	1153	10	300	0	0	.....	.....	.....	.....	202	274	.....	.....	.....	.....	72	72	.....	.....	0
TOTALS	80	2400	1236	865						1085	1137					72				0

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
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1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
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1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
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1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80																				

[illegible]

LOW CAPACITY PLANNING AND OPERATION SEQUENCING SYSTEM

VERSION 01 MOD 04 P7-S

PAGE 3

MODERNIZATION FACTORY

P7-S AMENDMENT LIST TO THE STORES SYSTEM DELIVERY DATES AND LEAD TIMES

CARROSS SYSTEM IDENTIFICATION			STORES SYSTEM RECORD TYPE 3526			STORES SYSTEM RECORD TYPE 3603				
ORDER NUMBER	ORDER NUMBER	QTY	INPUT CODE	COMMODITY CODE	ORDER NUMBER	SUFFIX NO	DELIVERY DATE	INPUT CODE	COMMODITY CODE	LEAD TIME
14C276AT	107793802	100	1 7 ***	6 15 *****	16 23 *****	26 ***	51 56 *****	1 4 ***	14 17 *****	53 ***
14C276AT	107793802	100	3626	62343091	14C276AT	001	150981	3603	62343091	52
14C276AT	107796802	400	2626	62216214	14C276AT	001	190981	3603	62216214	108
14C276AT	107796800	4	2626	62354111	14C276AT	001	080981	3603	62354111	126
14C276AT	107796800	8	2626	24656405	14C276AT	001	100981	3603	24656405	69
14C276AT	107796800	50	2626	62343062	14C276AT	001	140701	3603	62343062	71
14C276AT	107796800	2	2626	62344096	14C276AT	001	230981	3603	62344096	141
14C276AT	107796800	50	3626	51312503	14C276AT	001	190981	3603	51312503	108
14C276AT	107796800	4	2626	24656303	14C276AT	001	080981	3603	24656303	35
14C276AT	107796800	6	2626	62344503	14C276AT	001	091081	3603	62344503	153

END OF REPORT

STATUS OF PROGRAMS ARE FURTHER CATEGORIZED BY PRIORITY AND PRIORITY CLASSIFICATION									
NO.	NAME	NUMBER OF STUDENTS	SYSTEM COURSES	CAMPUS HOURS	PRIORITY CLASSIFICATION				TOTAL
					URGENT REQUIREMENT	AC HOURS	PLANNED SPLITTING	IMMEDIATE ACTION	
					NO HOURS	AC HOURS	NO HOURS	AC HOURS	
01	ARTS & SCIENCES	10	10	0	0	0	0	0	0
02	ARTS & SCIENCES	10	10	0	0	0	0	0	0
03	ARTS & SCIENCES	10	10	0	0	0	0	0	0
04	ARTS & SCIENCES	10	10	0	0	0	0	0	0
05	ARTS & SCIENCES	10	10	0	0	0	0	0	0
06	ARTS & SCIENCES	10	10	0	0	0	0	0	0
07	ARTS & SCIENCES	10	10	0	0	0	0	0	0
08	ARTS & SCIENCES	10	10	0	0	0	0	0	0
09	ARTS & SCIENCES	10	10	0	0	0	0	0	0
10	ARTS & SCIENCES	10	10	0	0	0	0	0	0
11	ARTS & SCIENCES	10	10	0	0	0	0	0	0
12	ARTS & SCIENCES	10	10	0	0	0	0	0	0
13	ARTS & SCIENCES	10	10	0	0	0	0	0	0
14	ARTS & SCIENCES	10	10	0	0	0	0	0	0
15	ARTS & SCIENCES	10	10	0	0	0	0	0	0
16	ARTS & SCIENCES	10	10	0	0	0	0	0	0
17	ARTS & SCIENCES	10	10	0	0	0	0	0	0
18	ARTS & SCIENCES	10	10	0	0	0	0	0	0
19	ARTS & SCIENCES	10	10	0	0	0	0	0	0
20	ARTS & SCIENCES	10	10	0	0	0	0	0	0
21	ARTS & SCIENCES	10	10	0	0	0	0	0	0
22	ARTS & SCIENCES	10	10	0	0	0	0	0	0
23	ARTS & SCIENCES	10	10	0	0	0	0	0	0
24	ARTS & SCIENCES	10	10	0	0	0	0	0	0
25	ARTS & SCIENCES	10	10	0	0	0	0	0	0
26	ARTS & SCIENCES	10	10	0	0	0	0	0	0
27	ARTS & SCIENCES	10	10	0	0	0	0	0	0
28	ARTS & SCIENCES	10	10	0	0	0	0	0	0
29	ARTS & SCIENCES	10	10	0	0	0	0	0	0
30	ARTS & SCIENCES	10	10	0	0	0	0	0	0
31	ARTS & SCIENCES	10	10	0	0	0	0	0	0
32	ARTS & SCIENCES	10	10	0	0	0	0	0	0
33	ARTS & SCIENCES	10	10	0	0	0	0	0	0
34	ARTS & SCIENCES	10	10	0	0	0	0	0	0
35	ARTS & SCIENCES	10	10	0	0	0	0	0	0
36	ARTS & SCIENCES	10	10	0	0	0	0	0	0
37	ARTS & SCIENCES	10	10	0	0	0	0	0	0
38	ARTS & SCIENCES	10	10	0	0	0	0	0	0
39	ARTS & SCIENCES	10	10	0	0	0	0	0	0
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43	ARTS & SCIENCES	10	10	0	0	0	0	0	0
44	ARTS & SCIENCES	10	10	0	0	0	0	0	0
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52	ARTS & SCIENCES	10	10	0	0	0	0	0	0
53	ARTS & SCIENCES	10	10	0	0	0	0	0	0
54	ARTS & SCIENCES	10	10	0	0	0	0	0	0
55	ARTS & SCIENCES	10	10	0	0	0	0	0	0
56	ARTS & SCIENCES	10	10	0	0	0	0	0	0
57	ARTS & SCIENCES	10	10	0	0	0	0	0	0
58	ARTS & SCIENCES	10	10	0	0	0	0	0	0
59	ARTS & SCIENCES	10	10	0	0	0	0	0	0
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62	ARTS & SCIENCES	10	10	0	0	0	0	0	0
63	ARTS & SCIENCES	10	10	0	0	0	0	0	0
64	ARTS & SCIENCES	10	10	0	0	0	0	0	0
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72	ARTS & SCIENCES	10	10	0	0	0	0	0	0
73	ARTS & SCIENCES	10	10	0	0	0	0	0	0
74	ARTS & SCIENCES	10	10	0	0	0	0	0	0
75	ARTS & SCIENCES	10	10	0	0	0	0	0	0
76	ARTS & SCIENCES	10	10	0	0	0	0	0	0
77	ARTS & SCIENCES	10	10	0	0	0	0	0	0
78	ARTS & SCIENCES	10	10	0	0	0	0	0	0
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80	ARTS & SCIENCES	10	10	0	0	0	0	0	0
81	ARTS & SCIENCES	10	10	0	0	0	0	0	0
82	ARTS & SCIENCES	10	10	0	0	0	0	0	0
83	ARTS & SCIENCES	10	10	0	0	0	0	0	0
84	ARTS & SCIENCES	10	10	0	0	0	0	0	0
85	ARTS & SCIENCES	10	10	0	0	0	0	0	0
86	ARTS & SCIENCES	10	10	0	0	0	0	0	0
87	ARTS & SCIENCES	10	10	0	0	0	0	0	0
88	ARTS & SCIENCES	10	10	0	0	0	0	0	0
89	ARTS & SCIENCES	10	10	0	0	0	0	0	0
90	ARTS & SCIENCES	10	10	0	0	0	0	0	0
91	ARTS & SCIENCES	10	10	0	0	0	0	0	0
92	ARTS & SCIENCES	10	10	0	0	0	0	0	0
93	ARTS & SCIENCES	10	10	0	0	0	0	0	0
94	ARTS & SCIENCES	10	10	0	0	0	0	0	0
95	ARTS & SCIENCES	10	10	0	0	0	0	0	0
96	ARTS & SCIENCES	10	10	0	0	0	0	0	0
97	ARTS & SCIENCES	10	10	0	0	0	0	0	0
98	ARTS & SCIENCES	10	10	0	0	0	0	0	0
99	ARTS & SCIENCES	10	10	0	0	0	0	0	0
100	ARTS & SCIENCES	10	10	0	0	0	0	0	0
101	ARTS & SCIENCES	10	10	0	0	0	0	0	0
102	ARTS & SCIENCES	10	10	0	0	0	0	0	0
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105	ARTS & SCIENCES	10	10	0	0	0	0	0	0
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107	ARTS & SCIENCES	10	10	0	0	0	0	0	0
108	ARTS & SCIENCES	10	10	0	0	0	0	0	0
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113	ARTS & SCIENCES	10	10	0	0	0	0	0	0
114	ARTS & SCIENCES	10	10	0	0	0	0	0	0
115	ARTS & SCIENCES	10	10	0	0	0	0	0	0
116	ARTS & SCIENCES	10	10	0	0	0	0	0	0
117	ARTS & SCIENCES	10	10	0	0	0	0	0	0
118	ARTS & SCIENCES	10	10	0	0	0	0	0	0
119	ARTS & SCIENCES	10	10	0	0	0	0	0	0
120	ARTS & SCIENCES	10	10	0	0	0	0	0	0
121	ARTS & SCIENCES	10	10	0	0	0	0	0	0
122	ARTS & SCIENCES	10	10	0	0	0	0	0	0
123	ARTS & SCIENCES	10	10	0	0	0	0	0	0
124	ARTS & SCIENCES	10	10	0	0	0	0	0	0
125	ARTS & SCIENCES	10	10	0	0	0	0	0	0
126	ARTS & SCIENCES	10	10	0	0	0	0	0	0
127	ARTS & SCIENCES	10	10	0	0	0	0	0	0
128	ARTS & SCIENCES	10	10	0	0	0	0	0	0
129	ARTS & SCIENCES	10	10	0	0	0	0	0	0
130	ARTS & SCIENCES	10	10	0	0	0	0	0	0
131	ARTS & SCIENCES	10	10	0	0	0	0	0	0
132	ARTS & SCIENCES	10	10	0	0	0	0	0	0
133	ARTS & SCIENCES	10	10	0	0	0	0	0	0
134	ARTS & SCIENCES	10	10	0	0	0	0	0	0
135	ARTS & SCIENCES	10	10	0	0	0	0	0	0
136	ARTS & SCIENCES	10	10	0	0	0	0	0	0
137	ARTS & SCIENCES	10	10	0	0	0	0	0	0
138	ARTS & SCIENCES	10	10	0	0	0	0	0	0
139	ARTS & SCIENCES	10	10	0	0	0	0	0	0
140	ARTS & SCIENCES	10	10	0	0	0	0	0	0
141	ARTS & SCIENCES	10	10	0	0	0	0	0	0
142	ARTS & SCIENCES	10	10	0	0	0	0	0	0
143	ARTS & SCIENCES	10	10	0	0	0	0	0	0
144	ARTS & SCIENCES	10	10	0	0	0	0	0	0
145	ARTS & SCIENCES	10	10	0	0	0	0	0	0
146	ARTS & SCIENCES	10	10	0	0	0	0	0	0
147	ARTS & SCIENCES	10	10	0	0	0	0	0	0
148	ARTS & SCIENCES	10	10	0	0	0	0	0	0
149	ARTS & SCIENCES	10	10	0	0	0	0	0	0
150	ARTS & SCIENCES	10	10	0	0	0	0	0	0
151	ARTS & SCIENCES	10	10	0	0	0	0	0	0
152	ARTS & SCIENCES	10	10	0	0	0	0	0	0
153	ARTS & SCIENCES	10	10	0	0	0	0	0	0
154	ARTS & SCIENCES	10	10	0	0	0	0	0	0
155	ARTS & SCIENCES	10	10	0	0	0	0	0	0
156	ARTS & SCIENCES	10	10	0	0	0	0	0	0
157	ARTS & SCIENCES	10	10	0	0	0	0	0	0
158	ARTS & SCIENCES	10	10	0	0	0	0	0	0
159	ARTS & SCIENCES	10	10	0	0	0	0	0	0
160	ARTS & SCIENCES	10	10	0	0	0	0	0	0
161	ARTS & SCIENCES	10	10	0	0	0	0	0	0
162	ARTS & SCIENCES	10	10	0	0	0	0	0	0
163	ARTS & SCIENCES	10	10	0	0	0	0	0	0
164	ARTS & SCIENCES	10	10	0	0	0	0	0	0
165	ARTS & SCIENCES	10	10	0	0	0	0	0	0
166	ARTS & SCIENCES	10	10	0	0	0	0		

ANALYSIS OF MAJOR AND MINOR DEFECTS										MODIFICATION IN CENTRAL WORKSHOPS										DATED		11/08/81	
PRIORITY CLASSIFICATION										PRIORITY CLASSIFICATION										IMMEDIATE ACTION		TOTAL	
AREA	NAME	NO. OF DEFECTS	NO. OF DEFECTS	NO. OF DEFECTS	NO. OF DEFECTS	NO. OF DEFECTS	NO. OF DEFECTS	NO. OF DEFECTS	NO. OF DEFECTS	NO. OF DEFECTS	NO. OF DEFECTS	NO. OF DEFECTS	NO. OF DEFECTS	NO. OF DEFECTS	NO. OF DEFECTS	NO. OF DEFECTS	NO. OF DEFECTS	NO. OF DEFECTS	NO. OF DEFECTS	NO. OF DEFECTS	NO. OF DEFECTS	NO. OF DEFECTS	NO. OF DEFECTS
01	NO. 1 AMMUNITION	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
02	ALUMINUM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
03	DEFINITIONS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
04	B.E.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
05	FUSE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06	NO. 2 AMMUNITION	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
07	CHEMICALS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
08	POWER STATION	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
09	PLANT AND INSTR.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	CENTRAL WORKSHOPS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	TRANSPORT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	CIVIL AND MINE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	FMS - SPACES CENTRE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	FMS - CENTRAL WORKSHOPS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	MINOR CAPITAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	MAJOR CAPITAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	UNKNOWN DEFECTS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GRAND TOTALS										GRAND TOTALS										GRAND TOTALS		GRAND TOTALS	

[illegible]

COND 70T PL

$$f(x) = \frac{1}{2} \ln \frac{1+x}{1-x} - \frac{1}{2} \ln \frac{1+x^2}{1-x^2}$$

TABLE 1. Data on the 1997-1998 season.

項目	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100

THE END • 3 •

AVERAGE DEVIATION FROM LEADERS		98
AREA SURROUNDING LINE		67
TOTAL PER WITH DUE DATE		166
TOTAL PER WITHOUT DUE DATE		6
TOTAL PER		172

[illegible]

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1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500 501 502 503 504 505 506 507 508 509 510 511 512 513 514 515 516 517 518 519 520 521 522 523 524 525 526 527 528 529 530 531 532 533 534 535 536 537 538 539 540 541 542 543 544 545 546 547 548 549 550 551 552 553 554 555 556 557 558 559 560 561 562 563 564 565 566 567 568 569 570 571 572 573 574 575 576 577 578 579 580 581 582 583 584 585 586 587 588 589 590 591 592 593 594 595 596 597 598 599 600 601 602 603 604 605 606 607 608 609 610 611 612 613 614 615 616 617 618 619 620 621 622 623 624 625 626 627 628 629 630 631 632 633 634 635 636 637 638 639 640 641 642 643 644 645 646 647 648 649 650 651 652 653 654 655 656 657 658 659 660 661 662 663 664 665 666 667 668 669 670 671 672 673 674 675 676 677 678 679 680 681 682 683 684 685 686 687 688 689 690 691 692 693 694 695 696 697 698 699 700 701 702 703 704 705 706 707 708 709 710 711 712 713 714 715 716 717 718 719 720 721 722 723 724 725 726 727 728 729 730 731 732 733 734 735 736 737 738 739 740 741 742 743 744 745 746 747 748 749 750 751 752 753 754 755 756 757 758 759 760 761 762 763 764 765 766 767 768 769 770 771 772 773 774 775 776 777 778 779 780 781 782 783 784 785 786 787 788 789 790 791 792 793 794 795 796 797 798 799 800 801 802 803 804 805 806 807 808 809 810 811 812 813 814 815 816 817 818 819 820 821 822 823 824 825 826 827 828 829 830 831 832 833 834 835 836 837 838 839 840 841 842 843 844 845 846 847 848 849 850 851 852 853 854 855 856 857 858 859 860 861 862 863 864 865 866 867 868 869 870 871 872 873 874 875 876 877 878 879 880 881 882 883 884 885 886 887 888 889 890 891 892 893 894 895 896 897 898 899 900 901 902 903 904 905 906 907 908 909 910 911 912 913 914 915 916 917 918 919 920 921 922 923 924 925 926 927 928 929 930 931 932 933 934 935 936 937 938 939 940 941 942 943 944 945 946 947 948 949 950 951 952 953 954 955 956 957 958 959 960 961 962 963 964 965 966 967 968 969 970 971 972 973 974 975 976 977 978 979 980 981 982 983 984 985 986 987 988 989 990 991 992 993 994 995 996 997 998 999 1000 1001 1002 1003 1004 1005 1006 1007 1008 1009 1010 1011 1012 1013 1014 1015 1016 1017 1018 1019 1020 1021 1022 1023 1024 1025 1026 1027 1028 1029 1030 1031 1032 1033 1034 1035 1036 1037 1038 1039 104

4474745

A7144 J. Valero et al. / *Ecological Economics* 64 (2007) 867–882

CASE 2005-1060 OVERVIEW

[illegible]

APRIL 2005 • JGIM • 20

440400 TELEVISION BROADCAST
 440420 ALUMINUM PIPE
 440430 TUBES & FITTINGS
 440440 TUBES & FITTINGS
 440450 TUBES & FITTINGS
 440460 TUBES & FITTINGS
 440470 TUBES & FITTINGS
 440480 TUBES & FITTINGS
 440490 TUBES & FITTINGS

TABLE 1. Continued

4748-4479-2004-4747

LATE JCS - DAYS OVERCUE

[illegible]

ST. CL. JERRY & DAVID

average deviation once plus
average rounding tie
TOTAL JOBS WITH RCF DATE
TOTAL JOBS WITHOUT RCF DATE
TOTAL JOBS

TABLE 1

$$E_{\text{HCL}} = f(\text{CS}) = 2.0 + 0.5 \text{ CALY}$$

DATE ISSUED - 1975 OCT 14

[illegible]
$$NC. \text{ CF } ^{-}H_5 \text{ LAHLY} =$$
[illegible]

[illegible]

NOVEMBER 1999

1	2
3	4
5	6
7	8
9	10
11	12
13	14
15	16
17	18
19	20
21	22
23	24
25	26
27	28
29	30
31	32
33	34
35	36
37	38
39	40
41	42
43	44
45	46
47	48
49	50
51	52
53	54
55	56
57	58
59	60
61	62
63	64
65	66
67	68
69	70
71	72
73	74
75	76
77	78
79	80
81	82
83	84
85	86
87	88
89	90
91	92
93	94
95	96
97	98
99	100

TABLE 1. *Continued*

ALTERED

4. *Mathematical models*

LATE JUNE - DAYS EVERGLE

[illegible]

22 • JOURNAL OF DOCUMENTATION

ED. DE JONGH & P.

AVERAGE SEPARATION FINE PLAN
AVERAGE SEPARATION FINE PLAN
TOTAL JOB WITH ECF CASE
TOTAL JOB WITHOUT ECF CASE
TOTAL JOB

Availability : 2

FAHRENHEIT - CENTS FALLO

LATE JCB5 - DAYS OVERDUE

[illegible]
$$+ \text{C}_2\text{H}_5\text{OH} \rightarrow \text{C}_2\text{H}_5\text{OC}_2\text{H}_5 + \text{H}_2\text{O}$$

602 DR. JAMES L. HAYES, JR.

AVERAGE DEVIATION FROM PLAN	
AVERAGE PLANSOUND TIME	
TOTAL JCPS WITH FCR DATE	
TOTAL JCPS WITHOUT FCR DATE	
TOTAL JCPS	

EWING, J. W. 1931. 11

TABLE 1. *Continued*

LATE JOB - DAYS CYCLE

ALPHA SHOT 12.24

NO. OF JUNE LATE = 11

PAYING DEVIATION FROM PLAN
 AVERAGE FUNDING YEAR
 TOTAL JCPS • WITH FCF ENVS
 TOTAL JCPS • WITHOUT FCF ENVS
 TOTAL JCPS

PLATE	CASE	DATE	PAGE

ence of a catalyst

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500 501 502 503 504 505 506 507 508 509 510 511 512 513 514 515 516 517 518 519 520 521 522 523 524 525 526 527 528 529 530 531 532 533 534 535 536 537 538 539 540 541 542 543 544 545 546 547 548 549 550 551 552 553 554 555 556 557 558 559 560 561 562 563 564 565 566 567 568 569 570 571 572 573 574 575 576 577 578 579 580 581 582 583 584 585 586 587 588 589 590 591 592 593 594 595 596 597 598 599 600 601 602 603 604 605 606 607 608 609 610 611 612 613 614 615 616 617 618 619 620 621 622 623 624 625 626 627 628 629 630 631 632 633 634 635 636 637 638 639 640 641 642 643 644 645 646 647 648 649 650 651 652 653 654 655 656 657 658 659 660 661 662 663 664 665 666 667 668 669 670 671 672 673 674 675 676 677 678 679 680 681 682 683 684 685 686 687 688 689 690 691 692 693 694 695 696 697 698 699 700 701 702 703 704 705 706 707 708 709 710 711 712 713 714 715 716 717 718 719 720 721 722 723 724 725 726 727 728 729 730 731 732 733 734 735 736 737 738 739 740 741 742 743 744 745 746 747 748 749 750 751 752 753 754 755 756 757 758 759 760 761 762 763 764 765 766 767 768 769 770 771 772 773 774 775 776 777 778 779 780 781 782 783 784 785 786 787 788 789 790 791 792 793 794 795 796 797 798 799 800 801 802 803 804 805 806 807 808 809 810 811 812 813 814 815 816 817 818 819 820 821 822 823 824 825 826 827 828 829 830 831 832 833 834 835 836 837 838 839 840 841 842 843 844 845 846 847 848 849 850 851 852 853 854 855 856 857 858 859 860 861 862 863 864 865 866 867 868 869 870 871 872 873 874 875 876 877 878 879 880 881 882 883 884 885 886 887 888 889 890 891 892 893 894 895 896 897 898 899 900 901 902 903 904 905 906 907 908 909 910 911 912 913 914 915 916 917 918 919 920 921 922 923 924 925 926 927 928 929 930 931 932 933 934 935 936 937 938 939 940 941 942 943 944 945 946 947 948 949 950 951 952 953 954 955 956 957 958 959 960 961 962 963 964 965 966 967 968 969 970 971 972 973 974 975 976 977 978 979 980 981 982 983 984 985 986 987 988 989 990 991 992 993 994 995 996 997 998 999 1000 1001 1002 1003 1004 1005 1006 1007 1008 1009 1010 1011 1012 1013 1014 1015 1016 1017 1018 1019 1020 1021 1022 1023 1024 1025 1026 1027 1028 1029 1030 1031 1032 1033 1034 1035 1036 1037 1038 1039 104

4. A. B. C. D. E. F. G. H. I. J. K. L. M. N. O. P. Q. R. S. T. U. V. W. X. Y. Z.

WEEKLY JOURNALS - DAYS EARLY

Left: JCBs - Dads' Canteen

[illegible][illegible]

NEW YORK: JONES & BARTON

NO. OF JERS LATE 7

+
 AVERAGE DEVIATION FROM ZERO
 AVERAGE STANDARD TIME
 TOTAL JOBS WITH ACF DATE
 TOTAL JOBS WITHOUT ACF DATE
 TOTAL JOBS

Part 1 Cont. 174

WILEY-JOHN & SONS - LANCASHIRE

LATE JEEP - DAYS OVERDUE

項目	単位	数値
総計	人	100
男性	人	50
女性	人	50
年齢別	人	100
10代	人	10
20代	人	20
30代	人	30
40代	人	20
50代	人	10
60代	人	5
70代	人	5
80代	人	5
90代	人	5
100代	人	5
職業別	人	100
学生	人	20
会社員	人	30
自営業	人	20
無職	人	10
その他	人	20
学歴別	人	100
小学校	人	10
中学校	人	20
高等学校	人	30
大学	人	20
大学院	人	10
その他	人	10
収入別	人	100
10万円未満	人	10
10万円以上20万円未満	人	20
20万円以上30万円未満	人	30
30万円以上40万円未満	人	20
40万円以上50万円未満	人	10
50万円以上	人	10

Q
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Y
Z

$$4C_1 + C_2 + C_3 = 18000 \quad (1)$$

NOV. 20 1957

AGE	AVG DIVISION	AVG PLAN
1	1.00	1.00
2	1.00	1.00
3	1.00	1.00
4	1.00	1.00
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48	1.00	1.00
49	1.00	1.00
50	1.00	1.00
51	1.00	1.00
52	1.00	1.00
53	1.00	1.00
54	1.00	1.00
55	1.00	1.00
56	1.00	1.00
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100	1.00	1.00

ALTERNATIVE

JCL 55 - 5445 EAC

ADDITIONAL SALES - ADDITIONAL

Country	Year	Value
China	2000	0.00
China	2001	0.00
China	2002	0.00
China	2003	0.00
China	2004	0.00
China	2005	0.00
China	2006	0.00
China	2007	0.00
China	2008	0.00
China	2009	0.00
China	2010	0.00
China	2011	0.00
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China		

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DATE	DESCRIPTION	AMOUNT	BALANCE
1/1/78	OPENING BALANCE	100.00	100.00
1/15/78	PAYROLL	50.00	50.00
1/20/78	RENT	25.00	25.00
1/25/78	UTILITIES	15.00	10.00
2/1/78	CLOSING BALANCE	10.00	10.00

[illegible]

ITEM NO.	ITEM NAME	UNIT	QTY	UNIT PRICE	TOTAL PRICE	DATE	PAGE
1	1000 2000 3000	100	100	10.00	10.00	10.00	10.00
2	1000 2000 3000	100	100	10.00	10.00	10.00	10.00
3	1000 2000 3000	100	100	10.00	10.00	10.00	10.00
4	1000 2000 3000	100	100	10.00	10.00	10.00	10.00
5	1000 2000 3000	100	100	10.00	10.00	10.00	10.00
6	1000 2000 3000	100	100	10.00	10.00	10.00	10.00
7	1000 2000 3000	100	100	10.00	10.00	10.00	10.00
8	1000 2000 3000	100	100	10.00	10.00	10.00	10.00
9	1000 2000 3000	100	100	10.00	10.00	10.00	10.00
10	1000 2000 3000	100	100	10.00	10.00	10.00	10.00
11	1000 2000 3000	100	100	10.00	10.00	10.00	10.00
12	1000 2000 3000	100	100	10.00	10.00	10.00	10.00
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21	1000 2000 3000	100	100	10.00	10.00	10.00	10.00
22	1000 2000 3000	100	100	10.00	10.00	10.00	10.00
23	1000 2000 3000	100	100	10.00	10.00	10.00	10.00
24	1000 2000 3000	100	100	10.00	10.00	10.00	10.00



CAPOSS INPUT DATA

CARD TYPE: CW 51 OPERATION CANCEL
CW 53 OPERATION MODIFY

CARD TYPE	AREA	WORKS ORDER NUMBER	SHUTDOWN CODE	CAPOSS NUMBERS	OPERATION NUMBER	WORK CENTRE	GROUP CODE	OPERATION DESCRIPTION	QUANTITY	STANDARD TIME	INSPECTION	PLANNED MEN	ALT W/C	RELATED FAC	DELAY
CW 53															
CW 51															

Processing Description

Figure 36 presents a general data flow of CAPOSS. It is subdivided into eight functional modules. They, in turn, consist of several phases. Most of the functions outlined in the section General Description of Application must be developed in stages through many phases. For example, to be able to allocate split operations in the Operation Sequencer, the data required is prepared by the preceding phases. This applies to all functions.

The Scheduling System

The Run Data Maintenance phases create and maintain the Run Data files which include all program parameters, input/output descriptions, work center data, and capacity event specifications. Several variations can be stored for phase parameters, input file descriptions, and report layouts. Before the scheduling program is executed, a short initialization phase must be executed to determine which variations of the phases are to be used, and to update the key date for the scheduling execution. The Work Center file and Capacity Event file are also created and maintained by this module. All data can be printed by special print options contained in this module.

The objective of the Order Management phases is to create and maintain the Order file. This is the order-dependent Data file used by the scheduling system. It is a permanent file and contains the master order information. For this reason, a forced backup is built into the data flow.

The new Order file, when created, is immediately used and checked by the succeeding phase. As the system is designed for large volume files, tape storage can be used to store the Order file.

The Order Management phases are assumed to be executed in a longer range cycle, e.g., weekly. Therefore, it is necessary to be able to update the Order file with all changes that have been made during the

week. This is done either by using the Subset Order file which is maintained in the later phases on a daily basis, or directly into the Order Management module if the Subset Order file is not being maintained as would be common in the early installation period.

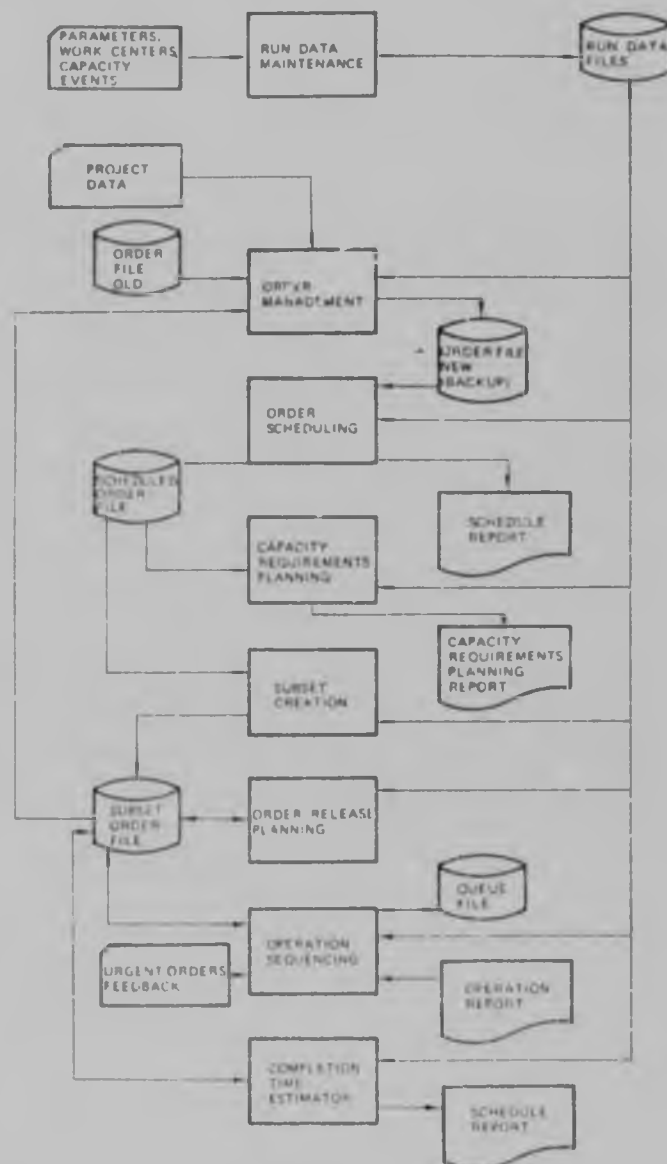


Figure 36. CAPOSS

The logic required to schedule single orders is simpler than that necessary to schedule networks. For this reason, and because in some application areas networks

are not used, the processing of orders and network scheduling have been separated. In Order Scheduling, material records can be used.

If networks are specified, critical path techniques are applied to compute the schedule dates. Orders from different projects may be interconnected within a network.

In Order Scheduling, only those orders are rescheduled for which data has been changed since the last scheduling execution.

The results obtained from Order Scheduling assume that there are no capacity restrictions. They test the feasibility of manufacturing an order by the user-specified due date. The results of this test are reflected in the priority computations used by the loading phases which respect capacity restrictions.

Capacity Requirements Planning evaluates the results of the Order Scheduling phases. It determines the overall latest and earliest start date loads and tries to level these over the available capacity. It also computes the offload possibilities in the event of overloads to alternate work centers if required. Computations such as this give an idea of the real capacity requirements. These computations can be made for all orders held in the Order file.

All modules up to this point process the Order file sequentially. For this reason, disk or tape storage was possible. The remaining modules require the data in direct-access mode and, in terms of a date

range, only require the imminent orders. For this reason, the main Order file is subset and this disk file used in the remaining modules. This is achieved using the Subset Creation phases.

Order Release Planning reviews each order to determine whether sufficient capacity is available to produce the order on time. If a bottleneck occurs, the resulting delay is used to influence the release of the order in the Operation Sequencer or to influence the order priority.

The Operation Sequencing phases perform the actual machine loading with regard to all functions outlined in the section General Description of Application. This module of the program is designed to be executed in short-range cycles. In the short-range cycle, e.g., daily, it includes a complete feedback system and allows the insertion of urgent orders and changes. It also supplies the operation report (work-sequence report) which gives the scheduled sequence of operations for each work center or, if required, for each subgroup or single machine. The Operation Sequencer computes the actual queue time for each operation and, therefore, does not use the user input value for the work center.

Based on these results, the Completion Time Estimator determines the probable continuation and completion of all orders in process. In addition, it loads the remaining orders on hand in the Subset Order file. It uses updated queue times considering the experience of the earlier executions of the Operation Sequencer phase.

Programming Systems

The IBM System/360 and System/370 Capacity Planning and Operation Sequencing System is written in Assembler language using the macro language facility. It can operate under the

- IBM Operating System (OS) MFT and MVT, or
- IBM Disk Operating System (DOS).

Both sequential and direct-access data management and access methods are used.

In addition, one of the following service programs is used:

- IBM Operating System, Sort/Merge (Program Product 5734-SM1 or Program Number 360S-SM-023), or
- IBM Disk Operating System, Tape and Disk Sort/Merge (Program Product 5736-SM1), or Disk Sort/Merge (Program Number 360N-SM-450).

The sort program is combined into the relevant CAPOSS mainline programs to ensure full control of the execution sequence of the phases within the data flow.

JOB SHOP PRODUCTION PLANNING & CONTROL - CASE STUDY
(AECI Modderfontein -- Central Workshops)

Part C

Implementation of Overall Management Study Recommendations

Part C

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INTRODUCTION

This report presents the implementation stage of the October 1980 Overall Management Study, in Central Workshops, from 15.3.81 to 15.10.81.

The first action taken following the recommendations, was to appoint the author as Workshops Planning & Control Engineer.

The report covers the main areas of treatment concerned with the general recommendations of Part A on this project and concentrates mainly on the Planning & Control section: The right approach for Job Shop Production scheduling, re-organization of the section, Floor management training, quality control procedures, recommended Bonus Scheme system and other matters concerning management in the Workshops.

1. JOB SHOP PRODUCTION PLANNING & CONTROL - GENERAL

The first assigned area for in-depth study, was the approach to scheduling in Job Shop Production.

A mandate was given to investigate and implement the right application of CAPOSS or, alternatively, to modify the system so that it suited our needs without eliminating the system entirely. As the latter was the case, we adhered to the CAPOSS approach, i.e. Job Priorities and Due Dates given by the customers.

Generally, the system works as follows:

Based on existing work in the system and on all other factors involved in scheduling, the programme creates a Calculated Finish Date for each job. However, as regards quality of service, it was a total failure, as Finish Dates were being changed frequently.

In the following paragraphs on system analysis, we try to follow the Systems Engineering hard methodology by Jenkins, which is essential when dealing with implementation of a computerised Management Information System. This is done by comparing what was done when CAPOSS was introduced 2 years ago to what should have been done and the manner in which the problems in the Planning & Control system have been rectified.

2. SYSTEM ANALYSIS

2.1. Recognition and formulation of the problem

Fundamentally, the main problems in the Central Workshops were:

- Manual system not functioning proficiently
- Work not being based on a schedule and production programme
- Work centres being overloaded
- Some work centres not being used to their full potential
- Shifting bottlenecks
- Loss of jobs
- Loss of paperwork and drawings
- Low efficiency
- Poor control over jobs and material in process
- Loss of control over outside materials/manufacturing orders
- Inability to determine CAPACITY requirements vs demands
- Average turnaround time of a job into the system being more than 12 days
- Low quality of work

The above are, in brief, the main problems which were identified before the implementation of CAPOSS, and the reason why an Engineer was appointed to carry out an investigation under the heading "Central Workshops - New Planning & Control System" and thereafter, to recommend a comprehensive solution.

2.2. Organization of the project

The Company has not had a great deal of systems experience.

The team conducting the study consisted of:

- i) An Industrial Engineer as team leader
(with no experience in production at all)
- ii) A Production Superintendent
- iii) 2 Programmers

The allocated budget amount for this project was approximately R100 000.

The team did not include an experienced Systems Analyst or high level Engineers who could have viewed the problem on a wider base and analysed the system correctly.

The investigation was short and included interviews with Customers, shop floor management and personnel in the Planning Office.

From the start, the approach was that Planning & Control should be computerized.

The team leader concentrated more on procedures and control than on the quality of service given by the Workshops.
The programmers were passive at this stage.

No flow charts were drawn up and knowledge concerning the requirements and objectives of the new system was vague.

The second part of the investigation consisted of trying to find a similar Workshop in South Africa, with a computerized Planning & Control System and to try to implement it in Central Workshops.

The team found a working system called "CAPOSS", which was in use at a shipyard in a South African Naval Base. Similarities existed between the two Workshops and in the type of service they offered.

Although the Navy personnel did not have much experience, they recommended the system and AECL decided to implement it in the Central Workshops.

2.3. Definition of system objectives

Due to the lack of knowledge and experience, this stage has not been done at all. The definition had been determined on the Planning & Control of Investigation Sheet (the mandate for the investigation).

Definition of system objectives is based on a broad study of the system, procedures and any constraints to which the system may be subject to. If the foregoing had been done properly, it would have become apparent that the Production Planning & Control objective is subject to certain constraints, such as:

- a) What is the correct philosophy of planning - real queue or system working on job priorities ?
- b) Should all jobs pass through the system or not ?

What happens in the event of breakdowns and plant shutdowns ?

- c) How will the system work with the computerized inventory system, which places orders for FMS (Factory Made Spares) work to the Central Workshops.
- d) What are the objectives of the system with regard to Plant Made Spares, which have different problems from that of Central Workshops as regards Production Planning & Control ?
- e) What are the economic criteria in order to make a decision on the chosen system ?

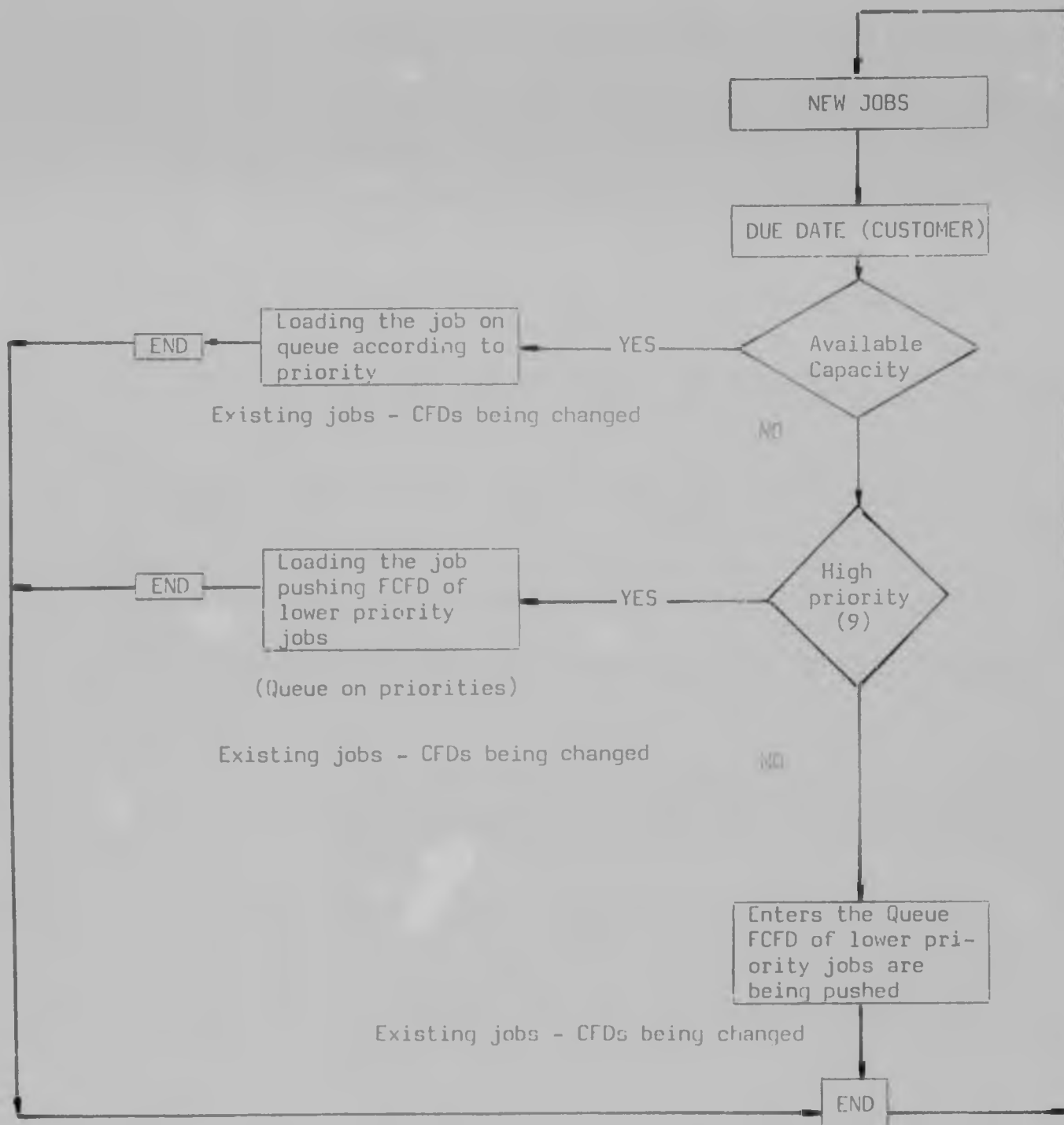
None of these questions were answered, although they are some of the main factors which should have been taken into consideration before deciding to implement CAPOSS.

2.4. System design

As mentioned previously, no systems design was used before the decision was made on the type of system required, and the design concentrated on procedures and paper work for the new system.

This chapter does not discuss CAPOSS as it is described in detail in Part B of this project, but it does give the practical results obtained when following the CAPOSS approach.

Actually, the whole priority approach built into CAPOSS can be illustrated schematically, by simplification, as shown on the following page:



FCFD - First Calculated Finish Date
CFD - Current Finish Date

2.4.1. Explanation

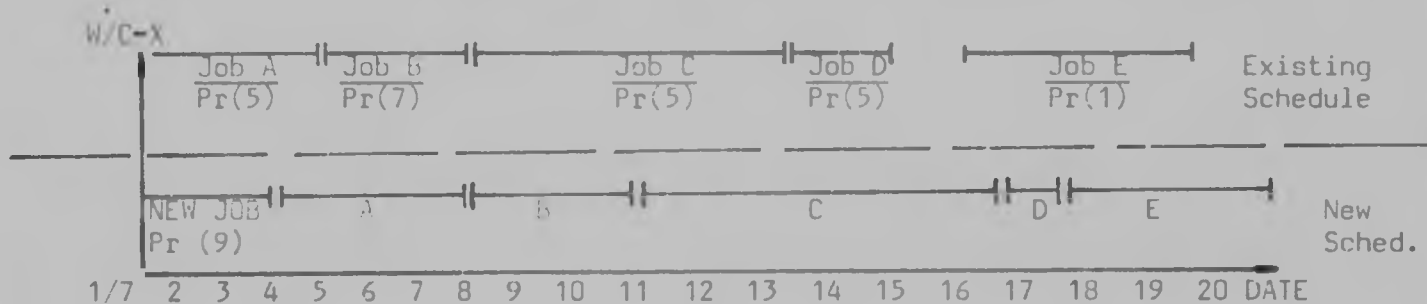
The key factor of the Programme in the process of determining the CURRENT FINISH DATE, is the flexibility.

The First Calculated Finish Date is based on due dates and external priority in the first stage and on operation priority only, in the second stage.

The scheduling programme for the existing jobs is changed depending on job priorities as compared with the new jobs entering the system.

The following figure illustrates what happens practically when such a system is in action:

Assume that the present loading programme in Work Centre X is as follows: (No matter if the W/C is over or under loaded)



Pr = priority

A new job with priority 9 coming in on 3 July and due to be delivered on 4 July, will change the whole schedule, and therefore all the promised First Calculated Finish Dates will be changed.

Now, it must be remembered that not only one job is coming into the system, but many others, and customers (the various plants) are not aware of the requirements of other plants, so the whole schedule for Finish Dates changed many times and there were jobs which were in the system for more than 2 years, simply because the customer was naive and gave priority 3, 2 or 1 for his order.

It was understood very quickly by the customers that, if they wished to get their job done, they had to use priority 9.

However, short jobs which were real emergencies could not appear on the Daily Work List because of the great backlog and automatic load of jobs (superior priority).

2.4.1. E .planation

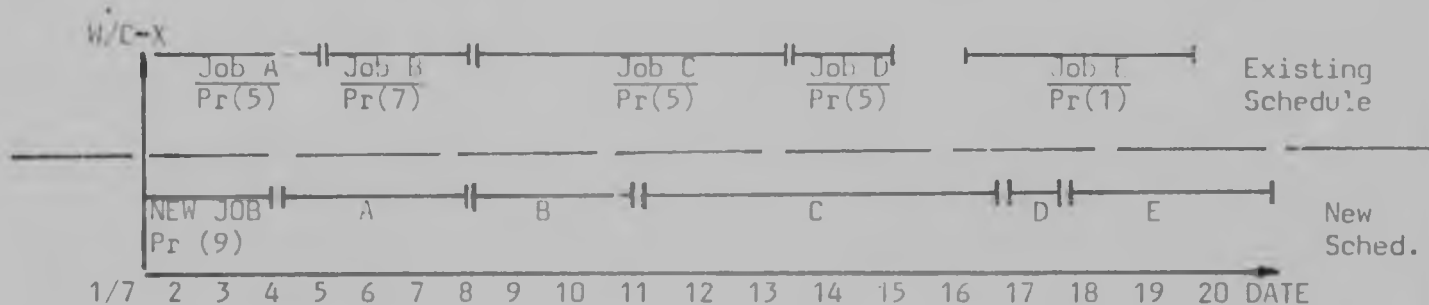
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It was understood very quickly by the customers that, if they wished to get their job done, they had to use priority 9.

However, short jobs which were real emergencies could not appear on the Daily Work List because of the great backlog and automatic load of jobs (superior priority).

W/C = Work Centre CSD = Current Start Date
FCFD = First Calculated Finish Date CFD = Current Finish Date

2.5. Modification of the system in order to rectify the situation

2.5.1. Analysis

The first step, was to find out the distribution of job priorities, job duration, capacity versus demand, backlogs and meeting of estimated times.

Findings:

- a) A significant finding, which contradicted the philosophy of the system, was that one customer was unaware of his job's priority in comparison with those of other customers. It was then decided to appoint a particular person in the Planning and Control Section, to determine the priority and due dates for jobs.

The appointee was an ex-Engineering Superintendent, with more than 30 years experience in the various plants throughout Modderfontein Factory. He undertook this job for more than 3 months. However, the exercise failed totally.

87...

- b) Another finding was that 45% of the total number of incoming jobs per month (500), are real Emergency or short jobs. All the others are Ordinary jobs which can be delivered within two months, or three in the case of awaiting spares.
- c) The average capacity required for Emergency jobs is 8% of the total. (For an analysis of Emergency job loading into the system, see Appendix 1).

A real Emergency job by definition is one which affects production. Hence, it must be completed within 24 hours of receipt, provided that problems such as outside ordering of material/manufacturing, quality control rejection, etc do not exist.

If processing Emergency jobs through the system and considering the above findings, means recurring changes to the existing schedule, this became one of the most important factors which upset CAPOSS, in our case.

- d) As Emergency jobs are sometimes completed before punching, their existence on the next day's work list means a boosting of waiting time. We found that the amount of waiting time due to this was, on average, 12, throughout the workshops, whilst the workshops capacity compared to input work was, theoretically, overloaded.

One could say that an on-line system could solve this problem. Theoretically, that would be correct, but as the volume of existing work in our system consumes large amounts of computer time per run, it is done only during the night.

- e) From discussions and interchange of ideas between workshops management and various plant engineers, it was clarified that our services are assessed using two factors:

- i) Quality of Product : Based on Factory agreed specifications
- ii) Quality of Service : Reasonable turnaround time and a constant delivery date with minor deviations (± 3 days)

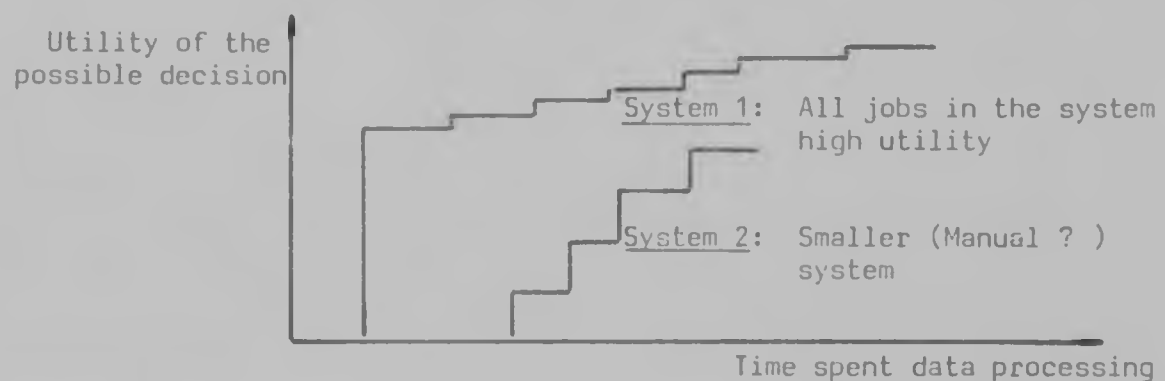
2.5.2. Discussion and decisions

a) Discussion

If the findings mentioned previously were discovered before introducing CAPOSS, it would appear that another system, with a different scheduling approach, was introduced.

As implementation of the 1980 Overall Study Recommendations was subject to the constraint of not eliminating CAPOSS, but modifying as required, a discussion on following a Systems Engineering approach for MIS, was held.

When considering the utility of MIS, the related idea is that different types of MIS cause different utility value as function of time spent for Data Processing. Assuming that CAPOSS is a very sophisticated system in relation to other systems, it can be illustrated as follows:



The idea behind this figure is that, if we can get quick answers in the first case, the more beneficial it will be to us. However, in System 2, we get an improved quality of ideas, in time.

The game is between getting the same suggested answer or quality of information from one system versus the other.

By modifying the system as described in subsequent chapters, we sacrifice gain due to delays but we gain an improved decision making and accurate delivery date system.

b) Decisions

Based on the findings already described and the above discussion, the following decisions were made in order to rectify the scheduling system:

There will be 2 systems: i) Manual Planning for Emergency jobs
ii) Computerized system for Ordinary jobs

The actions following this decision were:

- i) Allocation of an arbitrary capacity for emergency jobs (10%) and manual management of jobs from this class. (Emergency jobs procedure, paper work, printing into CAPOSS. Performance Measurement and reliability - See Appendix 2)

In future, the allocation of capacity for emergencies will be more accurate, as the new monthly report, "Emergencies per Work Centre", was introduced. (See Part B, Appendix 4). Using methods for forecasting, such as moving average, exponential smoothing, etc, will enable the analysing of hours required for Emergencies, from the data given in this report.

- ii) All other jobs will be called "ORDINARY JOBS" from now on. They will have the same priority (5) and the computerized system for these jobs should work on a real queue basis - First Come, First Served. This is done by giving due dates as per work centre and capacity, in the following way:

- i) Table 1 - Due Dates - State
- ii) Table 2 - Hours loaded per work centre - State

(Tables 1 & 2 - see Appendix 3)

Every operation of a new job coming into the system is allocated to the required work centre and the due date is determined, based on the latest due date of the work centre concerned. The due dates on the list are changed when the amount of hours allocated to the particular work centre is approximately equal to the capacity available in the work centre on a particular date. Figure 1 illustrates how this procedure is carried out:

Table 1 - Due Date State

Work Centre	M01	M02	S01	S02	F05	F06	C03	C04
Sequence	(1208	1206	126	1203	1211	1201	1198	1206
	(1209		1214				1199	1202
Running	(1210							1208
Due Dates	(							
	(							

Table 2 - Hours Loaded - State

Work Centre	M01	M02	S01	S02	F05	F06	C03	C04	B01	E02
Av. Capacity	49	41	36	72	189	116	38	62	280	
Hours Loaded	(16	0,5	38	16	172	24	13	112		
	(13	6	(2)	4	16		22	16		
	(18	3	13	12			(3)			
	(44	4								
	(3	2								
	(17	9	8							

Figure 1 - Determination of Due Dates

The data on these tables was extracted from various jobs, which are presented in the table shown in Figure 2. The numbers into the table are the hours required for operation as per work centre.

ORDER NO.	OPERATION - HOURS								DETERMINED DUE DATE	EXPLANATION
	M01	M02	S01	S02	F05	F06	C03	C04		
1	16	6	-	16	-	-	-	112	1208	M01 on day 1208, M02-1206, S02-1203, C04 required 2 days(1206,1207). New job coming will be on 1208
2	13	3	38	4	172	-	19	-	1211	M01 still on 1208, M02-1206, S01 required more than 1 day(1210,1211). New job on S01 will be on 1211 taking into consideration (2) hours consumed already S02-1203, F05-1211, C04
3	18	4	-	12	16	24	-	-	1211	M01-1208 next date w/c will be 1209, M02-1206, S02-1203, F05-1211, F06-1201
4	44	2	-	-	-	-	22	-	1209	M01-1209, M02-1206, C03-1198 (3) hours loaded on 1199)
5	3	9	-	-	-	-	-	-	1209	M01-1209, capacity for this date almost completed Next job will be on 1210 M02 - 1206
6	7	-	-	-	-	-	-	-	1210	M01 - New date 1210
7	-	8	-	-	-	-	-	16	1208	M02 - Still 1206, C04-1208
8	-	-	13	-	-	-	-	-		S01 new date 1211 (3 hours from previous job already loaded)

Figure 2 - Routing of incoming work

With this type of scheduling, there are gaps between jobs in the various work centres. An important feature of CAPOSS is that it eliminates these gaps, using the "PULL EARLY PROCEDURE".

By means of this procedure, the system loads the work centres on the basis of Maximum Capacity Utilization, as shown in Figure 3, and, as a result, eliminates waiting time. The Pull Early Procedure can be done up to 99 days.

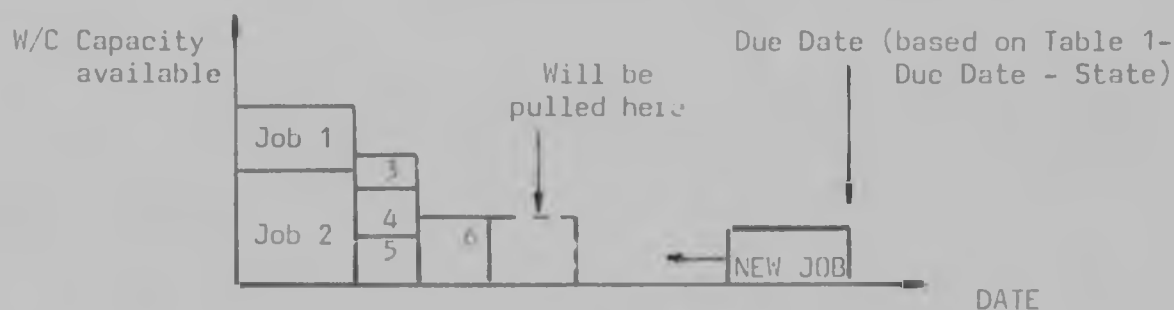


Figure 3 - Pull Early Procedure

SUMMARY:

The methods of scheduling as described above improved the policy of sticking to the First Calculated Delivery Dates significantly.

Nevertheless, there were still jobs with recurring changes to their FCFD, mainly jobs concerned with outside orders, quality control rejection, etc. These are dealt with in items 6 and 7 of this report. (Changes to CFDs due to the new scheduling approach - See Appendix 4).

2.5.3. Performance measurement & control

Control over the performance of the system is being done by the key result areas for the system, which are as follows:

- a) Emergency work : 95% of jobs are being delivered within 48 hours of receipt.
3% within 72 hours
2% within 10 days
- b) Ordinary work : 95% of jobs are being delivered on Adjusted due date $\pm$ 3 days
5% of jobs are being delivered subject to constraints and changes.
- c) Daily Production Programme : 99% of jobs on daily work lists should be completed on the same day, even if it will consume overtime.

- d) Master File Accuracy : 99% constant accuracy of data on the file.
- e) Punching : 0,1% errors on punching (average).
- f) Adjusted Delivery Dates : 0% of weekly errors on this procedure.
- g) Average Turnaround Time of Jobs in the System : 95% of total jobs - 5 weeks.

In order to stress the importance of having control over the system, a monthly report, based on these factors, was established.

The report is circulated by the Planning and Control Engineer to the Workshops Management, Engineering Department Management and the Industrial Engineering department.

2.6. Operation

After the system had been re-designed, the following steps were taken:

2.6.1. Initial operation

In order to achieve effective liaison between the Planning personnel and the users (i.e. Floor Management: Superintendent, foremen, Leading Hands), training sessions were conducted.

The training included explanation of the layout of the system, procedures, and the importance of having co-operation between Floor Management and Planning personnel.

Co-operation is in practice in the following areas:

- a) Completion of all jobs on the daily work list
- b) Feedback to Planning on problems regarding completion of the daily work list, such as:
 - Material not available
 - Waiting for a job from another Work Centre
 - Working overtime in the case of overloading because of emergencies
 - Strict discipline on meeting of estimated times
 - Co-operation with estimating office in order to become acquainted with job layouts, tooling, machine potential and instrumentation.

2.6.2. Retrospective appraisal of the scheduling system and improved operation

Determining delivery dates and adhering to them is the most important factor on deciding whether a system is successful or not.

A list of jobs was followed up during a few weeks, in order to find out if the CFDs were still being changed significantly.

It was found that the CFDs were being changed in cases where outstanding outside orders were awaited, thus changing the whole schedule.

This problem has been overcome by means of initiating a new procedure of determining due dates for jobs requiring outside orders. Supply Department buyers should adhere to and progress orders based on the new procedure.

Another finding concerned spares. Ordering of spares, not according to the lead time, has caused superfluous re-ordering of items, which affected the planning programme and resulted in excess stocks.

This problem has been solved by initiating a report to stores which included the delivery dates for Spares Orders and the lead time. This enables the stores to balance orders and to control re-ordering levels. (Delivery Dates and Lead Times Report - see Appendix 5).

3. DETERMINATION OF WORK CENTRE CAPACITY

An important factor on which scheduling is based, is the capacity of the various work centres.

It was found that, since introducing CAPOSS, the parameters for work centres, by the users, had not changed. It would be redundant to say that this is another factor affecting schedule accuracy and, as a result, one of the first activities when commencing implementation was to find out about backlogs, average efficiency per work centre, capacity required for emergency jobs and absence rate.

The analysis was based on available reports for management, which were not in use.

The results of this exercise were:

- a) Determining of capacity requirements. (For an example of an analysis in Factory Made Spares plant, see extracts from memorandum in Appendix 6)
- b) Allocating capacity to the various work centres, based on:
 - men available
 - efficiency (Performance Indices- report)
 - absence rate
 - capacity required for Emergency Jobs - as mentioned before, arbitrarily 10% at the first stage.(For an example of backlog analysis and determination of monthly work centre available capacities, see Appendix 7)

The task of determining capacity requirements for the various work centres, became an integral part of the responsibility areas of the Planning & Control Engineer, in conjunction with the Production Engineer, as it affects the overall scheduling performance, and, as a result, the quality of service given to the various plants by Central Workshops.

Another essential issue regarding capacity requirements, is the hours required for planned shutdowns.

When we asked what happened in this case, the answer was:

"In shutdown periods, the system is out of control".

However, this is an anti-system approach and we soon found that it is possible, by means of available data from previous shutdowns, to predict the capacity required from each work centre.

The solution is to allocate these known capacities to the Emergencies System as shutdown jobs are dealt with by this system.

4. PLANNING SECTION

4.1. Organization Structure

A part of the 1980 Overall Management Study Recommendations referred to the Organization Structure of the Planning and Control Section.

Based on the structure envisaged in the above report and the performances required from the Planning Section in particular and Central Workshops generally, a new organization structure was drawn up.

This consists of 2 main units:

- a) A Planning unit - responsible for:
 - Computer and Data control
 - Liaison with estimating office
 - Providing work lists and reports
 - Materials procurement
 - Materials preparation
 - Administrative convenience
- b) A Progressing unit - responsible for:
 - Progress of ordinary work in the various work centres
 - Progress and control of emergency work
 - Deliveries
 - Liaison with Floor Management
 - Liaison with customers
 - Feedback to planning unit

The idea behind this approach is that Planning deals with pre and post production stage activities and Progressing deals with production stage activities.

(Planning & Control Section - Organization Structure and Functions involved - Appendix 9)

4.2. Key Performance Areas

To determine the KPAs for the Planning section, four major factors were considered:

- Meeting of targets as set out in item 2.5.3. of this report
- Quantitative measurement of performances
- The performance level aimed at
- Simple enough to control and measure

The format used for this exercise is shown in figure 4 below.

It was carried out in such a way that every incumbent prepared KPAs for his subordinates, from the top to the bottom of the organization structure, with the assistance of the Planning and Control Engineer. The idea behind this was to achieve a commitment to and a better understanding of control and measurement by all Planning Section personnel.

Appendix 9 to this report consists of the key performance areas for all Planning Section personnel.

POSITION TITLE:

GRADE:

DATE COMPILED:

KEY PERFORMANCE AREAS	MAIN ACTIVITIES	PERFORMANCE STANDARD	WAYS TO MEASURE PERFORMANCE
Performance outputs	Detailed tasks and operations	Quantative achievement of tasks and operation	Quantative as possible target for tasks and ways to measure it: Reports, data, etc.

Figure 4 - Format used for compiling key performance areas

5. LONG TERM JOBS

5.1. General

At the beginning of implementation, there were 216 jobs, out of approximately 1350, which had been in the system more than 90 days. Of these 216, 41 were more than one year in the system.

The distribution of residence time was as follows:

Residence (days)	Quantity	%
0-10	305	22.7
10-20	241	17.9
20-30	154	11.4
30-40	108	8.1
40-50	108	8.1
50-60	83	6.2
60-70	52	3.8
70-80	32	2.3
80-90	49	3.6
90-100	13	0.9
100-125	60	4.6
125-150	30	2.2
150-175	29	2.1
175-200	21	1.6
200-225	16	1.2
225-250	6	0.4
250-300	17	1.3
300-350	15	1.1
350-400	4	0.2
400-450	2	0.1
450-500	1	0.05
500-550	1	0.05
600-700	1	0.05
TOTAL	1348	99.95

(Histogram of residence time - Appendix 10)

As the established target for turnaround time is 5 weeks (25 work days), action was taken to eliminate the large backlog.

This was done in 3 main stages:

1. Completion of jobs more than 200 days in the system.
2. Completion of jobs more than 90 days in the system.
3. Completion of jobs more than 60 days in the system.

5.2. Action Taken Stage 1

A few interesting facts were established when taking action in order to eliminate the backlog.

As the first group we dealt with was that of jobs more than 200 days in the system, we asked the Plant Engineers if they still required these jobs:

19 of the total number (41) were unknown or had been ordered by personnel no longer working at the plant

19/...

13 were waiting as a result of partial rejection by Quality Control because there were no procedures in planning to deal with such a problem

9 were waiting on outside orders for more than a year, and in the meantime, the plant had purchased them through an outside contractor

This part of the exercise led to the establishment of Quality Control procedures, spoiled work and placing outside orders by planning, in order to avoid the above phenomena.

Further details on these issues are given in items 6 and 7 of this report.

Stage 2

At this stage, more than 133 jobs with a residence of more than 90 days in the system, were completed. This was done by transferring these jobs from the ordinary system to the emergency system and by working overtime.

We found that, under normal circumstances, this is almost the upper limit of capacity available and we began drawing attention to the manpower problem. This will be dealt with in item 8.

Stage 3

As the constraint of capacity limited us in the number of work hours available, this stage is still being carried out slowly, as the shortage of artisans was too high in the first months of implementation.

An important factor concerning this issue was the use of an "ORDER-RESIDENCE" weekly report (see part B - Appendix 4), which gives a residence range to all the jobs on the list.

It was designed in such a way that, as this report is received, the last 2 groups of jobs should be pulled from the ordinary system and put into the emergency system and completed. However, as said before, difficulties were encountered when coming to jobs more than 60 days in the system.

6. PLACING OF OUTSIDE ORDERS

6.1. General

One of the reasons for recurring changes in delivery dates promised to the plants, was the long delay in receiving outside orders.

The procedure for placing these orders is shown in figure 5 below.

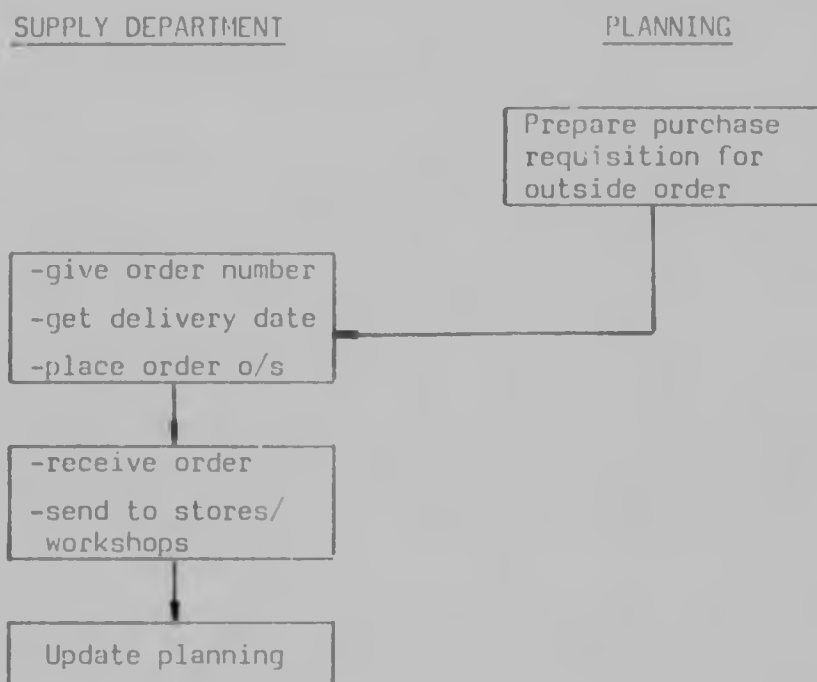


Figure 5 - Placing outside order procedure

The situation was that there was little control over outside orders or the quality of work done outside. Therefore, weekly meetings of the functions involved were held consisting of in-depth discussions on ways of placing outside orders for materials or manufacturing.

These meetings were on behalf of the Planning & Control Engineer and the Supply Department Manager. Those participating were:

- Supply Department Buyers
- Planning personnel from the Workshops
- Stores Manager - Supply Department
- Quality Control Engineer - Workshops

Three major problem areas were discussed and solved:

- a) The need to streamline the procurement system, including Quality Control Inspection, expediting and reject control.
- b) The need to avoid an "all your eggs in one basket" situation by arranging alternative supplier support.

- c) Backlog situation of materials resulting in upsets in CAPOSS and workshop planning and the ineffective delivery of components to customers.

6.2. Placing outside Material/Manufacturing order - Overall solution

A supplier and manufacturer list has been drawn up giving the estimated delivery periods of all suppliers currently used by Supply, on behalf of the workshops. Supply Department validated this list as being acceptable to them. This list forms the basis of workshops planning - estimating a delivery period for a component prior to advising the customer of the delivery date. For example, a component requiring casting and a pattern, would have delivery as follows:

Pattern making	=	5 weeks
Casting	=	15 weeks
Machining time	=	1 week x Factor of 3 = 3 weeks
Total	=	delivery of 23 weeks

For FMS components, the same system is used but incorporates a 4 week period covering the initial administration period between computer call up of a component and workshop planning receiving the order. The list will be updated quarterly to ensure that realistic delivery times are being maintained and used. (Approved list of supplier and manufacturer delivery time - Appendix 11)

When Supply receives an order, they will negotiate with the supplier to determine actual supplier delivery time and cost. They will inform Quality Control and workshop planning by sending the initiator copy of the order to them giving the negotiated and agreed delivery date. "Order by dates" given by a supplier must be worked according to Report 46 - Listing of outstanding orders - see Appendix 12. Planning controls outside orders according to Report P18 - see Part B Appendix 4.13.

A customer, on being advised of a delivery date, will either accept or reject it. Should rejection be because of the job being an emergency etc., e.g. planned shutdown work being done, Planning and Supply are in a position to perhaps negotiate with the supplier as to an improved delivery - this however, should be the exception not the rule.

6.3. Order inspection of expediting

All orders are subject to Quality Control monitoring. Quality Control advises the Supply and Planning departments, by means of a weekly progress sheet, of orders being manufactured.

Orders which are falling behind schedule are listed on the progress sheet and expedited by Supply department to ensure maintenance of delivery date.

6.3.1. Rejects

Quality Control, upon determining a reject situation, immediately informs the supplier and advise rework or immediate remake. Rejection notes and order documents are then forwarded to the buyers at Supply department for official notification and action. Planning department is also advised of rejects, in case there are amendments to the planning system. A weekly advice sheet detailing rejections is given to Supply and Planning.

Rejected components, if not collected by the supplier at time of rejection advice, are delivered to supplier by Stores, under the present system.

6.4. Backlog

The first step taken on this subject was to determine new delivery dates using the new procedure for placing outside orders. As it was a special effort, notice was given to the various suppliers. They collaborated and all outstanding orders were delivered within 6 weeks.

6.5. Alternative suppliers

As there were suppliers with long delivery periods and deteriorating quality of product, it was decided that:

A concentrated effort will be initiated to determine alternative suitable sources of supply. Supply Department shall undertake to approach such suppliers and submit names to Quality Control Engineering for assessment and audit.

Before this commences, supplier specification sheets, detailing supply requirements, shall be prepared, covering the various aspects of supply, i.e. quality, cost, delivery.

Specification sheets shall be prepared as follows:

1. Quality Assurance Criteria
2. Cost Criteria
3. Delivery Criteria

Completion of these sheets by a prospective supplier shall form the initial audit of the supplier. Quality Control Engineering, with support from other specialist sections as required, shall conduct the supplier audit and shall advise, in writing, acceptance or rejection of the supplier to Supply Department.

7. QUALITY ASSURANCE

7.1. Procedures

As mentioned before, not having set Quality Control procedures, led to such situations as rejected work and work under inspection lying on the shop floor for a considerable time without anyone being aware of their existence.

There was full participation in the preparation of this procedure by the Planning & Control Engineer and the Production Engineer, as it affects their shop's performance.

The factors taken into consideration were; responsibility areas, inspection control in the shop and on-site, batch inspection, non-batch inspection, reject control, equipment calibration and reports required for various management levels in the shop and in the Engineering department. (Quality Assurance Standard-Appendix 13)

7.2. Spoiled Work

When dealing with spoiled work, we found that jobs were being "stacked" on the work lists and in the system for a considerable time because Planning personnel did not know what to do when this happened.

There are three possible reasons for spoiled work:

- a) Scrapped after intermediate operation
- b) Scrapped after final inspection
- c) Partial batch being rejected

A detailed procedure for dealing with spoiled work from a computerised system point of view, was written and, as a result, these jobs are identified on the master file, controlled and progressed. (Spoiled Work Procedure - Appendix 14)

7.3. Rejected Work

As Quality Assurance operations improved, the quality of work done by the workshops improved as well.

Comparing figures of rejected work in 1980 to those for 1981 gives the following results:

	1980	1981
<u>Machine Shop</u>		
Standard hours worked*	21690	36890
Average % rejected work	9,36	4,2
% required remake	5,52	2,1
% accepted as substandard	3,84	2,1
% production time for remake	1,24	0,72
<u>Fitting Shop</u>		
Standard hours worked*	14381	25860
Average % rejected work	5,77	4,3
% required remake	2,44	3,1
% accepted as substandard	3,33	1,2
% production time for remake	-	0,4
<u>Factory Made Spares</u>		
Standard hours worked*	31112	33200
Average % rejected work	4,88	2,9
% required remake	3,56	1,1
% accepted as substandard	1,32	1,8
% production time for remake	-	-

* only skilled artisans due to the accounting system/method used

There is indeed an improvement in quality of product, although the large number of artisans, of various disciplines, recruited during the second half of 1981, may have added to the problem.

8. FLOOR MANAGEMENT : PROCEDURES, REGULATIONS AND TRAINING

8.1. General

When dealing with shop floor Management, irregularities regarding management method, discipline and reporting procedures were found.

Most significant were:

- No commitment to the work lists by the Foremen
- Plant personnel pushing jobs forward by virtue of their personal relations with Foremen
- Foremen doing jobs which did not appear on the Order File
- False reporting of hours invested for manipulating the Bonus Scheme
- No feedback to Planning on completed jobs
- High ratio of scrapped work in certain work centres
- Jobs on first day of the work list (Times Schedule) for more than 90 days and sometimes, even longer, without being done (See Appendix 15)

It is difficult to change work habits of a Foreman after many years of working in a certain way, but obviously, in our case, it was essential.

We attempted to do so by means of meetings, explanations, extra training, etc., but resistance to change was high. It must be remembered that the pride in their work once felt by tradesmen in this country (and all over the world), is lost and, as a result it is very difficult to motivate these people. We decided to do this through upgrading one of the Foremen. This exercise was very successful. The will to prove ability and gain upgrading motivated floor management to collaborate and from this stage, things began to move smoothly.

8.2. Daily Work List

As it is essential for the workshop not to deviate from promised delivery dates, work lists should be completed, as per schedule, every day.

The regulations we established regarding work lists are as follows:

8.2.1. Work Lists

- a) Work lists will be issued to all leading hands/foremen by 8 a.m. daily.
- b) The jobs shown on the work list will be commenced in the sequence shown on the list.
- c) The system of marking progress will be as follows:
 - i) Artisan's job card received: Underline the operation in red with a ballpoint pen, from the beginning of the line to the "quantity" column.

- ii) Job in progress: Underline from "quantity" column to "Insp" column.
- iii) Job completed: Underline from "Insp" column to the right hand margin.
- d) Problem jobs must be sorted out immediately. If the leading hand or foreman cannot solve the problem, it must be handed to the Planning department immediately.
- e) All work lists for the previous day must be sent, by messenger, to the Production Engineer by 10.00 a.m. daily. They must be correctly marked up. Problem jobs must have a brief explanation.
- f) Planning receives the marked work lists, checks and identifies problem areas, correct errors and checks if feedback cards were sent.

The above regulations help Planning a great deal in the accuracy of the Master File and various reports, as the following activities are done:

- a) Jobs which are scheduled but are still in a previous work centre (including inspection work centres) must be progressed by the progressor.
- b) Jobs with wrong material or a shortage of material are dealt with by the loader or material procurer, and results in updating of data.
- c) Jobs with routing/specification problems are referred to Estimating for immediate action.
- d) Jobs which are rejected but may be acceptable to the plant, are dealt with by Quality Control as quickly as possible.
- e) Jobs with drawing problems are referred to Quality Control for immediate action.
- f) Problem jobs which cannot be continued within 24 hours are re-programmed by Planning. Foremen notify Planning so that this can be done.

B.2.2. Partial feedback

It was found that one of the reasons for excess booking of waiting time was that there was no partial feedback on jobs requiring longer than 1 day's work. The system continued scheduling, based on the original duration of the job. In many cases, when a job required more than the daily capacity of the work centre, this was the only job on the work list, while the capacity could be utilized for more work.

Nevertheless, before implementing the Real Queue approach, having no partial feedback could result in work already started being pushed backward in the queue. Partial feedback gives the operation the highest priority (99) on the work centre's queue. The basic rules regarding partial feedback are as follows:

- a) Partial feedback information must be completed and sent to Planning by 3 p.m. each day, as the system is run every night.
- b) Any operation in progress at 3 p.m. and will definitely be completed the same day, will be considered as complete and a copy of the job card sent to Planning. Planning submit the feedback card, as the job should not appear on the next day's work list.
- c) Any operation which has up to 5 hours work remaining to be completed the next day, does not require partial feedback.
- d) Any operation which has over 5 hours work remaining to be completed the next day, does require partial feedback information.

8.2.3. Jobs appearing on first day's work list not being done

The importance of adhering to the daily work lists was stressed at all the weekly Foremen's Meetings.

The percentage of jobs in each work centre which are scheduled 1x, 2x, 3x and "4x and over", are used as one of the measures of each foreman's performance. The calculation is done, approximately, monthly.

The objective is to maximise the number of jobs which are done the first time they are scheduled (1x).

Before introducing this measure of performance, the overall figures for the workshops were as follows:

Times Scheduled:	01	02	03	04 & over
May	13%	12%	10%	65%
June	25%	20%	11%	44%

There were two target stages in the implementation of this issue:

	01	02	03	04 & over
Initial	60%	20%	10%	10%
Final	70%	25%	4%	1%

When judging performance, allowances are made for:

- a) Long jobs which accumulate the time scheduled.
- b) Volume of emergency jobs which will delay planned jobs.

8.3. Standard Times for Jobs

It is important that the Standard Time for a job is a fair time. If problems are encountered in achieving the time shown on the job card, then the estimator must be consulted in order to check the time.

The following are the most common reasons for not achieving standard time:

- a) The method has changed. This may be a justified change (in which case, additional time will be allowed), or it may be that the wrong method is being used, in which case, no additional time will be given.
- b) Extra work is required, which could not be forecast. Extra time should be given.
- c) The man is inexperienced, resulting in a longer time being taken. No extra time will be given.
- d) The job is more difficult than was estimated. The estimated time will be corrected.
- e) An error in estimating. The estimate will be corrected.

We stressed that it is wrong to assume that because a department is not on bonus, the standard time does not matter. Performance Indices are calculated and should show the time OPs and DP for department. If the standard times are corrected, it will probably show that the men will earn bonuses.

It is also wrong to say that a job can be allowed to take longer because the man will be on waiting time if he finishes the job earlier. This is overcharging the customer. It also lowers the OPs and DP.

The solution to the above problems is achieved through the following:

- Increasing the frequency of shop floor visits by estimators to check standard times.
- Foreman and leading hands to check if the standard times are being achieved by job basis and to get the estimator to check the problem jobs.

8.4. Training and Motivation

On looking into the training services offered by the Company, it was found very necessary that training should be improved within the Central Workshops.

Training was given mainly to two groups:

- a) Artisans
- b) Foremen

8.4.1. Artisans

A Training Officer was appointed and training programmes were drawn up. These consisted of:

- Refresher courses
- New tooling and fixtures
- Exercises
- Examinations

The action programme is being carried out in conjunction with the Foremen, based on requirements and identified weak areas in the various work centres.

8.4.2. Foremen

Training consists of courses on development of management skills outside the Company, Estimating, Planning & Control, simple applications of computers in production, costing and technical courses as per request and recognition of needs by the Company.

8.4.3. Summary

A great deal of work was done with the shop floor personnel in order to increase motivation and consequently, improve performances and the service given by the workshops. We tried to devise a merit scheme for artisans but encountered resistance from high level management in the Company. However, they accepted the alternative, which was a special increment of more than 10% to all Engineering and Maintenance personnel, including staff personnel such as Superintendents and Foremen.

Indeed, this, together with the introduction of the Bonus Scheme described in item 10, helped considerably in improving performances and in the recruitment of artisans.

9. ESTIMATING

9.1. General

As scheduling is based on estimated time, it is redundant to say how important the role of estimating personnel is in the execution of the Planning & Control system.

In the beginning, we investigated, through work study techniques, estimating accuracy. Having found that this was reasonably accurate, we then investigated the possibility of introducing a computer into the estimating section or introducing quick estimating systems such as coding and slotting.

The main area we concentrated on were:

- a) Liaison with the shop floor
- b) Feedback
- c) Specification and drawings
- d) Liaison with Planning

9.2. Liaison with shop floor

Every estimate should be reviewed and studied by the Foreman/Leading Hand in order to become familiar with the layout used by the estimator, machine feed and speed, tooling required, jigs, fixtures and timing. This means that shop floor management is responsible for artisans working to the estimate method under prescribed conditions.

If the Foreman/Leading Hand feels that the operation's estimated time is too tight or vice versa, it is his responsibility to bring it to the attention of the estimator and reach some sort of agreement.

9.3. Feedback

The best way for estimators to check their performance is to go the shop floor more frequently.

A random schedule for carrying out work studies, work sampling and watching the artisan actually doing the job is practised and used to verify estimates, updating times and methods and gives an indication to workshop management of efficiencies/performances on the floor.

9.4. Specifications and drawings

It was found that, in many cases, the wrong item was estimated and produced as a result of vague specification by the plant and insufficient space on the Engineering Work Order. Since this problem lies outside the boundaries of Central Workshops, we found it useful to introduce a CHECK LIST for the originator in the plant, in order to verify that all the required data, drawings, sketched and descriptions are available, before submitting the order.

If there is insufficient space on the Engineering Work Order or a drawing is not available, the originator can use a continuation sheet. (Engineering Work Order, Check List and Continuation Sheet - Appendix 16)

9.5. Liaison with planning section

The major work groups for estimating are:

- a) Repeat work, spares
- b) Emergency
- c) Projects
- d) Development

As repeat job estimates are filed and maintained, we found that a more useful and efficient way of getting the card in the planning section can be done by transferring 4 estimators (one for each trade) to the planning section.

They are entitled to deal with repeat work, short jobs, spares and emergency jobs.

Another benefit gained by doing this, is the technical ability required by the planning section on receipt of orders and negotiating with customers. A detailed report for re-organization of the estimating function with job layout was prepared and this is being implemented at present.

Appendix 17 to this report consists of the procedure followed by FMS-estimator planner and plant job-estimator planner.

10. BONUS SCHEME

10.1. Background

On investigating Central Workshops history regarding bonus schemes, we found that, for many years, it had not been done properly, but consisted of ad hoc systems and schemes for different work centres.

The systems were established mainly to prevent unrest in industrial relations and, as such, were often eliminated and re-introduced.

All of these systems were managed manually by non-qualified personnel as a result of the high turnover rate in the Work Study department.

When the new costing system was introduced, a part consisted of a new computerized bonus scheme. The system is computer based but the Inputs are derived from Engineering Time Cards coded by the artisan. (Engineering Time Card - Appendix 18) It's apparent however, that if an artisan has to feed the system with data such as standard time, time taken, work order number, cost centre, etc., it will result in total failure. We found that artisans in some cases were getting more than 9 times their basic salary as a monthly bonus. Other severe malpractices were found, thus we quickly abolished the scheme, without even trying to explain it to the Factory Industrial Relations Officer.

10.2. New bonus scheme

As the work input increases continuously because of new plants being put on-line and expansion of existing plants, we aimed at increasing productivity by 15 - 20%. This can be done by a "true" incentive scheme, based on 100 - 133% approach, as shown in figure 6.

This type of system is in use in Israel and the USA and forces the participants to increase productivity in order to earn more money. With this system, a bonus of more than 33% means that something is wrong with the standard time. The scheme is different from any others being applied at Modderfontein and, as a result, we had to discuss it with the Industrial Relations department. We succeeded in selling the scheme because we had support from high level management in the factory and also because the timing was right, i.e. immediately after a high increment had been given to the artisans.

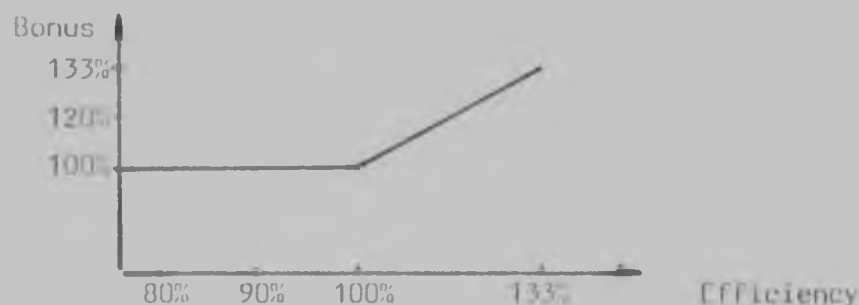


Figure 6 - 100% - 133% incentive scheme

10.2.1. Principles

The implemented scheme does not have manual interference on inputs. CAPOSS as a planning system has as one of its tasks, the preparation of work list print operation cards, based on the daily work list, for bonus scheme purposes.

The operation card consists of all data available for bonus computation, except the time taken, which is done by clocking the card. (Recommended Operation Card - Appendix 19) A timekeeper has been appointed in the workshops to control the system.

The procedure is as follows:

- a) When a man wants to start a job, he goes to the timekeeper, takes the appropriate operation card and fills in his name and check number.
- b) The man clocks the card on commencement and completion of a job.
- c) Upon completion of a job, a new operation card is taken and the same procedure applied.
- d) At the end of the day, the timekeeper extracts from the cards the time taken for each operation. If the total time taken is less than the duration of the shift, he will add 00 operation card - non-measured time, for the time required to complete shift duration.
- e) After all the cards have been collected and checked by the timekeeper, they are sent for punching.
- f) The basic data on the operation card is stored on diskettes, thus the only punching done is that of check number, status and times.
- g) The next morning, a printout of bonus percentages as per completed operation cards, for each artisan, is available.
- h) Uncompleted operations will be calculated as soon as the appropriate coding is written on the operation card by the timekeeper.
- i) Copies of the Incentive Scheme Report is sent to Wages department, who then pay the bonus amount shown.

10.2.2. Operation Card - Explanation

This item gives a brief description of the operation card, parameters considered and factors involved in the scheme.

SPACE	DESCRIPTION	EXPLANATION	INPUT SOURCE
1-9	CAPOSS No.		Route Card/CAPOSS
10-13	OPERATION		"
11-16	W/C		"
17-50	Description		"
51	T	Type of job: Ordinary, Emergency, unmeasured, overtime, evening shift, night shift	"
52	P	Number of people planned to do the job	"
53-56	S. Time	Standard time	"
57-60	T. Taken	Time taken: Coded for punching by timekeeper	Clock/Timekeeper
61-64	O. Time	Overtime	"
65	C	Call out, weekend	Timekeeper
66-71	Check No.	Artisan's Co. No.	Artisan
72	S	Status: Artisan, Leading Hand, Apprentice, Adult Trainee	Timekeeper

We see from the above table that, in contrast to the previous system, only one input is given by the artisan under this system, namely his check number. Moreover, the operation card is designed in such a way that the Foremen/Leading Hand will insert the data on time taken, overtime code, check number and status, and will then sign the card for his control and these will be checked by the timekeeper who inserts the data on the upper row, from where punching is done.

10.2.3. Reports

These are still being worked on at present. In general, the major reports will be as shown in figure 7 on the following page. The reports will give the efficiency percentage and hours gained and Wages department will give them monetary values.

FREQUENCY	REPORT	MARK	INDEX-BASED	FOR USE BY							REMARKS
				FMN	FST	PLN	MGT	WAG	ARN	IE	
Daily	Bonus hours per operation	BD1	Check number	X				X			Total summaries derived from these reports.
	Efficiency % per operation	BD2	CAPOSS Op. No.	X	X	X					
	Efficiency % per work centre	BD3	Work Centre	X	X		X				
	Unmeasured hours	BD4	Work centre	X							
Weekly	Bonus hours per operation	BW1	Check number					X	X		"
	Daily unmeasured hours	BW2	Check number			X			X		
Monthly	Average efficiency % per operation	BM1	CAPOSS Op. No.		X		X			X	"
	Average efficiency % per work centre	BM2	Work Centre	X	X	X	X			X	
	Total bonus hours per operation	BM3	Check number	X			X			X	

KEY

FMN - Foreman MGT - Workshops Management
 EST - Estimating WAG - Wages
 PLN - Planning ARN - Artisan
 IE - Industrial Engineering

Figure 7 - Recommended Reports

The basic format used for reports is shown in figure 8 with insignificant differences between the various reports as a result of different Index-Basis.

Work Centre:-----

Date: -----

CHECK NO.	INTLS	CAPOSS NO.	OP NO.	TP	PD	STD TIME	TIME TAKEN	OVER TIME	EFF %	BONUS HOURS
1	4	8	12	16	20	24	28	32	36	40
41	45	49	53	57	61	65	69	73	77	81

INDEX:

ST - Status PD - Planned number of men
 TP - Type of work EFF- Efficiency

Figure 8 - Basis format for reports

10.3. Summary

The main reason for adopting a 100%-133% scheme is to increase productivity rather than awarding increments. Under the 75%-100% scheme every standard time was reduced by 1/3, resulting in reduction of available capacity by 1/3, or paying 33% more for capacity available. The idea behind implementing our approach is that, we believe for basic salary basic output should be produced and standard times, as they consist of relaxation allowances up to a maximum of 22% (in our workshop), present basic output required to be produced.

11. COSTING

In order to obtain a true picture of workshops Management in money terms, a new costing system was introduced into the workshops at the end of 1980. This system is part of an overall computerized costing system in use throughout the Factory.

The actual costs of a job, i.e. labour, materials and overheads, are collected against the workshops work order number. On completion of the job, the cost is charged to the plant as an actual "contract services" cost.

The introduction of the system was phased as follows:

December 1980:	a) No overheads charged
	b) Materials debited directly to the plant's work order number
January 1981:	a) Overheads charged
	b) Materials collected against workshops work order number and recovered on completion of job
April 1981:	a) Actual charges to plant are the estimated cost of the job rather than the actual cost

Working subject to the final phase, required each work centre to meet times given by the estimators, minimum of waiting time, true picture of materials used, and monitoring of all orders placed outside by Central Workshops. However, costing using estimated times, could only be started by the end of November 1981, and problems are being experienced on true materials costing.

The reasons for not having qualified materials costing procedures are due to the following:

- Manufacturing orders being placed outside by 2 functions, namely Planning & Control and Spares Co-ordinator.
- Spares costing system being managed for both shops by Factory Made Spares, thus complicating the system and resulted in many of the Central Workshop jobs not being credited.
- Tailoring the system to a shortage of manpower situation in the costing department.

Temporary arrangements and procedures for placing outside orders and costing were prepared in order to collect all costs and overcome shortfalls. However, it was emphasized that the costing system should be revised and re-organized throughout the whole Engineering department of the Factory.

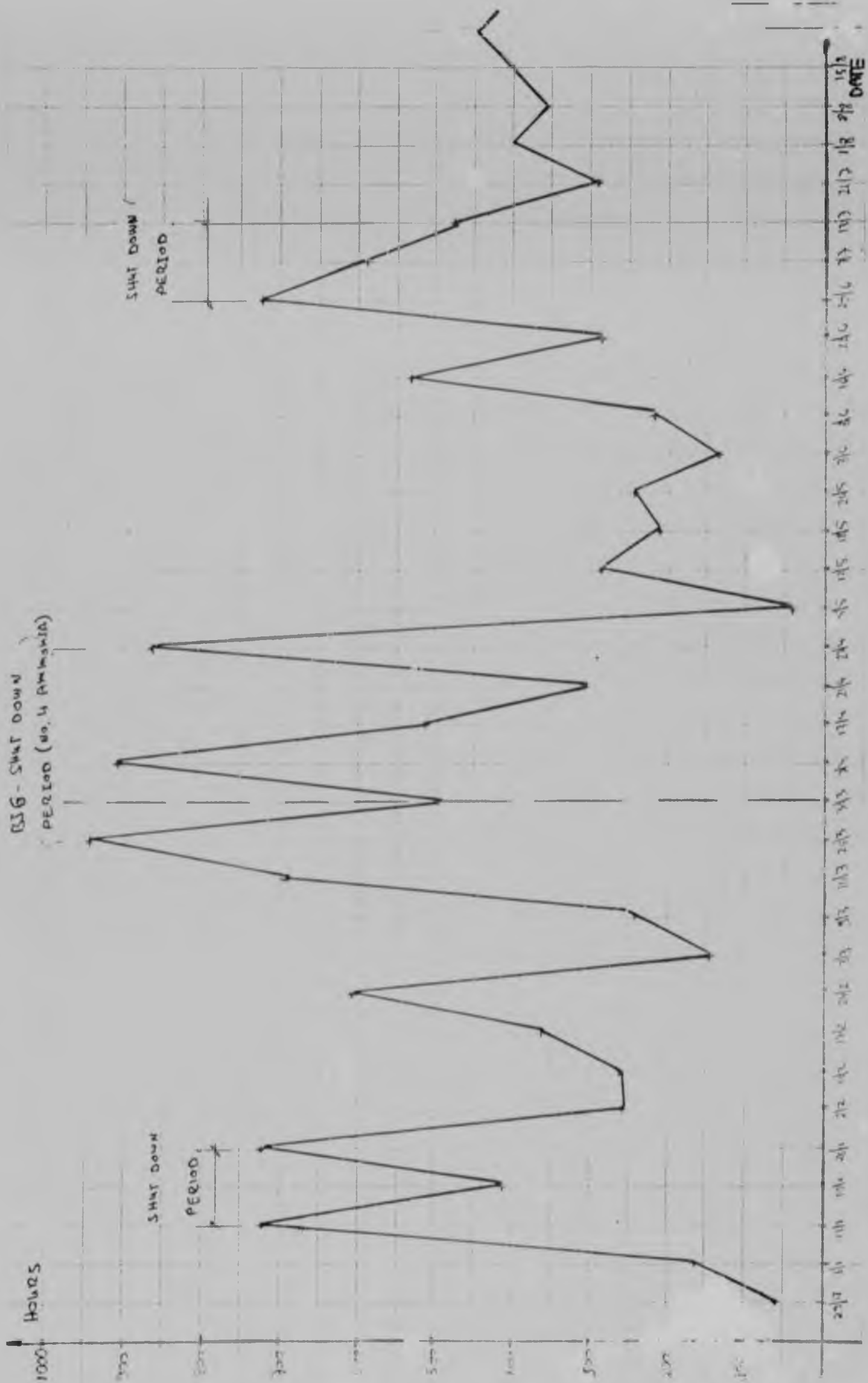
From the point of view of Central Workshops, we envisage that as Planning allocates jobs to Factory Made Spares and places outside orders, all costs should be credited to us as the costing centre and we will credit the various outside suppliers, manufacturers, as well as Factory Made Spares.

This principle was agreed to by the Chief Engineer and Costing Department and is being implemented at present.

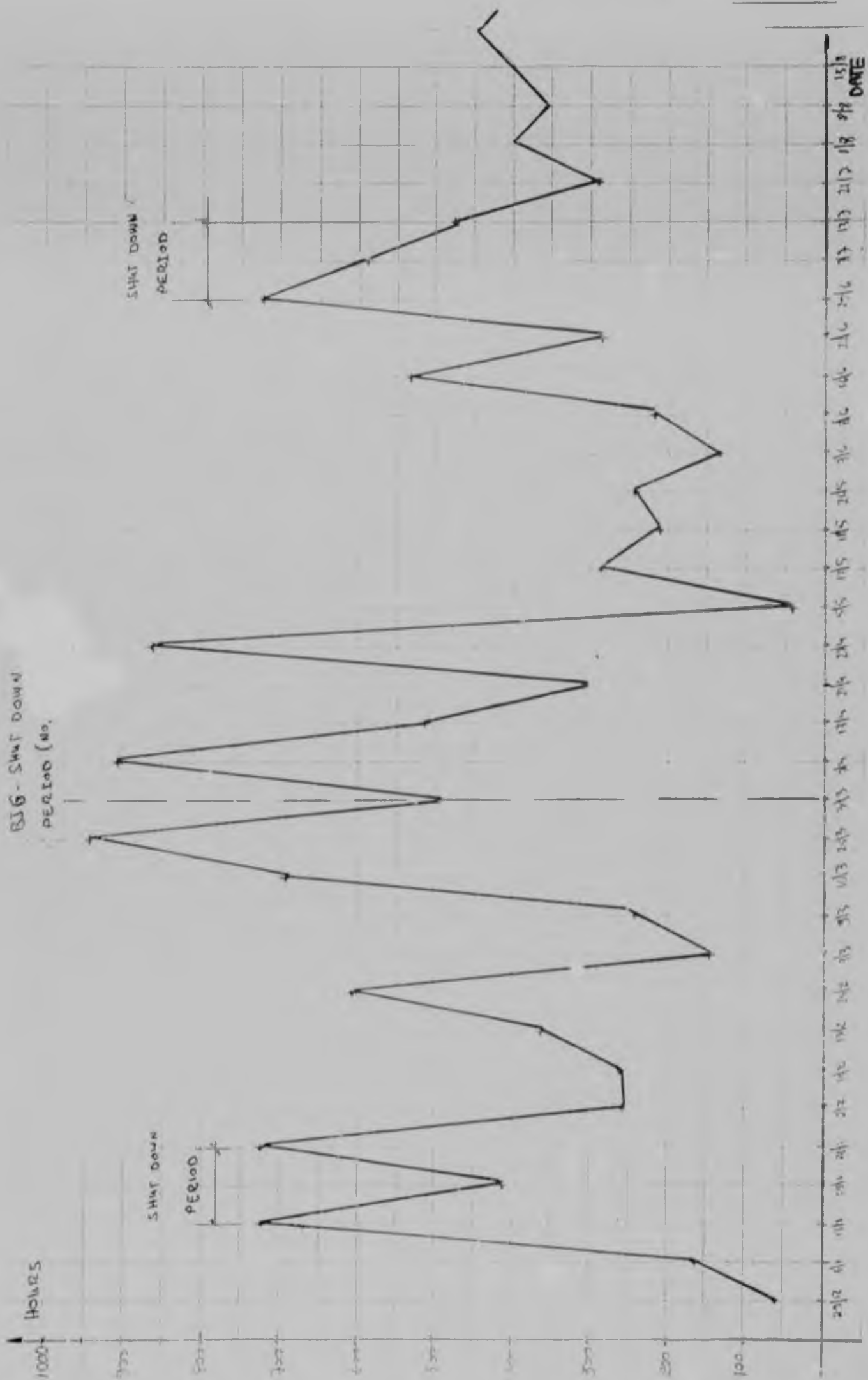
A P P E N D I C E S

- 1 : Emergency Jobs Loading into the System
- 2 : Emergency Jobs
- 3a : Planning & Control Section Delivery Dates - State
- 3b : Planning & Control Section Hours Loaded per Work Centre - State
- 4 : Changes in CFDs due to the new scheduling approach
- 5 : Amendment List to the Stores System Delivery Dates & Lead Times
- 6 : Factory Made Spares (Isando) - Capacity requirements
(Extracts from memorandum)
- 7a : Backlog & Incoming Work
- 7b : Monthly Work Centre Capacities
- 8 : Planning & Control - Organization Structure
- 9 : Planning & Control - Key Performance Areas
- 10 : Jobs Residence Time
- 11 : Approved list of Suppliers and Manufacturing Delivery Time
- 12 : Report 46 - Listing of outstanding orders
- 13 : Quality Assurance Procedure Standard
- 14 : Spoiled Work
- 15 : Illustration - Times Schedule
- 16a : Engineering Work Order
- 16b : Engineering Work Order - Check List
- 16c : Engineering Work Order - Continuation Sheet
- 17a : Estimator Planner - FMS job request procedure
- 17b : Estimator Planner - Plant job request procedure
- 18 : Engineering Time Card
- 19 : Bonus Scheme - Recommended operation card

EMERGENCY JOBS LOADING INTO THE SYSTEM



EMERGENCY JOBS LOADING INTO THE SYSTEM



	207	197	187	227	217	196	46	205	126	125	55	214	215	136	74	593	253	163	33	3/3	204	192	222	131	51	2012				
2 AMMONIA	16	27	127	39	33	52	42	4	24	112	78	2	63	40	67	375	341	103	25	126	42	198	113	99	40	88	51	233	43	0
NITROGEN	14	3	43	3	23	0	4	5	3	33	7	1	0	5	34	0	27	39	4	2	2	5	46	2	7	86	43	0	2	
DETONATORS	26	27	15	11	0	15	0	3	8	0	15	0	2	46	2	14	0	67	103	10	0	15	9	28	10	3	19	45	0	7
BLASTING EXPLOSIVES	28	3	9	48	40	14	49	17	43	31	83	4	26	36	118	47	58	200	37	15	28	5	13	25	80	41	19	30	0	11
FUSE	1	0	39	30	17	0	6	66	0	0	6	0	0	0	9	0	0	34	0	1	36	68	8	16	12	64	42	119	7	0
4 AMMONIA	2	29	13	8	0	0	0	1	8	14	21	4	36	26	13	64	10	30	2	34	4	0	0	23	0	18	5	20	5	13
CHEMICALS	53	46	58	33	27	44	24	43	11	8	9	5	18	1	53	68	7	119	3	2	6	120	70	7	29	0	12	38	33	0
POWER STATION	32	0	0	11	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	3	2	0	21	4	11	0	0	13
ELECTRICAL INSTALLAT.	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
CENTRAL WORKSHOPS	3	0	14	0	0	10	0	3	8	0	0	3	0	0	0	16	20	3	19	10	0	0	0	0	10	6	16	26	0	0
TRANSPORT	4	20	103	0	12	2	26	10	25	21	21	0	3	23	22	3	0	172	11	0	229	2	1	19	33	4	8	0	2	
CIVIL AND MISCELLAN.	64	215	95	120	76	150	67	0	50	12	4	0	60	98	0	62	0	42	24	25	4	4	4	0	1	28	3	12	1	0
F.H.S. SPARES	0	0	36	15	30	83	0	9	9	12	0	5	78	25	225	32	17	50	9	3	0	154	57	0	30	49	19	20	33	12
F.H.J. CENTRAL WS	0	40	27	0	0	0	0	0	52	0	0	12	0	0	0	24	5	52	172	10	0	0	80	15	0	10	132	71	40	0
TOTAL	293	470	581	715	280	533	219	131	241	213	276	43	867	306	516	304	487	347	681	240	145	1605	363	260	255	722	211	162	60	

EMERGENCY JOBS1. DEFINITION

An emergency job, by definition, is one which affects production and, as such, should be completed within 24 hours, provided that no problems exist, e.g. drawings, materials, samples or outside manufacturing.

2. TREATMENT OF EMERGENCY JOBS2.1. Receipt

- a) An Engineering Work Order (EWO) for emergency jobs (Priority 9), must be signed by the Plant Engineer or his deputy.
- b) The EWO must be delivered by the Foreman or Leading Hand, to the Progress Supervisor of the Planning Section in Central Workshops. Direct contact with a Shop foreman is not acceptable.
- c) The Plant Foreman should discuss the job until both he and the Progress Supervisor are satisfied that the requirements are clear. At this point, an approximate completion time should be given to the Plant Foreman.

If problems with materials or drawings exist, then the Plant Foreman will, through discussion, become aware of them at an early stage and could possibly assist in resolving them.

2.2. Workshops emergency treatment

The Workshops will treat emergency jobs as follows:

- a) Emergency jobs will not be processed on CAPOSS. On receiving the order, Planning will only register the order until the route card is received from the Estimators. Planning and Progressing will be done manually.
- b) Jobs will be commenced immediately unless there are exceptional circumstances preventing this.
- c) Jobs will be worked on continuously if required. This will be established in discussions with the Plant Foreman.
- d) Whilst the job is being processed, an estimate will be prepared immediately (as soon as possible), and sent to Planning.
- e) Planning, on receiving the route card, will feed it into CAPOSS and close it off at the same time.

2.3. Control

Manual control will be done by the Emergency Progressor. He will maintain the route card and register of jobs in process. The register will look like this:

PLANT	CAPOSS NO.	WORK CENTRE												DATE IN	DATE OUT	REMARKS
		M01	M02	M03	M04	M05	M06	M07	M11	M14	M15	M16				
Chemicals	106002300		X						X			X	12/4	14/4		

The date under date in/out will be used for performance measuring.

When the Emergency Progressor gives the job to the work centre concerned, he will add the new job to the emergency list of the work centre Progressor. The emergency work list and the daily work list are for use by the Foremen and both of them should be completed on the same day, provided no problems exist.

The emergency work list per work centre will look like this:

PLANT	CAPOSS NO.	FROM W/C	TO W/C	DATE IN	DATE OUT	REMARKS
Chemicals	106002300	M02	M11	12/4		

The same rule for ordinary jobs applies to the emergency work list. Completed jobs should be underlined so that the Production Engineer gets the right load picture of the work centre in his daily round.

When completing the operation, notice should be given immediately to the Emergency Progressor, so that the job can be moved to the next work centre.

2.4. Capacity requirements

At the end of each month, the Progress Supervisor in conjunction with the Planning & Control Engineer, will analyse demands for emergency capacity by means of the various reports produced by CAPOSS. Trends and forthcoming jobs will be charted, in order to enable accurate allocation of capacity for emergencies without upsetting the computerized ordinary jobs system.

PLANNING & CONTROL SECTION - DELIVERY DATE'S STATE

APPENDIX 3a

PLANNING; & CONTROL SECTION - HOURS LOADED PER WORK CENTRE - STATE

APPENDIX 3b

CHANGES IN CFDs DUE TO THE NEW SCHEDULING APPROACH

CAPOSS NO	REQUEST DEL DATE	ADJUST DUE DATE	FCFD	CFD1	CFD2	CFD3	CFD4	CFD5	CFD6
113825300	1146	2005	1213	1213	1208	1204	1208	1223	
113906100	1158	1175	1171	1171	1175	1181	1187	1191	
113912200	1140	1150	1154	1154	1159	1164	Comp	1158	
113915300	1162	2006	1203	1203	1211	1211	1202	1209	
114107300	1146	2007	1207	1207	1209	1209	1209	1209	
114115900	1145	1166	1162	1162	1166	1172	1165	Comp	
114117200	1157	1150	1150	1150	1151	1160	Comp	1156	
114205200	1150	1169	1166	1166	1151	1161	Comp	1154	
114303300	1162	2009	1206	1206	1206	1206	1206	1210	
114328200	1155	1190	1169	1169	1169	1169	1174	1179	
114406300	1155	2008	1209	1209	1209	1209	1205	Comp	
114425500	1165	1206	1165	1165		1160	Comp	1157	
114501900	1153	1182	1168	1168		1165	1168	1172	
114501901	1153	1181	1177	1177		1165	1169	1171	
114507300	1147	2008	1206	1206	1206	1206	1206	Comp	
114508900	1187	1208	1178			1178	1171	1174	
114508901		1205	1178			1178	1170	1174	
114518900	1163	2022	1234			1234	Comp	1155	Emergency
114608000	1161	1192	1197			1187	1173	1178	
114609900	1168	1183	1170			1170	1166	Comp	
114609902	1168	1184	1170			1170	1166	Comp	
114609903	1168	1185	1173			1173	1178	1172	
114616400	1161	1182	1157	1157		1162	1167	1190	
114619500	1168	1180	1156	1156		1160	1165	1170	
114702900	1169	1217	1173			1173	1168	1173	
114704700	1152	2022	1220			1220	1220	1220	
114705300	1148	2011	1211			1211	1211	1214	
114707900	1157	1176	1163			1163	Comp	1158	
114709300	1167	2021	1223			1223	1224	1224	
114710700	1158	1220	1177			1177	1178	1183	
114727000	ASAP	1191	1169	1169		1159	Comp	1157	
114803300	1167	2010	1213			1213	1210	Comp	Emergency

WAS AMENDMENT LIST TO THE STORES SYSTEM DELIVERY DATES AND LEAD TIMES

END OF REPORT

END OF REPORT

FACTORY MADE SPARES (ISANDO - CAPACITY REQUIREMENTS)
(EXTRACTS FROM MEMORANDUM)

The following tables represent the Analysis of Isando Capacity based on data of the last 18 months.

1. Average Backlog last 18 months (Monthly)

W.C	S01	S02	S04	S06	S10	S11	S12	S15	S16	S17	S18	S21	S26	S31
HOURS	472	601	141	998	912	376	596	7	586	92	1321	1707	709	1040

2. Capacity (including overtime)

HOURS	480	72	240	400 ¹	400	200 ²	200 ³	200	800	200	1400	1400	192	400

1. Could be 600 hours - (only 2 from 3 machines are being manned)
2. Could be more - (2 small Punch Grinders are not being manned)
3. Could be 400 hours - (only 1 from 2 Machines is being manned)

3. Capacity - Shortage

The following table represents the Capacity Shortage in the Shop. The results are based on the above tables assuming there is proper manning, and subject to the constraint of 4 weeks maximum jobs Turnaround Time in the Shop.

WORK CENTRE	SHORTAGE HOURS	MACHINE/MEN	WORK CENTRE'S NAME
S06	-	1-Man	CYLINDRICAL GRINDER-1
S10	512	1-Machine	TOOL AND CUTLER
S11	176	2-Men	SURFACE GRINDER -1
S12	196	1-Machine	PUNCH GRINDER
S15	307	2-Machines	MILLING MACHINE-1
S26	517	3-Machine	DRILLING MACHINE
S31	640	3-Men	LIFTING BAY

4. For your action.

CENTRAL WORKSHOPS-MONTHLY WORK CENTRE CAPACITIES

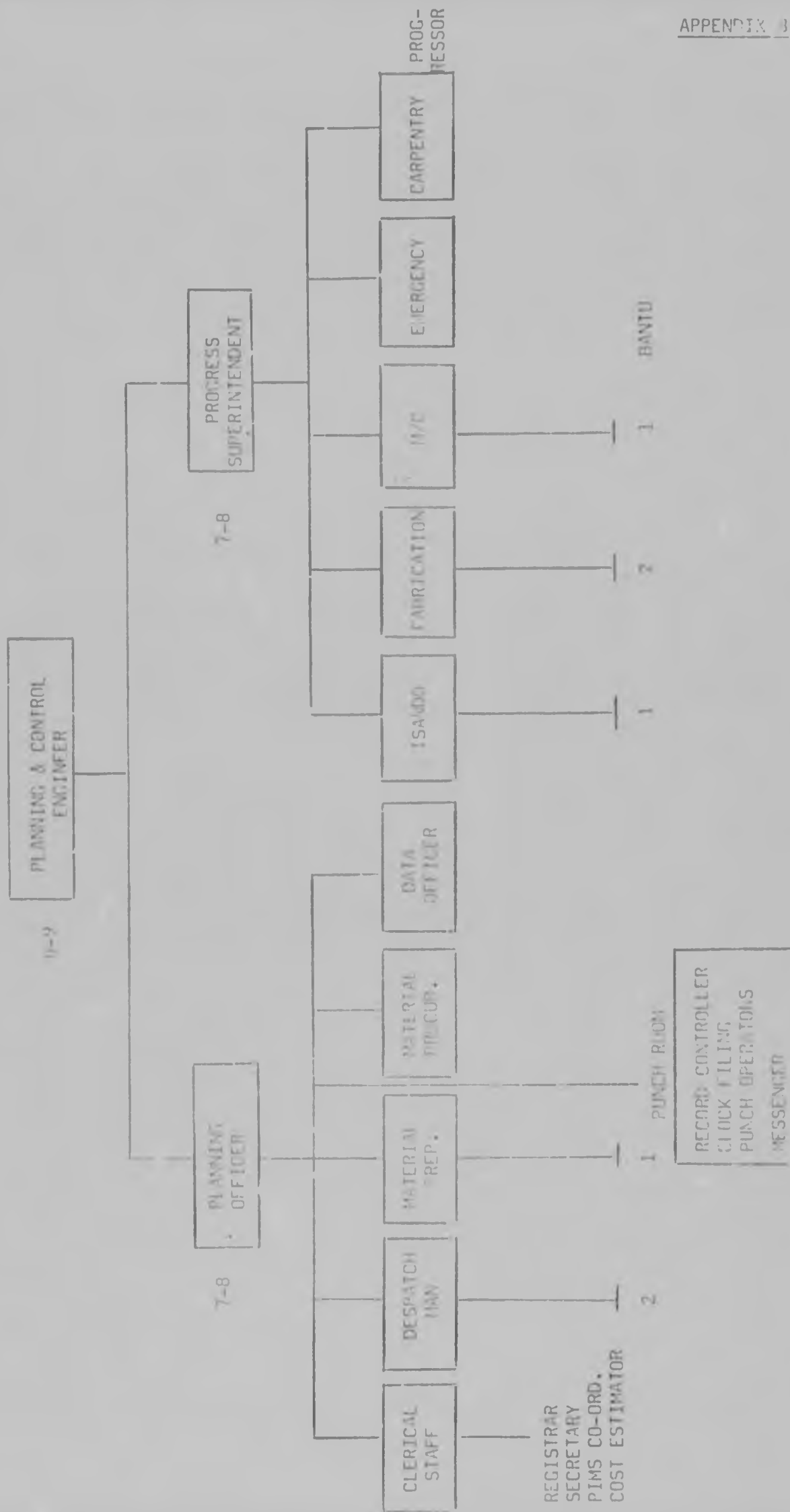
W/C	NAME	JULY 1981		M/P M/C	Regular Capacity	Emergency Capacity
		Available Hours*	Efficiency			
C02	Carp. Mac.	6.1		4	439.2	48.8
C03	Carp. Benc.	6.1		4	439.2	48.8
C04	Carp. Saddler	6.1	85%	1	72.0	8.0
C05	Timber Drying	9.2		1	165.6	18.4
C99	Inspection	9.2		1	165.6	18.4
F01	Welders shop	5.5	77%	15	148.5	165.0
F02	Welders plant	5.5		10	99.0	110.0
F05	B/Makers shop	8.6	121%	5	77.4	86.0
F06	B/Makers plant	8.6	121%	6	928.8	103.2
F11	Blacksmiths	5.9	82%	2	212.4	23.0
F13	Heat treat B/S	9.2	100%	1	165.6	18.4
F15	Plumbing	5.9	82%	3	318.6	35.4
F19	Rigging		100%	8	1324.	147.11
I98	Mech Final Inspection	9.2	100%	1	165.6	18.4
I99	Fab Final Inspection	9.2	100%	1	165.6	18.4
M01	Lathes	5.4		6	583.2	64.8
M02	Lathes	5.4		8	777.6	86.4
M04	Lathes	9.2		1	165.6	18.4
M06	Turret	5.4		2	194.4	21.6
M10	Vertical Borer	5.4		1	97.2	10.8
M11	Milling (1)	5.4	75%	4	388.8	43.2
M12	Milling (2)	5.4		3	291.6	32.4
M13	Slotter	5.4		1	97.2	10.8
M14	Horizontal Boring	5.4		1	97.2	10.8
M16	Grinder 1	5.4		1	97.2	10.8
M17	Grinder 1	5.4		1	97.2	10.8
M18	Grinder 5	5.4		1	97.2	10.8
M20	Horizontal Lath	5.4		1	97.2	10.8
M21	C/E Drilling	5.4	100%	3	291.6	32.4
M25	Fitter Assembly	7.2		3	388.8	43.2
M26	Central Fitters	7.2		6	777.6	86.4
M28	Heat Treat	7.2		1	129.6	14.4
P01	Mater M/C	9.2		1	184.	
P02	Mater Fab.	9.2		1	184.	
P13	Spares Prob.	9.2	100%	1	184.	
P18	Outside orders	9.2		1	184.	
P21	Materials	9.2		1	184.	

W/C	NAME	Available Hours*	Efficiency	M/P M/C	Regular Capacity	Emergency Capacity
P23	Problem Solver	9.2	100%	1	184.	—
P98	Delivery Note	9.2		1	184.	—
P99	Job Closure	9.2		1	184.	—
S01	NC Cent. Lath	12		2	432.	48.0
S02	NC Turret Lath	12		3	648	72.0
S03	Program NC	9.2		1	165.6	13.4
S04	Drill. Mach	10		1	180.	20.
S06	Grind. Cylinder	10		3	540.	60.
S10	Tool and cutter			2	360.	40.
S11	Grind. Surface	10		1	180.	20.
S12	Punch Grinder	10		1	180.	20.
S15	Turret small	10		1	180.	20.
S16	Turret Small	10		4	720.	80.
S17	Punch Turret	10		1	180.	20.
S18	Center Lath	10		7	1260	140
S21	Milling Mach	10		5	900	100
S26	Drilling Mach	9.2		1	1656	184
S31	Fitting Bay	10		2	360	40
ZZZ	Dummy Error	9.2		1	165.6	18.4

* Available Hours = Full Hours available x W/C efficiency x (1 - 0.1 (absence rate)) x 1.07

MODDERFONTEIN FACTORY
CENTRAL WORKSHOP - PLANNING & CONTROL SECTION

ORGANISATION STRUCTURE



PLANNING & CONTROL SECTION - KEY PERFORMANCE AREAS

POSITION SPECIFICATION

POSITION TITLE: PLANNING & CONTROL ENGINEER

GRADE: 1

DATE COMPILED:

KEY PERFORMANCE AREAS	MAIN ACTIVITIES	PERFORMANCE STANDARDS	WAYS TO MEASURE PERFORMANCE	ACTIONS	UNIT
A. PLANNING 1. Manage the planning and control section of the section.	Plan, lead, organize and control the work of the planning and control section of the section. This includes the following: - Planning and control of the section. - Planning and control of the section. - Planning and control of the section.	1.1. Job specifications for all jobs in the section are completed. 1.2. Control Supervisors are fully trained to maintain effectively total planning and control of the section. 1.3. Procedures to maintain the total planning and control section consisting of: - Control (Planning) - Control (Output) - Planning - Material Procurement - Delivery - Receipts and analysis - Section working are developed and being maintained at high level. 1.4. A schedule for every subsidiary and special job is identified and trained to take over such a job as and when necessary. 1.5. Specific objectives for the section are developed, agreed, understood and pursued by every incumbent. 1.6. Complaint personnel are doing the work allocated to them in a disciplined manner. Personnel are highly motivated to achieve the objectives of the section.	1.1. 95% of discrepancies in administration jobs will be corrected by FMC. 1.2. 100% of jobs are scheduled. 1.3. 95% errors in section output and delivery of jobs being delivered within 2-3 days from agreed delivery date. 1.4. Subordinates on leave: his job is being done properly by others. Will be checked by FMC. 1.5. 100% of accomplishments. Will be checked by FMC, who will interview from time to time special objectives for the section. 1.6. Will be checked qualitatively, based on the various criteria which have been established for the various incumbents.		

POSITION SPECIFICATION

POSITION TITLE : PLANNING & CONTROL ENGINEER

GRADE :

DATE COMPILED :

KEY PERFORMANCE AREAS	MAIN ACTIVITIES	PERFORMANCE STANDARDS	WAYS TO MEASURE PERFORMANCE	ACTIONS	INFORM
4. Work lists, reports, files, materials and tools.	2. Ensure that all required work lists, reports and files are being distributed to PE, foremen and appropriate customers of the planning services	2. Accurate work lists and work packing material requirements plan and tools are issued to the various work centres.	2. 0% deviation on all procedures involved under this subject.		
3. Problem solving (Planning)	3. Carrying out special programmes for completing long term jobs. - Recognising outstanding material orders - Processing outside jobs being done by outside firms.	3. - No more than 20 jobs longer than 120 days into the system. - No more than 1% of outside orders are delayed more than 3 days. - Outside firms are delivering jobs based on schedule.	2. - FWE to check monthly By Job residence report. - Outstanding Materials orders - Report to be used. - 0% deviation on this procedure.		
8. MANAGEMENT					
1. Manpower & Resources.	1. - Training & development programmes are initiated and carried out.	1. - No failures in success-ions of training programmes and promotion	1. Qualitatively. Will be controlled by FWE.		
2. System & Equipment Development.	2. Continuously investigate, improve use of computer system and better ship floor management.	2. Additional systems, reports and procedures are being established as required.	3. Qualitatively in general. Effectiveness will be checked by concerned subjects.		
3. Preparation & control of annual budget.	3. - Accurate budget is being identified. - All the budget require-ments are identified. - Existing programmes are being carried out. - Budget controls are being operated.	3. - No inexplicable excess expenditures. - Monetary quantitative indications for expenditures are identified.	3. - 2.5 % maximum excess from budget.		

POSITION SPECIFICATION

DATE COMPILED: _____

GRADE: _____

POSITION TITLE: PLANNING & CONTROL ENGINEER

KEY PERFORMANCE AREAS	MAIN ACTIVITIES	PERFORMANCE STANDARDS	WAYS TO MEASURE PERFORMANCE	ACTIONS	INFORM.
4. Workshop facilities, development and infrastructure.	4. Continuously investigate capacity requirements, machinery and shop floor procedures.	4. Agreed turnaround time on the floor in quantity or location of starter duration. Based on growth.	4. Will be derived from the various performance indices.		
5. Relief - PE & FWE	5. As required	5. No discrepancies on agreed standard of general management. A decision making.	5. Qualitatively.		

POSITION TITLE: PLANNING OFFICER
 DATE COMPLETED: _____
 NAME OF: _____
 POSITION, DUTIES, RESPONSIBILITIES

NO.	FUNCTIONS	STANDARDS	PERCENTAGE	ACTION	INFO.
1.	Manage and/or supervise	1.1. Job specification for each job in the section is completed. Subordinates are fully trained to maintain effectively total planning system. 1.2. Procedures to maintain the total planning system consisting of: - Material Procurement - Material Scheduling - Management Information System - MRP program are developed and recorded. 1.3. A successor for every supervisory and specialist job is identified and trained to take over such a job as and when necessary. 1.4. Specific objectives for the section are developed and understood and pursued to every incident. 1.5. Dependent personnel are doing the work allocated to them in a disciplined manner. Personnel are highly motivated to achieve the objectives of the planning Department.	1.1. 0.5% of subordinates in subordinate jobs' attention will be controlled satisfactorily. 1.2. 5% deviation in data of materials supply will be controlled from supplier of orders. 100% of jobs are scheduled. All reports and programs are used. 1.3. Subordinate on leave his job being done properly by others. 1.4. Qualitatively 1.5. Qualitatively		
2.	Accurate Input Data	2.1. Analyze output data and compile management information necessary to control data being done in your Center. 2.2. Inform concerned persons about errors immediately. Update production programs and reports.	2.1. 0.1% of errors per year in the various programs and reports. 2.2. 0.1% of errors per year in the various programs and reports.		

POSITION SPECIFICATION
GRADE

POSITION TITLE PLANNING OFFICER

DATE COMPLETED

K.P.A. No.	MAIN ACTIVITIES	PERFORMANCE STANDARDS	WAYS TO MEASURE PERFORMANCE	REASONS OF IDENTIFYING DEVIATIONS	ACTION	P.M.
3. Daily work programme	3. Ensure that all required reports are distributed to appropriate personnel.	3.1. An accurate daily work plan depicting work to be carried out at every work centre in issued to the various programme before 8 o'clock every morning. 3.2. An accurate job packet for each job listed on the daily plan is issued with the plan to every work centre.	3.1. 0.1% of errors per year in the various programme and reports. 3.2. 0% deviation in this procedure.			
4. Procurement of materials	4. Ensure that all required materials according to daily production programme are available.	4.1. 4 materials per programme plan is in question and is being actively executed. 4.2. Under no circumstances is the start of a job delayed for more than 3 months as a result of non-availability of materials.	4.1. 0.1% deviation in dispatching of materials based on programme. 4.2. 1% of material orders not being delivered later than 3 months after schedule. Controlled time register of orders.			
5. Problem solving.	5.1. Preparing list of long term jobs and promoting them. 5.2. Progressing outstanding material orders which are being delayed. 5.3. Sorting out Master File's programme problem. 6. Relieve P & CE when required.	5.1. An order must 20 jobs longer than 120 days into the system. 5.2. As above 5.3. 'Clean' Master File. 6.1. All reports required by Workshop Management and issued on time. Information is being checked and applicability ensured. 6.2. Management is actively informed of information reports available to assist them.	5.1. Controlling of the Master File. 0% of deviation in this area. 5.2. As above 5.3. 0.1% errors. 6.1. Quality and quantity based on the above mentioned factors. 6.2. 0% deviation.			

TESTING SPECIFICATION

DATE COMPLETED:

SECTION TITLE: STAGE 1 OF 1

CHART:

C.P.A. No.	MAIN ACTIVITIES	PERFORMANCE STANDARDS	WAYS TO MEASURE PERFORMANCE	REASONS FOR TESTING DEVIATIONS	ACTION	TESTING
		6.1. A deviation reporting system is developed and applicable expert vision and equipment are informed accordingly on time.	6.1. Quality will be measured by customer.			

DATE COMPILED:

POSITION SPECIFICATION

GRADE:

POSITION TITLE : DATA CONTROLLER

KEY PERFORMANCE AREAS	MAIN ACTIVITIES	PERFORMANCE STANDARDS	WAYS TO MEASURE PERFORMANCE	ACTIVITIES	INFO
1. Control computer input of information on completed operations.	1. Receive feedback from shop floor. 2. Review punch cards or data details as necessary.	1. 0.1 % deviation from actual completed job and computer output.	1. Sampling by Planning Officer on a weekly basis.		
2. Update and maintain Master File	2. Submit cards for nightly computer run. 3. Make completed report- 1000 in Master File 4. Maintain continuous audit of Master File by sampling of checker cards.	2. 0 % deviation. 3. 0.1 % deviation. 4. 0 % deviation.	2. Controlling by checking against feedback form from Foreman. 3. Weekly sampling. 4. Weekly sampling.		

POSITION SPECIFICATION

DATE COMPILED: _____

POSITION TITLE: MATERIAL CO-ORDINATOR

GRADE: _____

KEY PERFORMANCE AREAS	MAIN ACTIVITIES	PERFORMANCE STANDARDS	WAYS TO MEASURE PERFORMANCE	ACTIONS	INFORM
1. Control and expedite the procurement of such commodities that are not available ex-sizes.	1. We purchase remittances, ensuring correct details before placing in Supply Dept. 2. Process orders in accordance with delivery dates. 3. Arrange delivery of urgent materials. 4. Sub-contracting of works. 5. Provide feedback on delivery of materials.	1. 0 % delays in the start-up of a job on time because of material shortages. 2. The incumbent is however dependent on the advice given to him by the Supply Dept. Under these circumstances delays in 5 % of the jobs is acceptable. (It is notified any time on such cases)	1. Registration and control by Planning Officer. 2. Registration of failures occurs because of Supply Dept. and Planning Officer. Not more than 5 %.		

POSITION SPECIFICATION

DATE COMPILED:

POSITION TITLE: MATERIAL PROGRESSOR

GRADE:

KEY PERFORMANCE AREAS	MAIN ACTIVITIES	PERFORMANCE STANDARDS	WAYS TO MEASURE PERFORMANCE	ACTIONS	INFO
1. Procure raw materials from Factory Stores.	1. Checks requisitions to ensure that material is ordered for in correct and not in excess state. Attempts delivery from store and cutting if required. Checks deliveries for correct sizes and quantities.	1. 0.1 % delays in the start-up of jobs on line because of material shortages. (The incident is dependent on availability of material in stores) Feedback to Planning Officer who will control it in writing.	1. Planning Officer will monitor daily performance based on the production programme.		
2. Monitor 'stock out' situation.	2. Propose stock out or arrange for alternate materials. Deliver materials and route them to material store and ensure correct feedback. The above all done for emergencies as and when they arise.	2. Under these circumstances delays in % of the job is acceptable.			
3. Manage efforts of subordinates.	3. Plan, lead, supervise the activities of subordinates.	3. Subordinates are fully trained and disciplined to do their job properly.	3. Qualitatively.		

DATE COMPILED: _____

POSITION SPECIFICATION

GRADE: _____

POSITION TITLE: ASSISTANT MATERIAL MANAGER

KEY PERFORMANCE AREAS	MAIN ACTIVITIES	PERFORMANCE STANDARDS	WAYS TO MEASURE PERFORMANCE	ACTIONS	INFO
1. Assist in the procurement of materials from Factory Stores.	1. Prepare requisitor produced requisitions. Take to stores. Ensure receipt of material with correct invoice.	1. 1 % stock-outs at any one time is an acceptable level.	1. Spot checking by Material Procurement of all paperwork.		
2. Monitor stock-outs situation.	2. Cross check on re-stock items and re-requisitioning. Regularly route cards are filed.	2. 1 % stock-outs at any one time is an acceptable level.			
3. Receive goods at warehouse delivery point.	3. Check all items and signs available for received from stores and outside suppliers and ensure order is satisfied at the receipt thereof.	3. Material receiving bay always clean.			

POSITION SPECIFICATION

POSITION TITLE: MATERIALS BUY REEVEN

DATE COMPILED:

ORIGIN:

KEY PERFORMANCE AREAS	MAIN ACTIVITIES	PERFORMANCE STANDARDS	WAYS TO MEASURE PERFORMANCE	ACTIONS	INFORM
Ensure that raw material and semi finished products are always available when required.	Bin raw material with complete min-max ending accuracy and valid Census inputs. Ensure post-product correctly re-ordered after each quotation. Conduct regular bin audits in conjunction with the computer bin listing.	Pre-ordering area always clear. No errors in bin material reflected in the Master File There is no room for error in this area.	Spot checks. Spot checks by Progressor.		

POSITION TITLE: RECORDS CONTROLLER		POSITION SPECIFICATION		DATE COMPLETED:	
		GRADE:			
KEY PERFORMANCE AREA	MAIN ACTIVITIES	PERFORMANCE STANDARDS	WAYS TO MEASURE PERFORMANCE	ACTIONS	INFORM
Maintains a library consisting of: Job packs Completed job cards Master filing system by commodity code and drawing numbers	Ensures validity of filing system. Draws and refiles various documents from files as requested. Maintains history on file by providing new jobs and their completion on the system. Ensures live job file up-to-date. Ensures that completed jobs filed correctly.	0.1 % of misfiling is acceptable.	Control by weekly sampling and three monthly audits. 0.1 % variation is acceptable.		

POSITION TITLE: PUNCH OPERATOR

SUPPLIER SPECIFICATION

(GRADE)

DATE COMPLETED

KEY PERFORMANCE AREA	MAIN ACTIVITIES	PERFORMANCE STANDARDS	WAYS TO MEASURE PERFORMANCE	ACCOMPLISH	REPORT
1. Prepare computer input punch cards ensuring that there are no errors and the daily deadlines are met.	1. Form computer input for all new programs. 2. Check parameter in input as required. 3. Rectify all errors, by rekeying various types of input data. 4. Repunch cards as rectified by the Planning Officer.	1. 0.1 % allowable errors in the daily punching programme. 2. 0.1 % allowable errors in the daily punching programme.	1. Regular checks of daily error (added by Planning Officer).		

POSITION SPECIFICATION

POSITION TITLE: PROCESS SUPERVISOR

GRADE:

DATE COMPILED:

KEY PERFORMANCE AREAS	MAIN ACTIVITIES	PERFORMANCE STANDARDS	WFO TO HEADQUARTERS PERFORMANCE	ACTIONS	INFORM
1. Manage KPA's of subordinates.	1.1. Plan, lead, organize and control the activities of subordinate personnel to monitor the total system of all facilities.	1.1.1. Job specification for each job in the section is completed. Incidents are fully trained to monitor total processing 90%+.	1.1.1.1. 0% deviation from KPA's is accepted. Will be controlled qualitatively.		
		1.1.2. A successor for every job in the section is identified and trained to take over such a job when necessary.	1.1.2. People on leave - Job will be done properly by successor. Will be controlled with respect to quality.		
		1.1.3. Special objectives for the section are developed.	1.1.3. Achievements will be as stated in terms of quantity. 95% achievement is required.		
		1.1.4. Job is being done in a disciplined manner. Personnel are highly motivated to achieve the objectives of the program supervisor.	1.1.4. Will be controlled according to quality.		
	1.2. Control the joining programme and delivery of all jobs.	1.2.1. Procedures to maintain the processing system, consisting of: - Materials allocation - Tools are available - Records and reports are updated - Emergency jobs are processed and delivered on time - Ordinary jobs are being processed - Control reports are updated.	1.2.1. 0.1% deviation from daily production programme. Deviations will be controlled daily. Report to P & CC will be weekly based.		
2. Determine delivery rates for ordinary jobs.	2.1. Determine delivery rates based on feed sheet and available capacity.	2.1.1. Sectional delivery rates based on capacity not to be deviation.	2.1.1. 95% of jobs with 2-3 days deviation from form.		
	2.2. Adjust P & CC when required to be updated.	2.2.1. Overload is being controlled.	2.2.1. 3% deviation on assessments of machine facilities.		

DATE COMPILED: _____

POSITION SPECIFICATION

GRADE: _____

POSITION TITLE: MIDWINTER SUPERVISOR

KEY PERFORMANCE AREAS	MAIN ACTIVITIES	PERFORMANCE STANDARDS	WAYS TO MEASURE PERFORMANCE	ACTIONS	INFORM
3. Decide on incoming verbal material manufacturing.	3.1. Based on production programme, make decision if job will be done in-house or externally. 3.2. Negotiate with outside manufacturers on required delivery rates. 3.3. Prepare and control outside manufacturers.	2.3. Correct method and procedures in production jobs are being used. 3.1. A job will only be sent out when it is possible to meet the delivery date. Indication about short time and long term shortages of capacity will be given to P & EE. 3.2. Jobs being done outside are delivered on time. 3.3. Job is being done properly by manufacturer and conforms to the required standards.	2.3. 1% of scrap. (Will be controlled in conjunction with foreman) 3.1. 2.5% of machines' waiting time (working).		
4. Emergency jobs.	4.1. Make decision whether emergency job or ordinary job. 4.2. Apply emergency procedure, ensure availability of materials, tools and capacity.	4.1. Each emergency job is planned in conjunction with the originator, the applicable Foreman, the applicable Initiator and the Materials Foreman, within 1 hour after registration of such a job. 4.2. No emergency job is delivered late to the customer.	4.1. 0% delay of customers in planning. 4.2. 1% deviation on delivery dates.		
5. Relieve PD and P & EE.		5.1. System is working at high performance.	5.1. According to quality (will affect PQ and P & EE measured performances)		

POSITION SPECIFICATION

DATE COMPLETED

POSITION TITLE : PROJECT SUPERVISOR

GRADE :

KEY PERFORMANCE AREAS	MAIN ACTIVITIES	PERFORMANCE STANDARDS	WAYS TO MEASURE PERFORMANCE	ACTIONS	INFORM
1. Progress daily work list	1.1. Obtain daily work list with all required materials and items. 1.2. Allocate jobs based on daily work list to foreman. 1.3. Control jobs in progress and ensure completion of work list.	1.1. All jobs on daily work list completed. Uncompleted jobs can be explained. 1.2. Required facilities, materials and tools are available, listed on programme. 1.3. All jobs are meeting delivery dates on one programme.	1.1. 10% of uncompleted jobs for every day will be measured on a daily basis by the Progress Supervisor when obtaining the work list back. 1.2. 10% deviation. 1.3. 95% of jobs within - 2 days of planned delivery date. Will be measured by P & CE.		
	1.4. Inform Progress Supervisor of errors and discrepancies on work lists. 1.5. Follow up completed jobs on quality control and ensure that deliveries are made on time. 1.6. Ensure that completed material/jobs feedback is given to the Data Controller in time.	1.4. All errors and discrepancies are sorted out by 9 o'clock every morning. 1.5. Completed jobs are not more than 8 hours in quality control bay. 1.6. Daily feedbacks are given to the Data Controller every day before 3 o'clock.	1.4. 10% of errors on work lists. Will be measured daily by the Progress Supervisor. 1.5. 10% deviation. 1.6. 10% deviation.		
2. Liaison between Foreman and Planning & Control.	2.1. Rectify errors on D.P. reports. 2.2. Update Master File. 2.3. Progress jobs.	2.1. All required operations in order to have applicable work list and jobs are done as per foreman request.	2.1. 10% deviation.		

POSITION SPECIFICATION

2

POSITION TITLE : PROGRESSOR

GRADE :

DATE COMPILED:

KEY PERFORMANCE AREAS	MAIN ACTIVITIES	PERFORMANCE STANDARD	WAYS TO MEASURE PERFORMANCE	ACTIONS	INFORM
3. Progress special job lists as per Progress Supervisor request.	3. Make all required preparations to meet completion of job.	3. Required facilities, materials and tools are available.	3. 0% deviation.		
4. Update Progress Supervisor.	4. Give daily feedback to Progress Supervisor regarding work list, work in progress and work in progress.	4. Progress Supervisor is updated with all the work items. Action is being taken to sort out problems in, outstanding orders, lack of materials, work packs, drawings and tools.	4. 100% of jobs or operations being effected perfectly.		

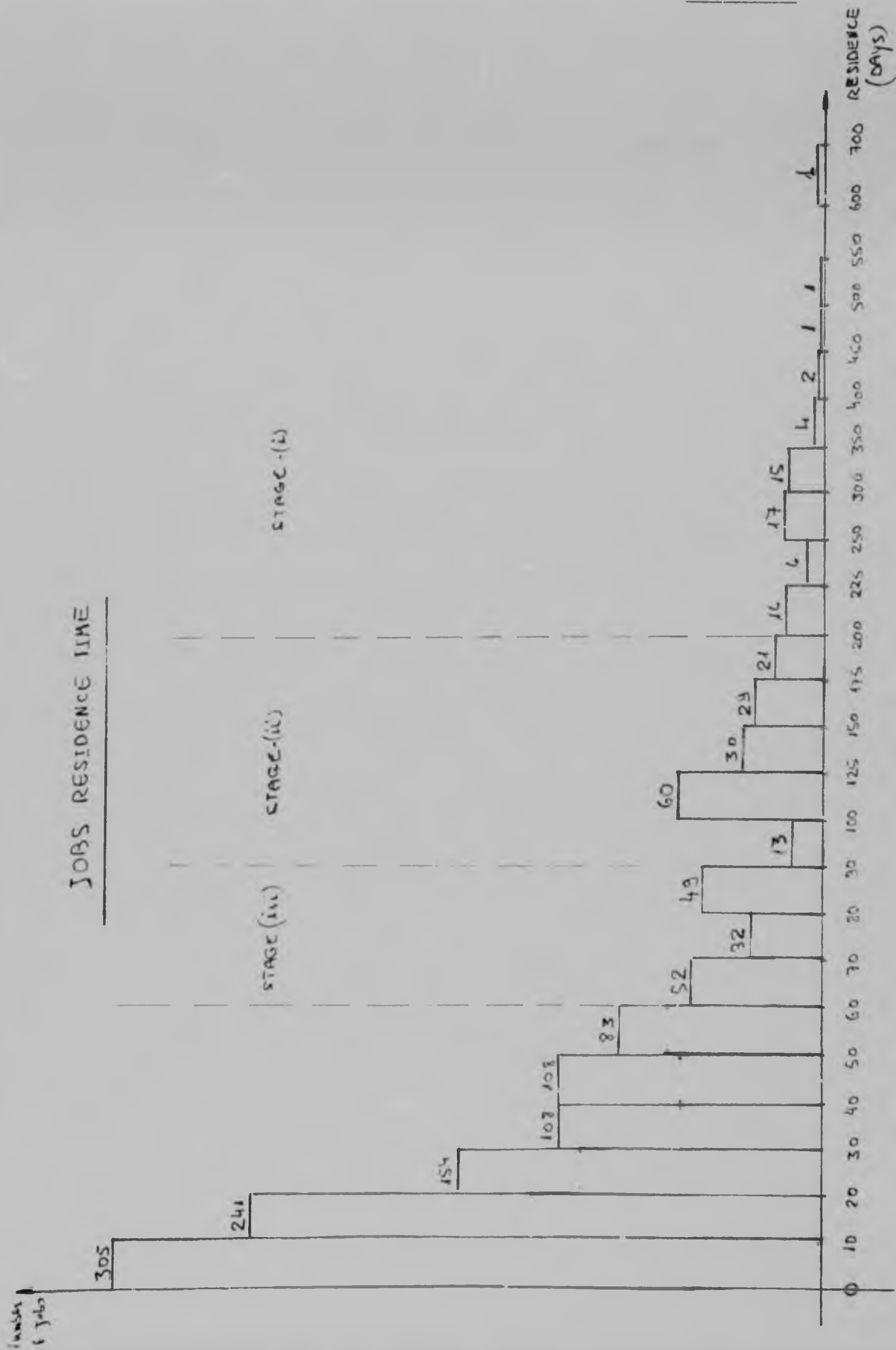
POSITION SPECIFICATION

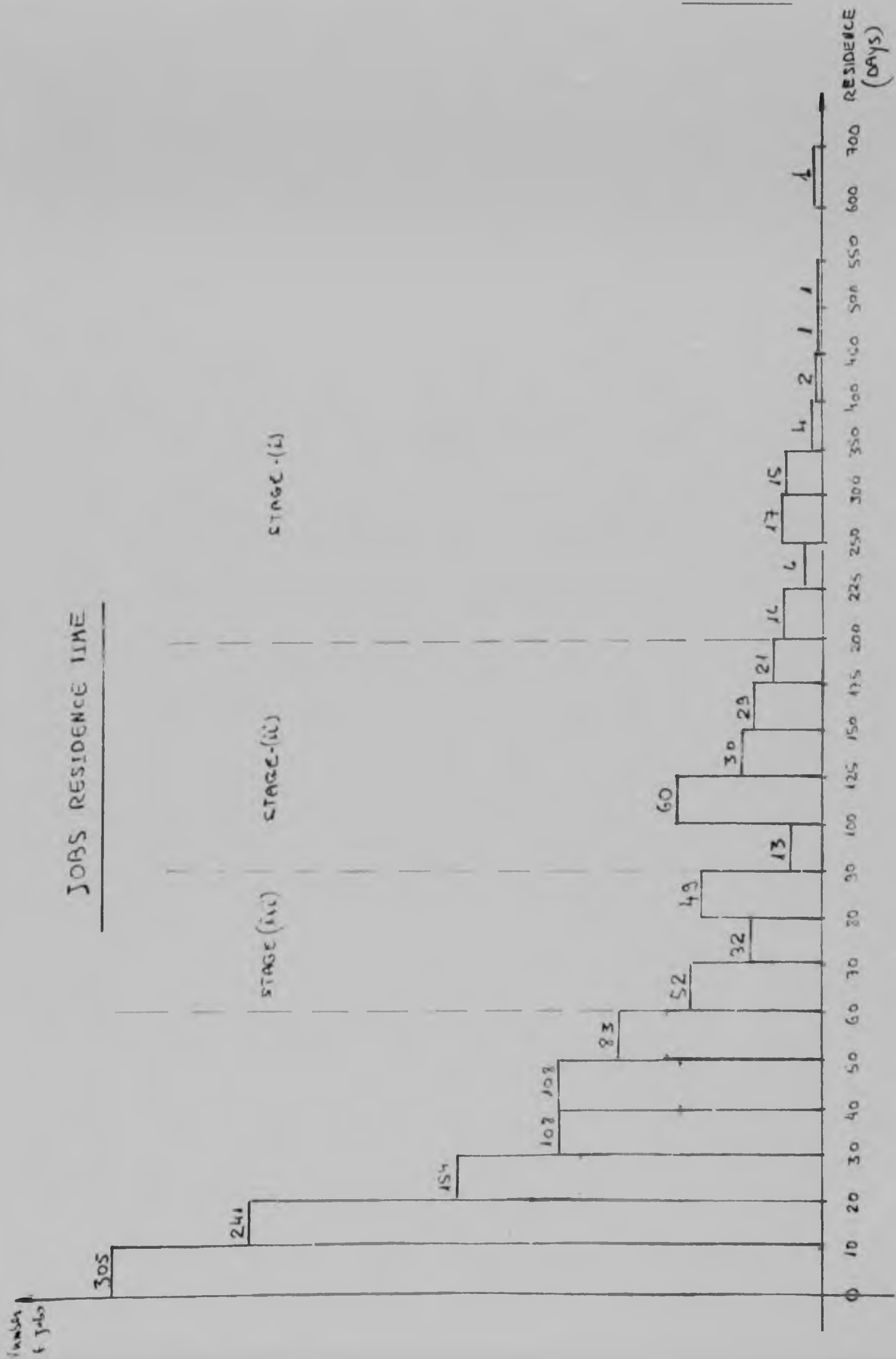
NAME:

DATE COMPILED:

POSITION TITLE: EMERGENCY PREPAREDNESS

KEY PERFORMANCE AREAS	MAIN ACTIVITIES	PERFORMANCE STANDARDS	WAYS TO MEASURE PERFORMANCE	ACTIONS	INFO
1. Emergency jobs	1.1. Make decisions whether emergency job or ordinary job. 1.2. Apply emergency procedure. Ensure availability of materials, tools and capacity. 1.3. Prepare proper registration and control procedure and framework for emergency job. 1.4. Control the job in process. 1.5. Control completed emergency job in quality control bay. 1.6. Liaise with customer and ensure timely delivery.	1.1. Only "real" emergencies are being accepted as emergency jobs. 1.2. Jobs are being re-queued immediately when machines or tooling are available. 1.3. Jobs are being controlled. 1.4. Jobs are progressed according to layout and properly. 1.5. Jobs are not being delayed in quality control bay. 1.6. Jobs are being delivered within 24 hours. Acceptance of job is being ensured by the Emergency Preparedness. 2. As above.	95% of emergency jobs are being delivered within 24 hours. 35 of emergency jobs are being delivered within 2 days. 25 of emergency jobs are being delivered within 4 days. Will be controlled by Progress Supervisor.		
2. Shut-downs.	2. Get shut-down jobs. -Ensure availability of materials, tools & capacity. -Ensure completion on day of receipt. -Liaise with customer. -Ensure delivery.				





APPROVED LIST OF SUPPLIERS AND MANUFACTURING DELIVERY TIME

APPENDIX 'B'

Approved list of Supplier and Manufacturing delivery times for the purpose of Workshop Planning, estimating and advising customer plants of likely delivery periods for component manufacture.

Date of approval/agreement of the list 81.1.7.

Date of next update of list 81.10.8.

Estimated Delivery Times

SUPPLIER	MATERIAL TYPE	DELIVERY IN WEEKS
THOMAS & PILLINER	STEEL & MEEHANITE CASTINGS	16-20
DURBAN ALLOYS	STAINLESS CASTINGS	16-20
BRONZE CASTINGS	CAST BRONZE	6-8
ALROCAST	ALUMINIUM CASTINGS	2-3
SWEIGERS & SMITH	RAW STEELS	1-2
JACKSON	RAW STEEL	1-2
N.T.C.	RAW STEEL	1-3
ROBOR	RAW STEELS	1-2
KENNETH RAY	KEY STEELS	1-2
METALLURGICAL PROCESSES	S/STEEL HOLLOW BAR	6-8
PROCESS PIPE	PIPES & FLANGES	4-6
TANK END	DISHED ENDS	4-6
HEAT EXCHANGERS	BOTLER PLATE	2-4
TESCO	FORGING MATERIAL	4-8
BROWN BAILEY	RAW STEEL	2-3
PRIMAFORCE PIPE	PIPING	1-2
MAKSAL TUBES	ALUMINO TUBES	12-16
CAMEC SPECIAL	TOOL STEELS	1-3
MARATHON STEEL	TOOL STEELS	1-3
BOHLER STEEL	TOOL STEELS	1-3
SANDERSON NEWBOLDT	TOOL STEELS	1-3
STARCO SPRINGS	SPRING WIRE	2-3
CLYDE TRADING	TOOL STEELS	1-3
SANDVIK	STEEL PLATE (SPECIALS)	10-12
CAMDER (FRANCE)	TUNGSTEN	20-30
HERMAN STEELING	PIPE WITH	4-6
ANDREW MENTIS	FLAT BAR	1-2
TUFNOL PTY	TUFNOL SHEETS	6-8
LAND SEA & AIR	STEEL	1-2
MARC ETTER	STEEL	4-6
GAP ENG.	STEEL	3-4
PROLOCK	NEOPRENE SHEET	5-6
CHICK HENDERSON	NEOPRENE TUBES	3-4
WEVELL BROS.	RUBBER BLADING	3-4
ALLANSON/WARMAN	RUBBER COVERING	6-8
GACO PRODUCTS	OIL SEALS	3-4
FIBRE GLASS SERVICES	INSULATION	4-5
COMPAIR	VALVES	10-12
E. LOWE	VALVES	10-12
FESTO	VALVE FITTINGS	2-3

Estimated Delivery Times

SUPPLIER	MATERIAL TYPE	DELIVERY IN WEEKS
LONGDALE ENG.	NON RETURN VALVES	2-3
PARKER HANNIFIN	CONNECTIONS	1-2
B.S. & W. WHITLEY	RED FIBRE - CELERON	4-6
BEARINGS & BELTING SUPPLY	BEARINGS AND PLUMMER-BLOCKS	1-2
ATLAS BEARINGS	BEARINGS & STEEL BALLS	2-3
S.K.F.	BEARINGS	2-3
REUNERT & LEINZ	FENNER PULLEYS & STAIR TREADS	2-3
RENOLD CROFT	PINIONS	3-5
METER SYSTEMS	COUPLINGS & PLUGS	4-5
GLACIER	BUSHES	3-4
DRITE BOLT	RIVETS & BOLTS	1-2
H. W. GOODWIN	PISTON RINGS	8-10
TRANSVAAL MOTORS	MOTORS (ELECTRIC)	6-8
INDUSTRIAL GALVANISERS	GALVANISING	4-5
MCSER H/CHROME	HARD CHROMING	8-12
R.A.R.E. EDENVALE	STEEL & CERAMIC COATING	4-6
MARATHON H/TREATMENT	HEAT TREATMENT	2-3
DYNAMIC BALANCING	FAN BALANCING	1-1 1/2
CERITE ENG.	GRINDING	3-4
R. B. FASTENERS	FASTENING DEVICES	2-4
FALK ENG. SUPPLIES	MISCELLANEOUS	1-1 1/2
KENTERRY	MISCELLANEOUS	1-1 1/2
PATTERN MAKING	PATTERNS	4-6
OVERSAYS	MISCELLANEOUS RAW MATERIAL	25-30
DIKEAS CLEARING	MISCELLANEOUS RAW MATERIAL	4-6

AECT REPORT NO. 46

PROGRAM NO. C55527

SEQUENCE - BUYER/SUPPLIER/ORDER

STOKES SYSTEM - MCCORMICK

ON DEMAND LISTING OF OUTSTANDING ORDERS

RUN DATE 9/04/81

PAGE NO. 89

BUYER CODE	SUPPLIER CODE	COMMODITY CODE	DESCRIPTION	ORDER NUMBER	ORDER QTY	ORDER DATE	DUE DATE	CURRENT RATE	ORDER VALUE
14	0001	72463374	IMPELLER PART 25.0	14C0291 001	1	040320	040620	970.620	970.62
14	0001	72463375	IMPELLER PART 25.01	14C0290 001	1	040320	040620	907.120	907.12
14	0001	72463351	SHAFT CU LIG BOOST PUMP	14C2510 001	2	200301	200301	50.000	100.00
14	0001	72463371	GLAND CU LIG BOOST 3-1200	14C2384 001	2	290101	290101	10.000	20.00
14	0001	72463374	WING OIL CU LIG BOOST PUMP	14C2385 001	2	290101	290101	5.250	11.00
14	0001	72474307	GEAR ICL STCKR HTSNEG TAPPU 05	14C0785 001	2	150280	150280	40.250	127.30
14	0001	72474307	GEAR ICL STCKR HTSNEG TAPPU 05	14C2327 001	4	150101	150101	20.250	274.00
14	0001	72474314	COVER BRG STCKR TAR PUMP	14C0196 001	2	141170	140120	39.250	79.20
14	0001	72474324	VIRING GEAR PUMP IDLER GEAR	14C1218 001	2	200280	200280	71.120	140.24
14	0001	72505610	SLIPPER	14C1243 002	1	030420	270780	75.213	75.21
14	0001	72521452	BUSH-1-12100 CAPP-LIG-INJECT11	14C1982 001	2	101020	100401	107.290	322.77
14	0001	73424422	ULTS102 LINK CORE 3 250/1 05	14C2441 001	260	100201	100521	2.200	900.00
14	0001	73424423	INSIDE LINK CORE 3 250/2 05	14C2442 001	360	100201	100521	2.200	900.00
14	0001	73424425	ROLLER CORE CCNN 3 250/4 05	14C2405 001	400	110201	110521	5.000	2000.00
14	0001	73424423	WASHER CORE CCNN50R3 250/1705	14C2711 001	500	020401	041001	5.00	250.00
14	0001	73442020	SLAT WCN 100x75x20	1412006 001	190	121100	120201	1.170	25.20
14	0001	73471311	BUSH-DUCK-SHAFT 1-37530ELEVAT05	14C2719 001	400	000201	021001	5.110	2044.00
14	0001	73471338	LINK-INNER 1-37541 BUCK-ELEV05	14C2697 001	150	020401	020701	2.692	403.80
14	0001	73471341	SPACER 1-37537 BUCKET-ELEVAT05	14C2718 001	400	080401	081001	1.004	393.00
14	0001	73471371	LOCK-PL 1-37535 BUCK-ELEVAT05	14C1709 001	100	210800	210201	1.250	120.00
14	0001	73471371	LOCK-PL 1-37538 BUCK-ELEVAT05	14C2701 001	100	020401	020701	1.000	109.00
14	0001	73512411	REV SCHW HAW BLN CAR PULL	14C2952 001	2	100301	100601	130.247	273.09
14	0001	74131331	UPPER BNG SLEEV	14C2263 001	10	191200	190301	64.002	640.02
14	0001	74131332	UPPER BEARING	14C2262 001	10	191200	190301	43.021	430.21
14	0001	74131333	LOWER BEARING	14C2261 001	10	191200	190301	79.200	795.00



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1. INTRODUCTION

This procedure standard identifies the inspection methods and systems that shall be operated by Quality Control Engineering in respect of components manufactured by the Central Workshops units of machine shop, fitting shop and fabrication shops so as to ensure that adequate levels of quality, reliability and performance are maintained for all components manufactured by these units.

2. SCOPE

The scope of this procedure details the specific methods of inspection that shall be applied during all phases of a components' manufacture, the systems for dealing with rejected work, and the responsibility and administration for the recovery of such defects through feedback and corrective action.

3. RESPONSIBILITY

3,1 QUALITY CONTROL ENGINEERING

It is the Quality Control Engineering Departments' responsibility in terms of the Factory Engineering Quality Policy to assure that all components manufactured fulfil their intended purpose with regards to safety, reliability and performance as well as such other quality aspects that may apply in specific cases by:-

3,1,1 Providing an effective and economic means of controlling quality by recognised and approved inspection methods and systems.

3,1,2 Acceptance or rejection of a component based on the requirements of the relevant drawing or specification.

3,1,3 Customer liaison in determining recovery of rejected components through acceptance or corrective action.

3,1,4 Assuring that defective or incorrect drawings and specifications are rectified.

3,2 CENTRAL WORKSHOPS

It is the manufacturing units of Central Workshops responsibility in terms of the Factory Engineering Quality Policy to manufacture quality components by:-

3,2,1 Ensuring accuracy of manufacture in producing components to the requirements of the drawing or specification supplied.

3,2,2 Bringing to the attention of Quality Control Engineering defective or incorrect drawings or specifications.



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3,2,3 Bringing to the attention of Planning and Estimating departments defective or incorrect work routings for corrective action.

4. INSPECTION CONTROL - REQUIREMENTS AND SYSTEMS

4,1 GENERAL

All components manufactured shall be subject to quality control monitoring and inspection throughout every manufacturing operation of the component to completion and final acceptance.

Components shall be inspected to ensure compliance of the component to the relevant drawing, specification or quality standard and shall be accepted or rejected on their requirements.

Inspections shall be carried out under a system of three phase inspections as follows:-

- 4,1,1 First-off Inspection.
- 4,1,2 Patrol Inspection.
- 4,1,3 Final Inspection.

All inspections shall be undertaken by quality control inspectors who shall be responsible for nominated manufacturing work areas. The inspectors shall be accountable to the relevant Senior Inspector for all inspection work undertaken by them. The Senior Inspectors are accountable to the Quality Control Engineer for all inspection work undertaken by the department.

4,2 DEFINITIONS

The definition of the expressions used in this standard shall be as follows:-

4,2,1 "FIRST OFF" INSPECTION: The method of inspection of the first made component of a manufacturing run which will ensure that the following are being achieved.

1. Any deviation of the component from the drawing or specification will be detected and rectified immediately.
2. Manufacturing instructions, drawings and specifications are correct and understandable.
3. Correct material has been issued.
4. Manufacturing equipment has been 'set up' and functioning correctly.



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4,2,2 PATROL INSPECTION:- The method of inspection which provides for periodic sampling of a manufactured batch conducted during the progressing of the batch through manufacture to completion.

4,2,3 FINAL INSPECTION:- The method of inspection that will be undertaken prior to final acceptance of a component batch.

4,2,4 BATCH QUANTITY:- For the purpose of this standard a batch quantity will mean a manufacturing order in excess of three components.

4,2,5 NON BATCH QUANTITY:- For the purpose of this standard a non batch quantity will mean a manufacturing order of upto a maximum of three components.

4,3 INSPECTION PROCEDURES

It is a requirement of this procedure standard that all components manufactured shall be subject to the methods of inspection as follows and such inspection shall be carried out in respect of any and every operation during the manufacture of the component.

4,3,1 BATCH QUANTITIES

i) First off Inspection

a. The 'first off' shall be submitted to the area inspector by the operator for a full visual and dimensional inspection before continuing with the batch.

b. The inspector will ensure that the inspection is carried out accurately and efficiently ensuring minimum delay to production.

c. On acceptance of the component as complying to drawing or specification the inspector shall immediately inform the operator to continue production and shall stamp, (using personal stamp) or mark (using green marking ink) the component to indicate acceptance.

d. The inspector shall then initiate an Inspection Record Card with the Job details taken from the job route card and shall complete the "first off" portion and sign the card indicating acceptance. The card will then be placed within the work pack.

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ii) PATROL INSPECTION

a. On acceptance of a component on 'first off' inspection, the inspector will initiate a series of patrol inspections carried out at random on the component throughout the manufacture run.

b. The inspector shall carry out both visual and dimensional inspection and shall inform the operator and Leading Hand of any deviation from specification for necessary action.

c. The inspector shall update the inspection record card indicating his finding of the inspection, recording the time of inspection and signing the card for every inspection carried out.

iii) FINAL INSPECTION

a. Final inspection shall be carried out within the inspection areas after the components, drawings, route card etc. have been submitted by the operator.

b. Such inspections will be based on the information detailed on the inspection record card and should comprise:-

a. A cursory visual inspection to ensure no damage has occurred during transporting to inspection area.

b. A random dimensional check to satisfy the inspector of possible doubtful dimensions.

c. On completion and acceptance the inspector shall complete the inspection record card indicating quantity accepted, quantity rejected (if applicable) against original order quantity and shall sign and date the card.

d. The Job route card shall be completed to show quantity accepted, signed and dated by the inspector.

4,3,2 NON-BATCH QUANTITIES

i) First-off Inspection

a. The operator shall call the area inspector to carry out visual and dimensional inspection of the component at the area of manufacture when it is not possible to convey the component to the inspector.



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b. The inspector will ensure that the inspection is carried out accurately and efficiently, ensuring minimum delay to production.

c. On acceptance of the component as complying to drawing or specification the inspector shall immediately inform the operator to continue production and shall stamp, (using personal stamp) or mark (using green marking ink) the component to indicate acceptance.

d. The inspector shall then initiate an Inspection Record Card with the Job details taken from the job route card and shall complete the "first off" portion and sign the card indicating acceptance. The card will then be placed within the work pack.

ii) PATROL INSPECTION

a. On acceptance of a component on "first off" inspection, the inspector will initiate a series of patrol inspections carried out at random on the component throughout the manufacture run.

b. The inspector shall carry out both visual and dimensional inspection and shall inform the operator and Leading Hand of any deviation from specification for necessary action.

c. The inspector shall update the inspection record card indicating his finding of the inspection, recording the time of inspection and signing the card for every inspection carried out.

iii) FINAL INSPECTION OF OPERATION

a. Final inspection shall be carried out within the inspection areas after the components, drawings, route card etc. have been submitted by the operator.

b. Such inspections will be based on the information detailed on the inspection record card and should comprise:

a. A cursory visual inspection to ensure no damage has occurred during transporting to inspection area.;

b. A random dimensional check to satisfy the inspector of possible doubtful dimensions.



QUALITY CONTROL ENGINEERING
MODDERFONTEIN

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4,3,3 FINAL INSPECTION OF COMPONENT

On completion of all operations and inspections the following shall be carried out:-

The inspection record card, route card, drawing and specification as applicable shall be passed to Quality Control Inspection Administration for preparing of Delivery Notes, (when applicable) forwarding of route cards to planning for the closing of CAFOSS and arranging delivery to customer. FMS components being sent for protection coating and packing before delivery to stores.

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5. REJECT CONTROL - REQUIREMENTS & SYSTEMS

5,1 GENERAL

All components which do not conform to specification or drawing requirement shall be rejected by the inspector pending further investigation, plant feedback and/or corrective action decision.

Rejection of a component shall be made regardless of the extent of the deviation from the specification or drawing.

The procedure to be adapted for rejects shall vary according to the circumstances of requirements as detailed under. The skilful application of rework and corrective action methods will effectively reduce rejection costs.

"Not all rejected components are necessarily scrapped"

5,2 COMPONENT REJECTION

1. On rejection of a component at the 'first off' patrol or final inspection stage the inspector shall immediately inform the respective operator and the Leading Hand of the discrepancy and shall discuss and advise possible rectification and rework action.

2. The rework action permissible will vary according to whether the component is a:

- i) Factory Made Spare (F.M.S.)
- ii) Maintenance Component.
- iii) Emergency work component.

3. The responsibility for deciding whether rework and the method of rework is acceptable or whether the component must be scrapped rests with Quality Control Engineering who will consult with plant and workshop personnel before decision.

4. When possible, rework decisions will be taken quickly to enable rework to be carried out on the same manufacturing set up.

5,3 REWORK DURING MANUFACTURING OPERATION PERIOD

1. The components shall be reworked by the approved and agreed method and it shall be submitted by the operator for inspection as laid down in section 4,3 of this procedure.

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2. A Quality Control Rejection Note shall not be issued for rejections that are reworked during the manufacturing operation period.

3. If a suitable rework method cannot be agreed the reject shall be dealt with as specified in section 5,4. The job route card shall be adjusted to reflect quantity accepted.

4. Inspection record card shall reflect the quantity accepted and a detailed description of the rework method entered.

5,4 REWORK AFTER MANUFACTURING OPERATION PERIOD

1. A reject that cannot be effectively rectified during the manufacturing operation period shall, at the request of the inspector, be removed from the batch pending a decision on the rework method from a higher authority.

2. The Leading Hand shall be notified of the rejection and the batch quantity on the job route card adjusted.

3. The inspector shall complete a Quality Control Rejection Note detailing the extent of deviation to specification. The Inspection record card shall reflect quantity accepted and quantity rejected detailing briefly cause for rejection.

4. The inspector shall pass information of reject to the Senior Inspector who shall deal with the reject and initiate possible rework and corrective action after discussion with plant personnel, and considering the requirement of section 5,6.

5. On a decision to rework the Senior Inspector shall liaise with workshop and planning personnel as to rework method and requirements. The details of the rework method shall be fully detailed on the reverse side of the Rejection Note. Copy of the note being submitted to Planning Department for action.

6. When a rework method or corrective action cannot be determined and/or agreed the Senior Inspector shall refer the matter to the Quality Control Engineer for a decision on the course of action after consultation with plant and workshop engineers.

5,5 SCRAP

1. Rejects which cannot be rectified to ensure compliance with specification, or which would be uneconomic to rectify shall be scrapped and the Rejection Note and Inspection record card updated to reflect the decision.



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REV 'E'	2. Components scrapped shall be marked with red marking by Inspection and shall be removed from the workshops.	
REV 'D'	3. On a decision to scrap a component the Senior Inspector shall advise Planning Department of the action. Planning shall if the order quantity is critical initiate a sub-order for re-manufacture of the quantity scrapped.	
REV 'C'	5.6 <u>DEVIATION FROM SPECIFICATION</u>	
REV 'B'	The acceptability of a deviation from specification shall vary according to the status of a component as to whether it is a:- i) Factory Made Spare (F.M.S.) produced on a stores work order for stores stock. ii) Maintenance work produced on an engineering work order for use on the plant. iii) Emergency work produced on a stores work order or engineering work order.	
REV 'A'	The requirements of feedback information and corrective action methods shall be carried out as under. 5.6.1 <u>FACTORY MADE SPARES (F.M.S.)</u> "ALL COMPONENTS MANUFACTURED , S FMS STORES STOCK <u>MUST</u> CONFORM TO DRAWING SPECIFICATION. ON NO ACCOUNT WILL NON-CONFORMING FMS COMPONENTS BE HELD IN STORES." a. Deviation from specification, which may be either functional or non-functional shall be brought to the attention of the relevant plant personnel by the Senior Inspector for clarification and possible acceptance. b. Acceptance and agreement by the plant personnel of the deviation as not affecting the components function and reliability will require that the drawing specification is altered to accommodate the deviation. Such alterations will ensure acceptability of the component. c. Dimensional deviations that are accepted by the plant personnel but agreement on drawing alteration is not given will render the component unacceptable. Such components will be rejected.	
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REV 'E'	d. The Senior Inspector shall on agreement of acceptance complete an Acceptance/Clearance Note detailing fully the deviation, have the drawing "marked up" and both signed by the accepting engineer and signing himself. Copy 2 of the Acceptance/Clearance Note shall be attached to and filed with the relevant inspection record card. The Quality Control Rejection Note shall be signed by the accepting engineer and filed with the inspection record card. NB. Alterations affecting component tolerances shall have such tolerances enlarged to the maximum acceptable. e. The senior inspector shall prepare a Modification Proposal slip, detailing the alterations and ensuring company standards requirements, submitting the proposal with "marked up" drawing and Acceptance/Clearance Note attached to the Quality Control Engineer and relevant plant Section Engineer for signature. f. The approved and signed proposal with attachments shall then be submitted for corrective action as detailed in Quality Assurance Procedure Standard QA/ADMIN/OO5 - Engineering Drawing Control.	
REV 'D'		
REV 'C'		
REV 'B'		
REV 'A'		
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5.6.2 MAINTENANCE WORK

- a. Components produced for maintenance work and not conforming to drawing specification may, on discussion between Quality Control Engineering and the relevant plant personnel, be accepted without alteration to drawing specification.
- b. The senior inspector shall discuss deviations to drawing specification with the plant and shall request that on acceptance of deviation the relevant drawing specification be altered. In this situation, the methods as detailed in 5.6.1 shall be followed.
- c. Components that are accepted but where the plant consider that no alteration need be effected in respect of the drawing the senior inspector shall complete the Acceptance/Clearance Note fully detailing the deviations and shall have this and the relevant Quality Control Rejection Note signed by the accepting engineer. The Acceptance/Clearance and Rejection Notes shall be attached to, and filed with the inspection record card.



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5,6,3 EMERGENCY WORK

- Components that are being produced on an emergency basis and are rejected as not conforming to drawing specification shall be dealt with immediately by the Senior Inspector on the rejection being determined.
- The method of feedback and corrective action shall be as detailed in sections 5,6,1 and 5,6,2 depending on the type of emergency work being undertaken.
- Discretion shall be exercised related to the degree of the emergency and the circumstances.

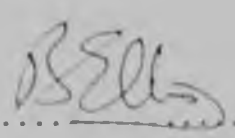
6. EQUIPMENT CALIBRATION

All measuring equipment used within the machine shops and inspection areas will be subject to official calibration of the equipment carried out on a set calibration programme system. Details of the system are contained in Quality Assurance Procedure Standard QA/ADMIN/006 Equipment Calibration Control.

PROCEDURE APPROVED BY:

SIGNED: 
QUALITY CONTROL ENGINEER
DATED: 21.6.22

PROCEDURE AGREED BY:

SIGNED: 
ON BEHALF OF CENTRAL WORKSHOP
DATED: 16/7/81

SPOILED WORK

INTRODUCTION

This paper presents the procedures which have to be taken in a case of spoiled work. Actually, this is a completion to the Quality Control Reject Centre Procedure (See Appendix Q.C. Procedure Standards - Chapter 5) from the side of Planning and Control.

There are three possible situations:-

- scrapped after intermediate operation
- Scrapped after final inspection
- partial batch being rejected

1. Scrapped after intermediate operation:

1.1 Example you have a route card with the following operations.

OP. No.	WC No.	GP CD	BIN No.	DESCRIPTION	SPEC. BY DATE	QTY.	STD. TIME	Ins. P.L. Man	Att. W/C	Asst.	Delay Before Op.	ESTIMATE NUMBER	INSP. INT.
000	P00			CUT 10 MM M/S PLATE x 1115 x 700 MM	J.D.K.	1	45					R 7076	
001	P01			CUT PLATES TO TEMPLATE ON TO-SILL		20	25					233	
002	P02			MILL PLATES TO DRG. ALLOW 3MM ON THICKNESS FOR FINAL MACHINING		20	70					1811/1	
003	P03			STRESS RELIEVE PLATES.		20	88					TD14	
004	P04			STRAIGHTEN PLATES IF REQUIRED		20	81					U.C.42	
005	P05			MILL PLATES TO DRG. ALLOW .25 ASIDE ON THICKNESS FOR SURFACE GRINDING		20	53					1811/1	
006	P06			SURFACE GRIND PLATES TO DRG.		20	174					13072	
007	P07			MILL PLATES ON N/C MACHINE		20	102					10102	
008	P08			FINAL INSPECTION		20	1						
009	P09			PLANT ACCEPT JOB	STOKES	20	1						
010	P10			PLANNING CLOSE JOB		20	1						

Assume that on operation 0040 the job has been scrapped by Quality Control. A Quality Control Rejection Note shall be received in Planning (PLNS Co-ordinator), before taking action.

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1.2 Procedures to be applied:

- a) produce a scrapped job card and give it priority 6. Scrapped Job Card; A copy of the original card with operations from 0020 (the first) to 0040 (inclusive), without all the other operations (0050-9999).
- b) Connect operation 0040 to 0050 on the back side of the Scrapped Job Card.

OPERATION CONNECTIONS								
CARD CODE	AREA	WORK ORDER No.	CAPOSS NUMBER	O.P. No.	Primary Area	PRIMARY WORK ORDER No.	PRIMARY CAPOSS NUMBER	PRIMARY O.P. No.
CW72								
CW72								
CW72								

Now there are 2 Route Cards for the job in the system: The card with operations from 0020 to 0040 on priority 6. The other card with operations from 0050 to 9999 on priority 5 and the two of them are connected, i.e., the other card will not appear on the Work Lists until the operations on the first card are completed.

- c) Costing - use scrapped cost centre (817061) for the scrapped part of this job and the rework on it (i.e. charged to workshop). The Work Centre concerned will be charged by this cost. The original Cost Number (F xxxxY) will continue containing the regular costs.

2. Jobs scrapped after final inspection

When a completed job is rejected on final inspection (operation 7777), the same procedure as in 1 will be applied: on the planning side scrapped job card will be prepared from operation 010 to 7777 with connection to operation 8888 in the Original Card. Costing will apply the same procedure as in 1.2 (c).

3. Partial batch being rejected.

In a case of part of items on a batch job being rejected, the job will continue in the normal way. Rework and extra work will be considered as an emergency. Costing will apply the same procedure as 1,2 (c).

4. GENERAL

It is recommended that in case of any rejected work the Foreman concerned will inform the Planning Officer.

2000

Number of days job on first day's work list
without being done.

[illegible]

Number of days Job on First day's Work List
without being done.

ENGINEERING WORK ORDER

PI 51

ENGINEERING WORK ORDER

Forward this copy to the Data Co ordinator immediately

MODDERFONTEIN - WORKSHOPS

DEPT.

Sched. Maint. No.

Commodity or Drawing No.

Area	Work Order No.	Foreman Code	Plant Item Code
10	1557		

Job Title		Originator's Initials

Work Requested

Originator	Phone
Plant Section	Date Originated
Early Begin Date	Date required
	Clearance required

PRIORITY		Red safety hazard	☐
(Tick one box)		Planned shut down	☐
Production loss	☐	Imminent production loss	☐
Imminent red safety	☐	Planned	☐
Small job	☐		
Reason for priority			
Priority Authorisation			

PI 52

5 22
as
above

JOBCAT 1 (circle one only)	
TYPE OF COST	
Normal	N
	S
Capital	C
E P /Project Number	

JOBCAT 2 (circle one only)	
RESPONSIBILITY	
Mechanical	M
Electrical	E
Instruments	I
Civil	C

JOBCAT 3 (circle one only)	
TYPE OF WORK	
Scheduled	S
Break down	B
Other	Z

Standard Hours	Critical Duration	Estimated Labour to Expend	Est. Material to Expend

AECI

AECI

MODDERFONTEIN ENGINEERING WORK ORDER CHECK LIST

1. Check whether item is held in stores.
2. On E.W.O.:
 - (a) Print name of originator.
 - (b) Insert phone number.
 - (c) Insert plant section.
 - (d) Insert date originated.
 - (e) Insert date required: Must be reasonable, in accordance with the amount of work involved in job.
 - (f) Sign E.W.O.:
 - (a) EMERGENCY to be signed by Section Engineer.
 - (b) ORDINARY planned jobs to be signed by Plant Engineer.
 - (g) Give clear written description of requirements including number of items required.
3. Attach to E.W.O.: Approved drawing, or signed sketch (By Section Engineer).
4. Plant sketch to include the following:
 - (a) Type of material to be used.
 - (b) Special dimensions or finishes required.
 - (c) Tolerances.
 - (d) Welding Specification.
 - (e) Item and Part numbers clearly specified.
 - (f) Special instructions.
5. Before submitting E.W.O.:
 - (a) Confirm material availability.
 - (b) Check whether drawings are:
 - (i) Not under or over specified.
 - (ii) Legible.
 - (iii) Latest issue, preferably metricated.
 - (c) Check whether job can be done by plant shop rather than Central Workshops.
6. If insufficient space on E.W.O.: Use "E.W.O. Continuation Sheet".

NOTE!: NO SAMPLES WILL BE ACCEPTED

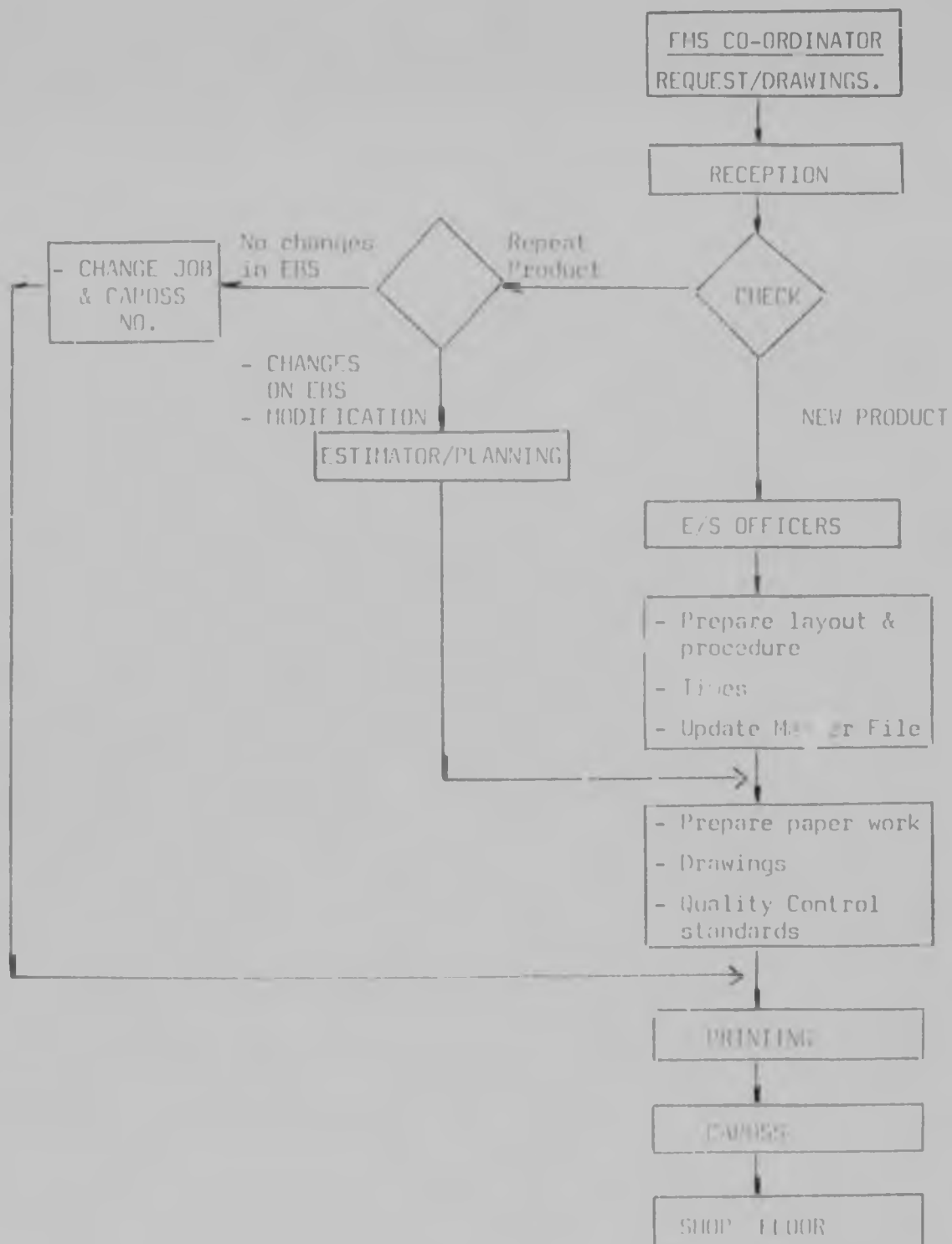


E.W.O. - CONTINUATION SHEET

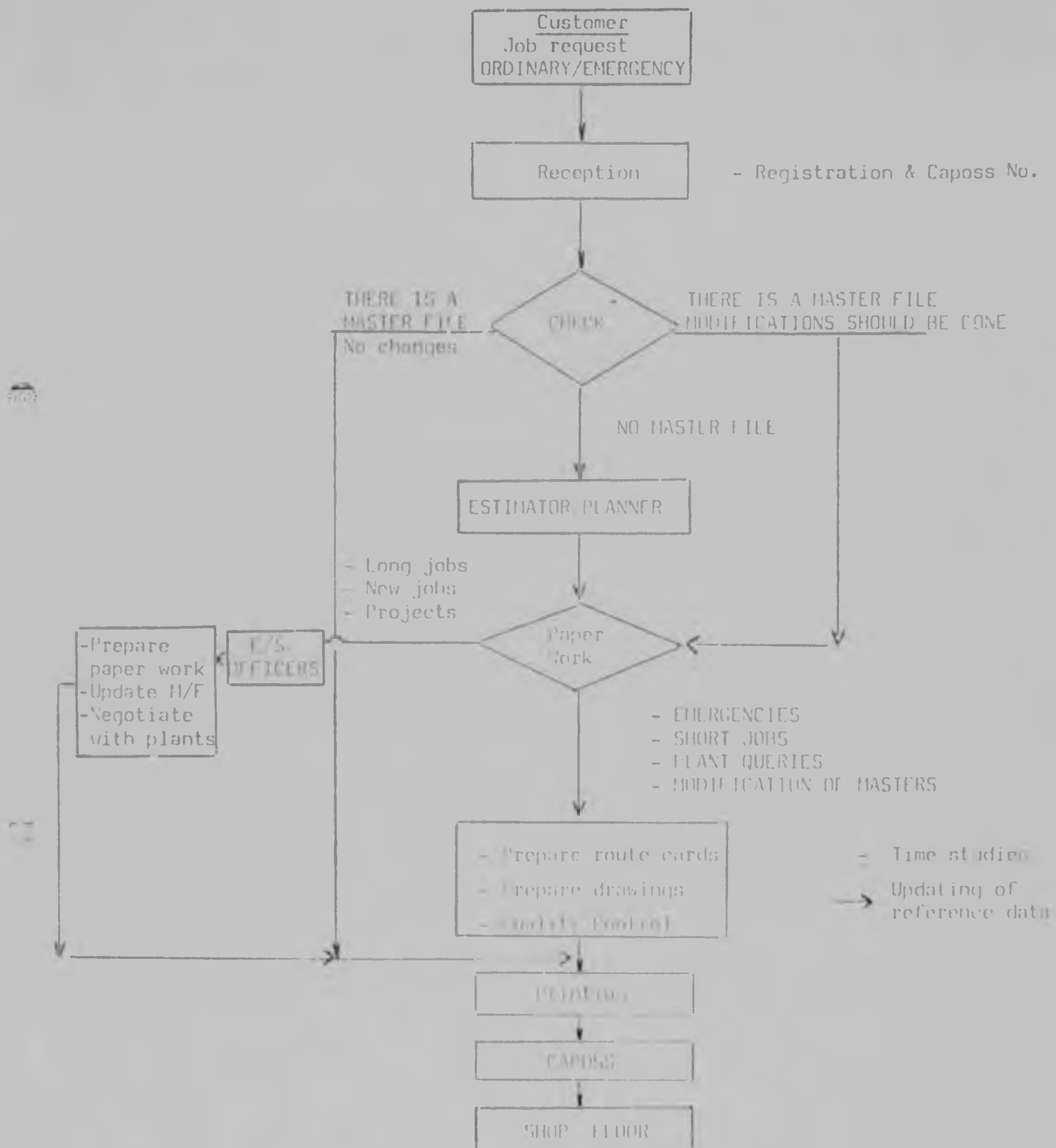
APPENDIX 16c

NO.	DRAWING NO.	JOB DESCRIPTION / MAT. SPEC. / ADD. WORK	SKETCH									
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FMS JOB REQUEST PROCEDURE



PLANT JOB REQUEST PROCEDURE



01430

[illegible]

1. JOURNAL MAN
2. APPOINTED LEADING HAND
3. ACTING JOURNAL MAN
4. OPERATOR
5. APPRENTICE
6. LEARNING LEADING HAND
7. LEARNING ON BONUS
8. WOT
9. LEARNING MANAGER
UNCONTROLLED WORK
10. FULL TIME
11. ACTING LEADING HAND
12. ACTING LEADERS THAMPE

TITLE
 NUMBER AND DATE OF ISSUE
 AUTHOR(S)
 COMPLETE ADDRESS OF AUTHOR(S)
 DATE OF PUBLICATION

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BONUS SCHEME - RECOMMENDED OPERATION CARD

CAPOSS No	OPER	DESCRIPTION	T/P	STANDARD TIME	Wk
CAPOSS No	OPER	DESCRIPTION	T/P	STANDARD TIME	Wk
1	9/12 13/11 14/11	5-515255 5057 674 64 65			13072



MODERNIZATION-CENTRAL WORK SHOP

OPERATION CARD

DATE

TIME

DATE

TIME	DATE
53	64 65

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TIME

PLEASE, WRITE CLEAR!

JOB SHOP PRODUCTION PLANNING & CONTROL - CASE STUDY
(AECI Modderfontein - Central Workshops)

Part D

Final Report - Results of the Project

Part D

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INTRODUCTION

This report is the final report following a series of four reports issued since December 1981 on my project for an MSc degree - "Job Shop Production Planning & Control - Case Study" (AECI Modderfontein - Central Workshops).

The report outlines the results achieved during the period March - October 1981 in improving the service provided by Central Workshops at AECI Modderfontein.

As a final report, it gives data on Planning & Scheduling, Production, and other matters concerning Central Workshops, and recommendations for maintaining and improving the quality and quantity of service given by Central Workshops to the various plants in the Factory.

1. PROJECT SUMMARY AND CONCLUSIONS

- 1.1. As a result of a survey of Central Workshops, carried out in October 1980, a programme to implement the recommendations was commenced in mid-March 1981.

A Production Engineer and a Planning & Control Engineer were appointed to augment the existing management structure and provide the main thrust for implementing the recommendations.

- 1.2. The main results are:

- The delivery of jobs on the due date has increased from 20 jobs per month (5%) to 391 jobs per month (56%).
- The average turnaround time of jobs (i.e. the period from receipt to delivery) has improved as follows:

Ordinary jobs (Priority 5) - was 50 days, now 37 days
Shutdown jobs (Priority 7) - was 56 days, now 4 days
Emergency jobs (Priority 9) - was 63 days, now 6 days

Approximately 75% of priority 9 (emergency) jobs have a turnaround time of 2 days.

- The volume of work completed by the Workshops has increased from:
6818 hours per month to 10075 hours (+ 48%)
- The volume of work received has increased from:
6198 hours per week to 9847 hours (+ 59%)
- The backlog of work has decreased from:
14850 hours to 9499 hours (- 36%)
- Product quality has improved.

- 1.3. Factors contributing to these results are:

- Implementation of new approach to scheduling:
Real queue for ordinary jobs, manual system for emergencies.
- Better creation of the planning system.
- Improved shop floor discipline; working to daily work list plan.
- Better progressing of jobs.
- More use of contract labour.
- Improvement in artisan performance.
- Better estimating service.
- Improved quality control procedures

- Improved supplies service
- Improved management control

1.4. Significant improvements have been achieved. Areas now receiving attention are:

- Job costing, accounting (including labour and overhead rates) and related management information system.
- Revised incentive schemes.
- Carpenters shop capacity.
- Recruitment of artisans.

Progressively improving results are anticipated over the next few months.

2. ORDINARY JOBS

An ordinary job, by definition, is a regular job which can be scheduled, in relation to the available capacity of the work centre concerned and with a delivery date within a maximum of 5 weeks.

2.1. Turnaround Time

Employing the accepted method for determining delivery dates and job scheduling, a comparison between customers required delivery date and actual delivery date has been made over the last 8 weeks. (15 August - 13 October 1981)

		<u>Average deviation</u>
i)	Central Workshops :	<u>1.002 days late</u>
ii)	EXACTUM :	<u>35.68 days late</u>
iii)	Jobs concerned with outside orders (both shops) :	<u>43.43 days late</u>

For details, see Appendices 1, 2 and 3

2.1.1. Analysis

The above results can be attributed, to a large extent, to the REAL-QUEUE approach which has been implemented for ordinary jobs in Central Workshops. This insists on maintaining rigid queue and a strict policy of completing all the operations on the daily work list. Otherwise, work is deferred again and again, giving a "false" indication that there is enough capacity. The reason why Exactum gives a longer turnaround time, is that Exactum's management adopted another concept (REGISTRATION DATE + 60 DAYS = DUE DATE), which is contrary to the new approach.

2.2. Delivery Date

2.2.1. General

The main problem which affected the quality of service given by the Workshops was recurring changes to current calculated delivery dates, due to the priorities approach built into CAPOSS. We aimed at modifying the system in such a way that our production programmes would adhere to the FIRST CALCULATED DELIVERY DATES, allowing for minor deviations only. This was done by having only one priority, as well as a manually manipulated registration of DUE DATES, given as input to CAPOSS. This part of the planning process became the most important part of control over inputs and hence the delivery service given to the client.

Previously, promised delivery dates were changing every run over an extended period. The new approach eliminates this phenomenon and changes, if any, are over a smaller period of time.

Using the priority approach, every new job coming into the system with an earlier due date and a higher priority rating than jobs already scheduled, resulted in a re-scheduling of all the jobs and old jobs were pushed back and replaced by new jobs. Under the new approach, this cannot happen. In cases where a job on the daily work list is not done on the first day, the job in that particular work centre is pushed back by 1 day. If it happens again, the job is pushed back by 2 days, and so on, until the job can be done.

In other words, before implementing this approach, the jobs were in a flexible queue which changed every day. Now the queue is rigid for as long as there is control over the running sequence of Due Dates and the Capacity of the various work centres.

A sample of the outcome of the approach is given in Appendix 4 (Changes in Calculated Finished Dates due to the new approach).

It should be noted from this Appendix the manner in which the Calculated Finished Date approaches the Adjusted Due Date.

2.2.2. Adjustment of Due Dates

2.2.2.1. Introduction

As previously stated, adherence to the new approach to scheduling requires manual modification of Due Dates. At first, this was established by discussing delivery dates with every customer. We soon learned that giving a high priority rating and an "early" delivery date, was done in order to ensure reasonable delivery regardless of the real importance of the job.

The importance of adhering to the first calculated delivery date, even if it was 2 months or more after the job had been initiated, was pointed out by the customers. After 3 months of implementation, it was no longer necessary to have negotiations with the customers, as the plant report indicated delivery dates; the actual delivery dates proved to the customers that the first calculated delivery dates were, more or less, being met.

Thus, the situation eased and it is now only necessary to discuss Emergency jobs with the customers.

The following table shows the results, over the last 6 months, of this procedure:

TOTAL % OF JOBS	ACCEPTED: CAN MEET DEL. DATE	REQUESTED DEL. DATE HAS BEEN PUSHED BACK	CLASSIFICATION CHANGED TO EMERGENCY	SENT OUTSIDE
100%	3%	90.7%	5.5%	0.8%

The effect of the new approach is significant when comparing the percentage of accepted job Due Dates in March to the average presented above:

Whereas in March, 70% of job Due Dates were accepted by planning, as requested by the customers, in October, only 3% were accepted on the date requested originally by the customer.

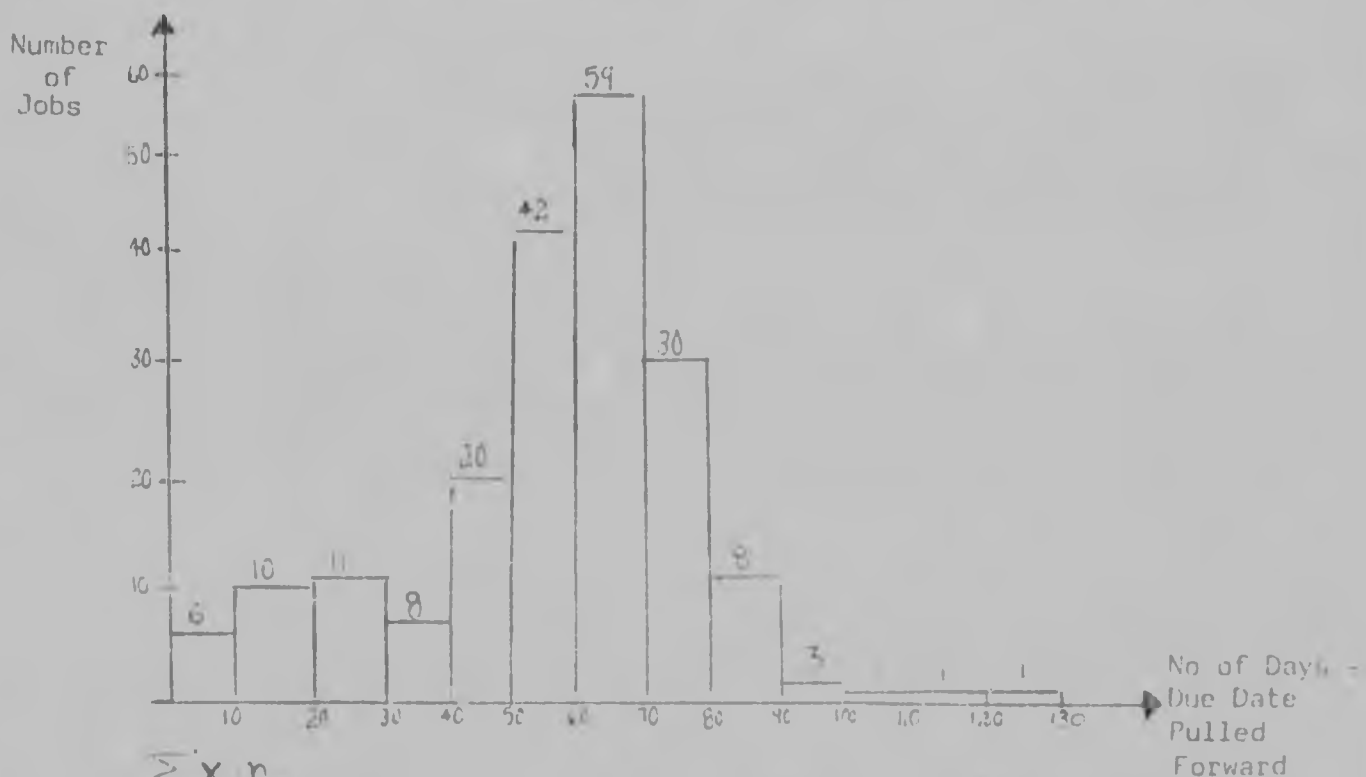
This gives another indication of the inadequacy, for job shop production planning, of priorities built into CAPOSS.

Theoretically, if every customer could identify the importance of his job in relation to all other jobs existing in the system, and if he knew the last date of the planned jobs in every work centre, then the system could perform properly. However, the original implementation of CAPOSS, using determined priorities and customer due dates, was not successful.

This brought us to the conclusion that customers can only give an indication of the job's classification, either ORDINARY or EMERGENCY, which can be controlled easily. Workshop planning is the function which will give them the Due Date based on work in process, capacities and technical expertise availability. If it suits the customer, he will accept it. If not, the job will either be put under emergency classification, or it will be done in another way, i.e. by overtime work or by contracting it out.

2.2.4.7. Adjustment of Delivery Dates - Distribution Function

A finding which enforces our claim that "Requested Due Date" for a job by a customer is meaningless in our type of production is the adjustment of delivery dates which is given on the following page. A representative weighted average distribution curve for 200 jobs during the last 6 months gives the following results:



$$\frac{\sum x \cdot n}{\sum n} = \text{MEAN PULL of Delivery Dates} = 53,25 \text{ days}$$

MODE INTERVAL (The interval with the majority of observations) = 60-70 days

$$\frac{x_{n+1}}{2} = \text{MEDIAN (The intermediate interval)} = 60,51 \text{ days}$$

2.2.2.3. Analysis

When analysing the above data, we find that the Average Push of Due Dates is approximately 53 days. As a result of this, it would appear that the Turnaround Time of jobs in the Workshop is at least 53 days.

The way in which we pushed a job backwards in the queue of existing jobs in the system originally was that

every new job was given Due Dates based on a running number of dates. In order to avoid one job overtaking a previous job, we allocated only one job, per day, per work centre, while the available capacity was sufficient for more than one job. This created float between jobs in the work centre's queue.

To close these gaps, the system was allowed to pull the jobs forward, thus achieving the best utilisation. Due to a systems constraint, jobs could not be pulled forward by more than 99 days, thus leaving several jobs "stacked beyond" 99 days.

This brought us to the conclusion that we should allocate jobs to the various work centres as per capacity and as a result, the range of the pull became shorter. This yielded maximum capacity utilisation and an average deviation from requested delivery dates of 1.002 days.

2.3. Conclusion

The above findings have proved that the best way of scheduling ordinary jobs in job shop production, is the REAL QUEUE approach. As CAPOSS cannot be modified to do so on its own, manual control over inputs is required in order to monitor Due Dates based on capacity per work centre. In other words, the GANTT approach to scheduling should be done outside of the system for every work centre.

However, monitoring of Due Dates cannot be done precisely by manual involvement. and, under the present circumstances, we can say that it is only 90% accurate, as there are aspects concerned with outside orders, quality control rejects and other problems that the manual control cannot manage.

Additional comparison between Residence Time requested by the customer to Residence Time after Due Date is adjusted by Planning is given in Appendix 5.

2.4. Additional note from the Author

Although, in principle, CAPOSS also uses the GANTT approach, the large number of priorities previously available, caused jobs to skip queues. By limiting the number of priorities, the system was forced to stick to a rigid queue, therefore not allowing jobs other than emergency work to pass existing jobs in a queue.

Emergency work is handled by reserving capacity in very much the same way as supermarkets reserve counter capacity at a "Quick Exit".

Some jobs, because of the need to be done very quickly, are allowed to go through the "service counter" (operations) quickly. However, the number is restricted and the majority follow the "rigid queue" approach.

3. CAPOSS MONTHLY TURNAROUND TIME ANALYSIS

For the first time since April 1981, the computerised report is "clean", i.e. data appears only for priorities 5,7 and 9.

This follows working on the basis of two types of jobs:

ORDINARY(5) or EMERGENCY(9). SHUTDOWN jobs are under priority (7) and are treated as emergencies.

This should be retained and it requires the maintenance of an accurate Masterfile ("Bible") and strict control over inputs.

Completed Jobs Turnaround for various priorities resulted this week (13.10.81) as follows:

3.1. Results based on Due Dates

a) Central Workshop

PRIORITY	1	2	3	4	5	6	7	8	9	TOTAL
AVERAGE DEVI- ATION FROM REQUESTED DATE	0	0	0	0	63	0	5	0	7	40
AVERAGE TURN- AROUND TIME	0	0	0	0	45	0	7	0	4	29
TOTAL JOBS WITH DUE DATE	0	0	0	0	309	0	33	0	173	515
TOTAL JOBS WITH- OUT DUE DATE	0	0	0	0	0	0	0	0	0	0
TOTAL JOBS	0	0	0	0	309	0	33	0	173	515

b) Exactum

PRIORITY	1	2	3	4	5	6	7	8	9	TOTAL
AVERAGE DEVI- ATION FROM REQUESTED DATE	0	0	0	0	41	19	26	0	16	38
AVERAGE TURN- AROUND TIME	0	0	0	0	69	19	57	0	4	65
TOTAL JOBS WITH DUE DATE	0	0	0	0	86	2	10	0	3	101
TOTAL JOBS WITH- OUT DUE DATE	0	0	0	0	0	0	0	0	0	0
TOTAL JOBS	0	0	0	0	86	2	10	0	3	101

* Have not the same meaning as in Central Workshop - on account of Exactum's approach.

** Lower than Central Workshop because every FMS job is automatically being pushed backwards in the queue by 60 days.

3.2+ Results based on the first calculated finish date

a) Central Workshop

PRIORITY	1	2	3	4	5	6	7	8	9	TOTAL
AVERAGE DEVIATION FROM PLAN	0	0	0	0	30	24	2	0	0	10
AVERAGE TURNAROUND TIME	0	0	0	0	45	35	7	0	4	29
TOTAL JOBS WITH FCED	0	0	0	0	280	1	5	0	173	290
TOTAL JOBS WITHOUT FCED	0	0	0	0	29	0	28	0	0	227
TOTAL JOBS	0	0	0	0	309	1	33	0	173	516

* An outcome of the scheduling approach.

** Further details are given below:

PRIORITY : 2

EARLY JOBS - DAYS EARLY																	LATE JOBS - DAYS OVERDUE										
>-50	-50	-40	-30	-25	-20	-15	-10	-8	-6	-4	-2	0	2	4	6	8	10	15	20	25	30	40	50	>50			
0	0	1	0	0	0	0	1	0	0	0	0	169	0	0	0	0	0	0	0	0	0	1	1	0			

NO. OF JOBS EARLY = 2

LATE JOBS - DAYS OVERDUE

NO. OF JOBS LATE = 2

AVERAGE DEVIATION FROM PLAN	=	0
AVERAGE TURNAROUND TIME	=	4
TOTAL JOBS WITH FCF DATE	=	4
TOTAL JOBS WITHOUT FCF DATE	=	169
TOTAL JOBS	=	173

1) Exatum

PRIORITY	1	2	3	4	5	6	7	8	9	TOTAL
AVERAGE DEVIATION FROM PLAN	0	0	0	0	25	7	40	0	0	33
AVERAGE TURNAROUND TIME	0	0	0	0	67	12	57	11	0	65
TOTAL JOBS WITH FCFO	0	0	0	0	0	2	10	0	0	98
TOTAL JOBS WITH FCFO	0	0	0	0	0	0	0	0	3	3
TOTAL JOBS	0	0	0	0	0	2	10	0	3	101

For further detailing and better understanding, see Planning's "Turnaround Time File"

4. EMERGENCY JOBS TURNAROUND TIME

4.1. September - October Results

The following table presents the results of the past 6 weeks for emergency jobs:

NUMBER OF DAYS	0-2 DAYS	3 DAYS	4 DAYS	5-10 DAYS	10-20 DAYS	20-30 DAYS	< 30* DAYS	TOTAL
Number of Jobs	214	27	19	20	31	6	32	349
%	61.4%	7.7%	5.4%	5.7%	8.9%	1.7%	9.2%	100%
Accumulated %	61.4%	69.1%	74.5%	80.2%	89.1%	90.8%	100%	100%

* Long-Term jobs and Carpentry work - classification changed to emergency.

4.2. Comparison Between Final Results To Previous Months Results

The objectives set by Central Workshop's management for Emergency Jobs Turnaround Time are as follows:

Group I : 95% of emergencies : 0-2 days

Group II : 3% of emergencies : 3 days

Group III : 2% of emergencies : 3-10 days

The above objectives have been determined arbitrarily as Central workshop's management had no accurate figures of the number of incoming emergency jobs and the capacity required for them, at the beginning of the implementation.

The following table presents the results for emergency jobs of group(I) since March 1981.

As previous months results have been presented in different ways, some of the results were adjusted to this way of representation : See following page.

MONTH	TOTAL NUMBER OF EMERGENCY JOBS COMPLETED	GROUP I 0-2 DAYS	AVERAGE TURNAROUND TIME (DAYS) FOR GROUP I
MARCH	123*	116 95%	1.53
APRIL	182	136 75%	2.00
MAY	200	132 66%	2.00
JUNE	201	139 69%	2.00
JULY	227	189 83%	2.00
AUGUST	260	136 52%	2.00
SEP-OCT(15)	349	253 73%	2.00

* only 15 days.

3. Discussion

From the above table, we learn that there are high fluctuations in the number of emergency jobs and in the percentage of jobs being done by average of 2 days. To a large extent, it can be attributed to old jobs which have been pulled from the system, to the Ardeer Packer Jobs and to Carpentry Jobs, which have been a long time in the system. It should be emphasized that, during this period, the policy for accepting emergency jobs was strictly practised.

The average results from the above table are:

- 220 emergency jobs/month
- 83% of them have Average Turnaround Time of 2 days.

It is recommended that the objectives set for emergency jobs, be amended to the following:

Group I	:	75% of emergencies	:	0 - 2 days
Group II	:	7,5%	:	3 days
Group III	:	7,5%	:	4 days
Group IV	:	5%	:	5 days
Group V	:	5%	:	5 - 10 days

These objectives should be reviewed from time to time, to improve on previous best performance. This should be based on the number of jobs in the system and not an average turnaround time

5. LONG TERM JOBS (Jobs more than 200 days in the system)

5.1. Results

The following table presents the number of old jobs remaining in the system at various dates:

	CENTRAL WORKSHOP	EXACTUM
6.04.81	74	52
13.04.81	73	47
22.06.81	41	27
30.06.81	33	21
31.07.81	28	14
31.08.81	22	16
30.09.81	17	16
13.10.81	12	14

The reasons for jobs being delayed at present are as follows:

	CENTRAL WORKSHOP	EXACTUM
Carpentry Overload	6	-
Waiting for outside order	2	4
Quality Control	4	3
Problems	-	7
	12	14

5.2. Summary

In Central Workshop, there are no more jobs from 1979. Action was taken in October to complete the above list of remaining jobs in Central Workshop and, from November, long term job lists will consist of jobs being more than 150 days in the system.

The aim is to arrive at a situation where 90 days will be the upper limit for jobs being in the system. There are exceptions such as outside orders and rejection of jobs in interim operations, which will always happen, but this is negligible.

6. OUTSIDE ORDERS

There has been a significant improvement in services given by Supply Department, and as a result, long term outstanding orders have been eliminated.

Control over accented delivery dates is fully implemented and it would appear that Turnaround Time of jobs concerned with outside orders has been reduced significantly. (See Appendix 3).

The one problem remaining is the placing of MC OUTSIDE FMS orders.

It is strongly recommended that, as soon as the report on "Recommended new procedures for placing O/S-FMS orders", is approved, it should be implemented. This will result in planning having full control over all outside orders, jobs being done outside will be progressed and inspected and, as a result, the quality of service given by Planning will be higher.

7. QUANTITY OF SERVICE

7.1. Results

The main results under this heading are:

- a) The volume of work received has increased by 59% (hours).
- b) The volume of output has increased by 48% (hours).
- c) The order file (backlog) has decreased by 36% (hours).

7.2. Analysis

The volume of incoming work has increased substantially since January. Throughput has increased even more, resulting in a 30% reduction of backlog hours.

1981	INPUT		OUTPUT		ORDER FILE	
	JOBS	CAPOSS HOURS	JOBS	CAPOSS HOURS	JOBS	CAPOSS HOURS
JAN	458	6255	383	6378	955	15400
FEB	499	6142	499	7259	N/A	14300
MAR	518	10691	412	8029	N/A	17000
APR	410	9043	668	9098	943	16900
MAY	675	4582	772	7632	880	14500
JUNE	527	7400	761	7804	656	13000
JULY	589	8619	726	11128	513	10500
AUG	486	9333	699	9163	452	10156
SEP	564	10361	731	10988	383	8842

(For a graph on the above, see Appendix 6)

NOTE: The hours figures do not balance exactly, due to cancellations and the cleaning of redundant jobs from the system. May and June input and output hours are suspect because No. 4 Ammonia shutdown jobs were processed on an ad hoc basis.

Using an average of the first two months as 100% and an average of the last two months as the current situation gives the following figures:

1981	INPUT		OUTPUT		ORDER BOOK	
	JOBS	CAPOSS HOURS	JOBS	CAPOSS HOURS	JOBS	CAPOSS HOURS
JAN/FEB	478	6198	441	6818	955	14850
AUG/SEP	525	9847	715	10075	420	9499
CHANGE	+10%	+59%	+62%	+48%	-56%	-36%

At this stage, there is no information available as to the type and volume of work that is still being placed with outside firms by the plants. It is therefore impossible to state whether Central Work-shops is fulfilling key objectives e(i) and c(ii) established in Part A item 2.1. of this project.

In March, there were 13 work centres in an overload condition, totalling 4080 hours overload. Currently only the carpenters shop is overloaded (3 work centres) and the total hours are 410. However, the lead time for carpentry work remains excessive at 5 months (100 days) due to a shortage of manpower. Of the 10156 hours in the order book, 4000 hours are carpentry work.

8. OPERATING RESULTS (COSTS)

It is not possible at this stage to quantify whether the workshop is cheaper, on average, than outside firms (one of the key objectives). This will require an organised sampling procedure. In addition, changes will be needed to the present basis upon which labour rates and overhead rates are calculated in order to maximise the competitive edge which the workshops possess.

Turnover to the end of July appears to be R3,8m (R6,5m annually), but it is known that all costs are not included in this figure.

Discussions are presently in progress with Accounts Department to revise the accounting procedures and the job costing system with a view to obtaining more accurate and comprehensive information and presenting it in a more logical form.

In the area of job costing, it will be necessary to have a much improved feedback of progressive costs on a daily basis, if the concept of charging on a quoted price is to be introduced. Also, the method of establishing the estimated price will need revision.

9. INDUSTRIAL ENGINEERING

9.1. Estimating

The estimating service is considerably improved. Further changes in the organisation and location of the estimators will result in further improvements to the service. The number of shop personnel receiving estimator training is being increased to provide more reliefs. Relationships between the Estimator and the shop floor have improved.

9.2. Incentive Scheme Revision

The preparation for changing to an individual incentive scheme will be completed within 2 months. The present group scheme has very little motivating effect, as the accuracy of collecting and calculating performance indices for the scheme is very poor.

9.3. Computer System Support

During the last 2 months, there has been a significant improvement in support by system and Head Office computer personnel.

However, due to a lack of knowledge in production systems by these personnel, and reluctance to hear other views on job shop production planning & control, there were no discussions or interchange of ideas which could contribute to the implementation of planning & control systems in other AECI factories.

An important factor concerning this issue, is the role of the Factory Systems Co-ordinator. His position is not clearly defined but it is considered that he should be involved in promoting the recommendations of the present report.

10. MANPOWER & TRAINING

10.1. Recruitment & Contract Labour

The recruitment and retention of artisans still causes concern. There has been no improvement following the increases which were granted recently to journeymen.

ARTISAN TURNOVER

	START	LEAVE
March	5	1
April	3	4
May	3	7
June	9	5
July	5	7
Aug	6	5

Source : FIRO

There are 46 vacancies (26%) for journeymen in Central Workshops.

Contract artisans have been used extensively during the last six months, to alleviate the situation.

CONTRACT ARTISAN HOURS AND COSTS

1981	Hours	Rands	R/hr	% AECI Wages
Jan	805	7300	9,06	8,2
Feb	1059	10419	9,83	4,5
Mar	1766	17628	9,98	10,0
Apr	2269	26629	11,73	15,8
May	4793	52016	10,85	27,1
June	5077	57197	11,26	28,7
July	4500	48070	10,68	23,2
Aug	4400	47608	10,82	23,0
Sept	3100	34162	11,02	19,0

10.2. Training

The workshops establishment is 114 artisans and 61 trainees (adult trade trainees and apprentices). Although, the apprentices are not all in the workshops simultaneously (tech; army etc), it was considered that the volume of trainees justified a full-time Workshops Training Supervisor in order to co-ordinate and programme the training.

A Training Supervisor has been recruited and is at present carrying out programmes for each trade and adapting the standard E.I.I.B. module system to our needs.

With this system, the training period is split up into periods of approximately 6 months. Each period is covered by:

- a) A syllabus
- b) A text book (manual) showing in detail the skills to be learned.
- c) A log book, which is kept and maintained by the trainee, showing the work he has done.
- d) A series of phase tests, usually at 3 or 4 weekly intervals, where the trainee does a test piece incorporating the skills recently learned. This is recorded in the log book and assessed and marked.

It is anticipated that the new system will be introduced into all departments by end-October.

11. ITEMS OUTSTANDING

The major tasks remaining to be completed are:

- a) Carpenters shop
- b) Accounts, job costing
- c) Incentive schemes
- d) Full achievement of 95% jobs delivered on time

11.1. Carpenters Shop

The present delivery period is around 6 months. This remains as the only problem shop in the workshops. The shop is under capacity, but efforts to recruit or hire artisans of the necessary calibre have been unsuccessful. Attempts to offload some of the work have met with only limited success and the cost has been high, sometimes 400% higher than workshops prices.

The wood machining section is the main bottleneck. The solution is believed to lie in the area of de-skilling the job to some extent by training specialists on single machines rather than trying to recruit artisans who are skilled on all machines. However, we have, so far, had no success in recruiting adult trainees for this work.

Until this problem can be solved, it is unlikely that the Carpenters Shops can be expanded to provide a service to the new explosives factories currently being planned.

11.2. Other Tasks

No further comments.

12. MINUTES FROM DISCUSSION OF THE FINAL REPORT WITHIN THE COMPANY

The author's final report on his 10 month Workshops project was discussed at a meeting attended by the Chief Engineer, Assistant Factory Manager, Industrial Engineering Manager, Workshops Manager and the author. Details of Final Recommendations and their outcome is given below.

SUMMARY OF RECOMMENDATIONS

It is strongly recommended:

- a) That jobs continue to be strictly scheduled using the "REAL-QUEUE" approach, as has been the case during the last seven months. (April - October 1981)
- b) That EXACTUM jobs be scheduled in the same manner as Central Workshop jobs.
- c) That EMERGENCY & SHORT JOBS continue to be managed manually by continuous control of the capacity allocated to such jobs.
- d) That present procedures continue to be followed for:
 - i) The placing of outside orders and the strict control of their delivery.
 - ii) The implementation of decisions made at Supply/Planning meetings.
- e) That a suitably qualified and experienced Planning & Control Engineer be appointed as soon as possible.
- f) That the present Planning Officer be replaced by a suitable candidate.
- g) That a Materials Co-ordinator be appointed as soon as possible.
- h) That estimating planning re-organisation be carried, out, using the programme devised by A. Franco. (Report issued 31.8.81)
- i) That FWE and ACE(M) agree on definite key responsibility and decision areas for the Production Engineer and for the Planning & Control Engineer.
- j) That there should be close co-operation by FWE with the Planning & Control Engineer, Production Engineer and Quality Control Engineer.
- k) That Maintenance and Industrial Engineering - Pinelands be kept informed of the "REAL-QUEUE" concept of scheduling as implemented in Central Workshops.

AGREED	ACTION BY
Agreed	FWE
Agreed	FWE
Not agreed Awaiting finalisation of report.	
Agreed	FWE
Agreed Strong w/s background essential	MIE & FWE
Agreed	MIE & FWE
Agreed	Done
Agreed	MIE
Agreed	FWE
Agreed	FWE
Agreed	MIE

Maintenance & Industrial Engineering,
Pinelands - Company's highest level of I.E.
FWE - Factory Workshops Manager
MIE - Factory Industrial Engineering Manager

APPENDICES

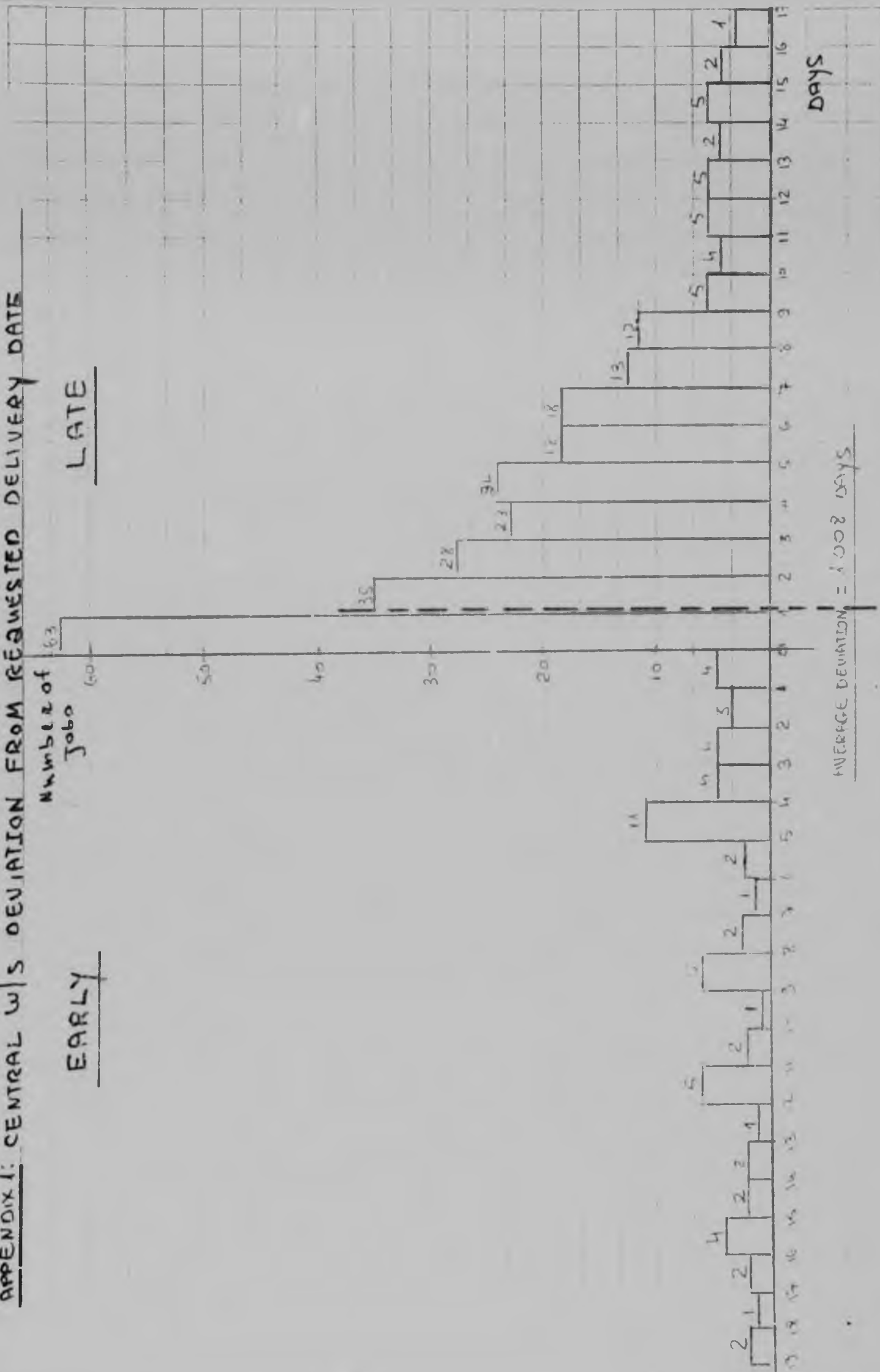
- Appendix 1 - Central Workshop : Deviation from jobs required delivery date
- Appendix 2 - Exactum : Deviation from jobs required delivery date
- Appendix 3 - Outside Orders : Deviation from jobs required delivery date
- Appendix 4 : Changes of CFDs due to the new perception
- Appendix 5 - Central Workshop : Residence Time of jobs in the system
- Appendix 6a - Central Workshop : Number of jobs per input, output and order file January - September 1981
- Appendix 6b - Central Workshop : Number of hours per input, output and order file January - September 1981

APPENDIX I: CENTRAL W/S DEVIATION FROM REQUESTED DELIVERY DATE

Number of Jobs

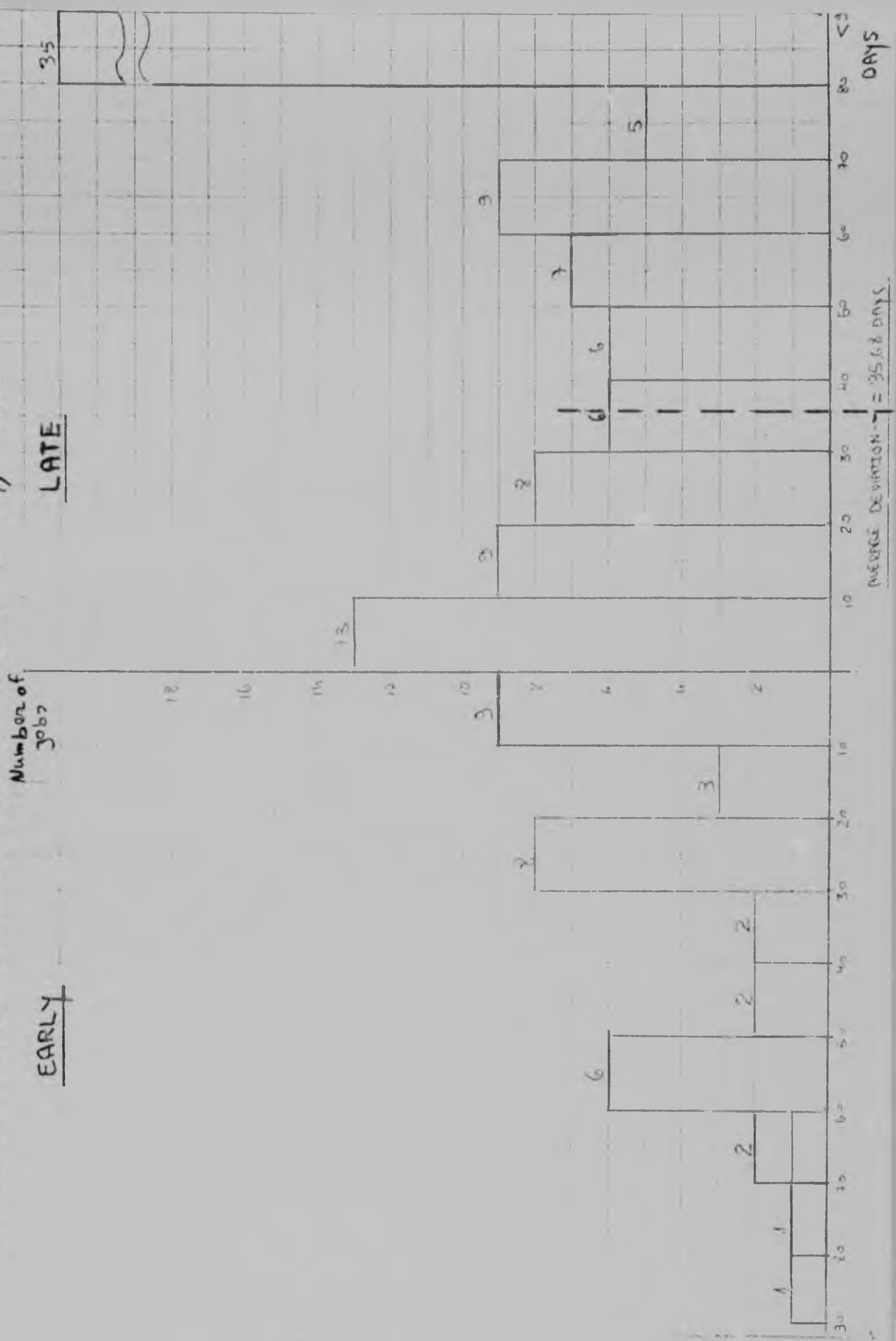
EARLY

LATE

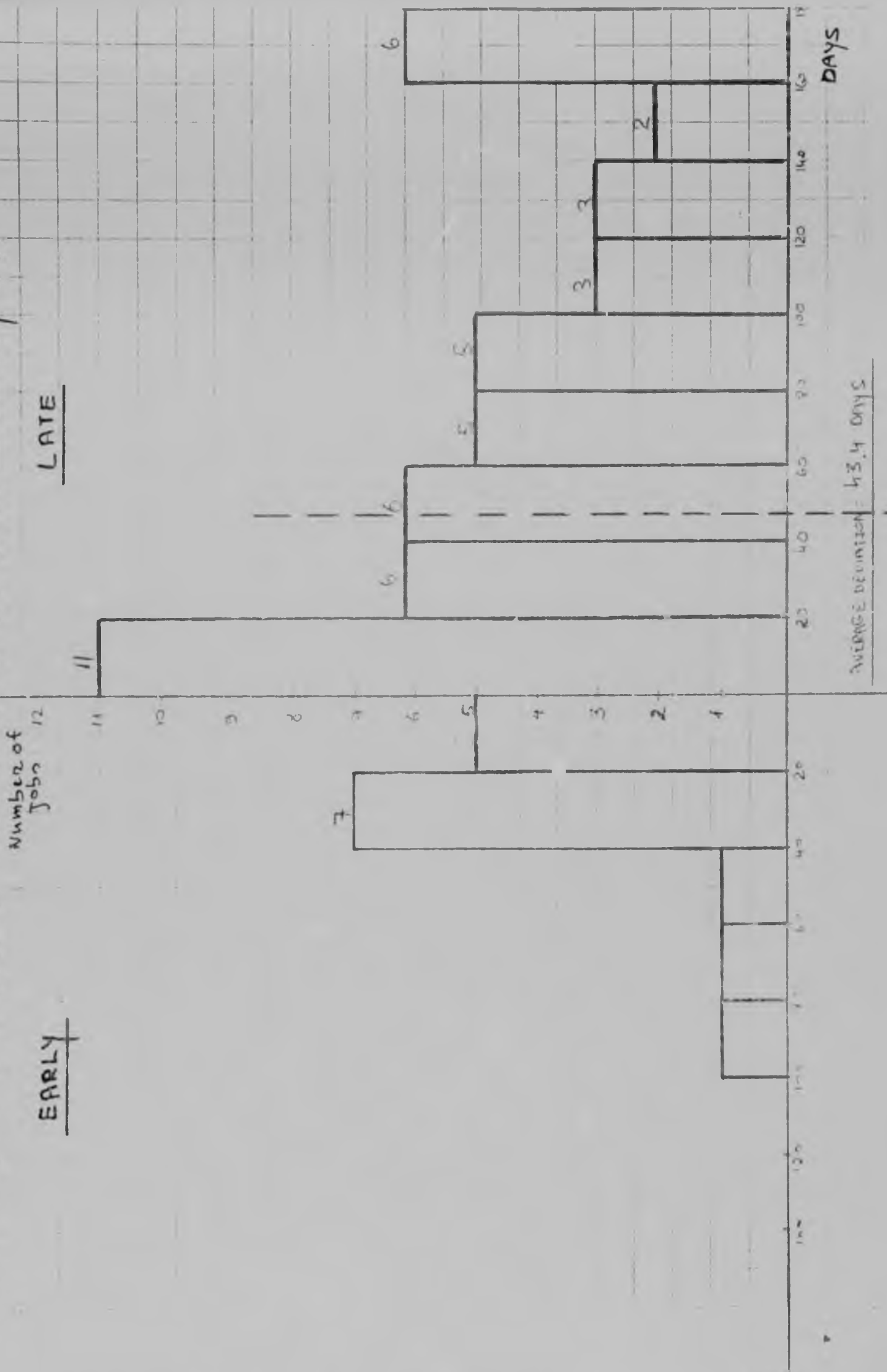


AVERAGE DEVIATION = 1.008 DAYS

APPENDIX 2: ISANDO - DEVIATION FROM REQUESTED DELIVERY DATE



APPENDIX 3: OUT SIDE ORDERS - DEVIATION FROM REQUESTED DELIVERY DATE

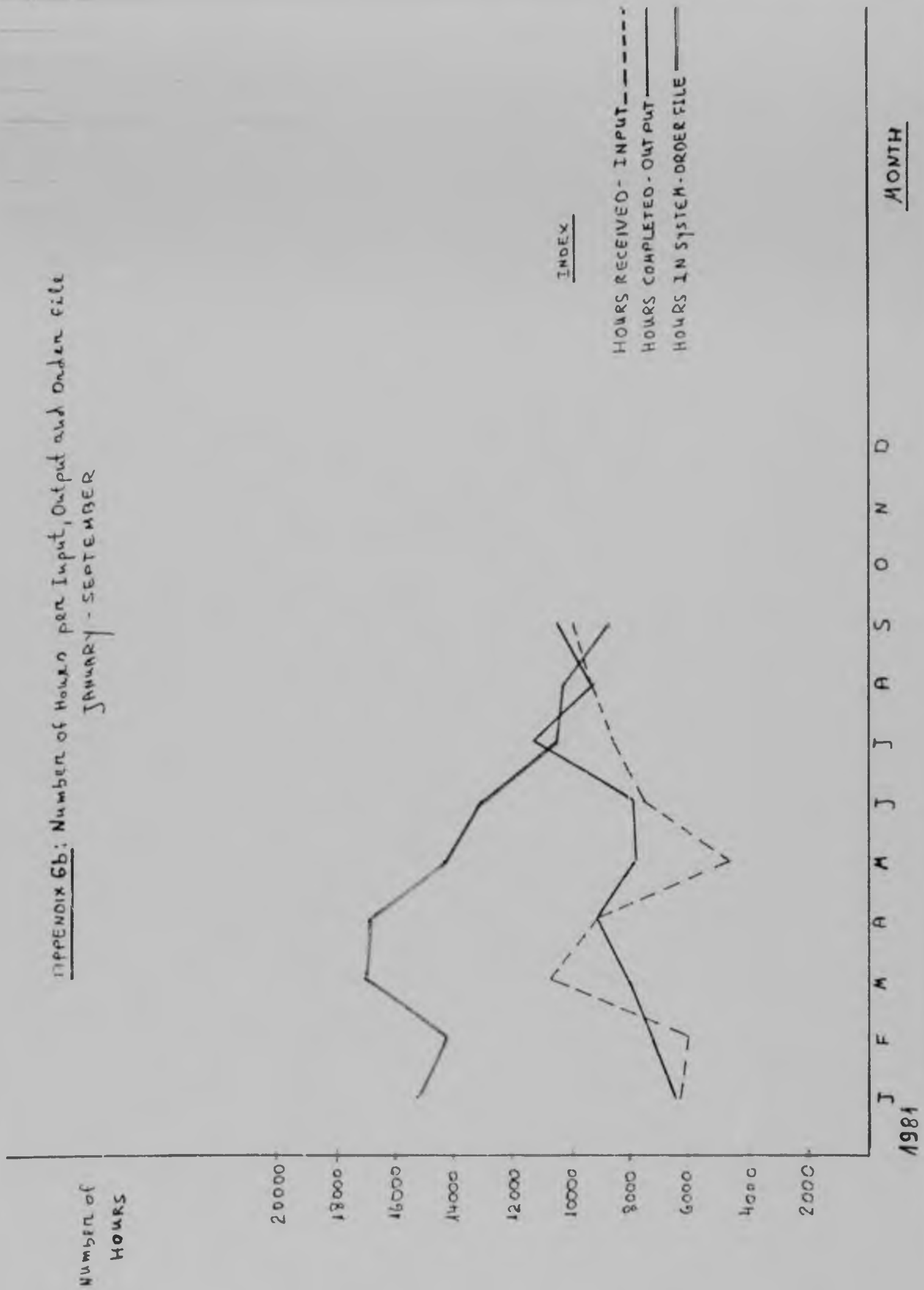


APPENDIX - 4

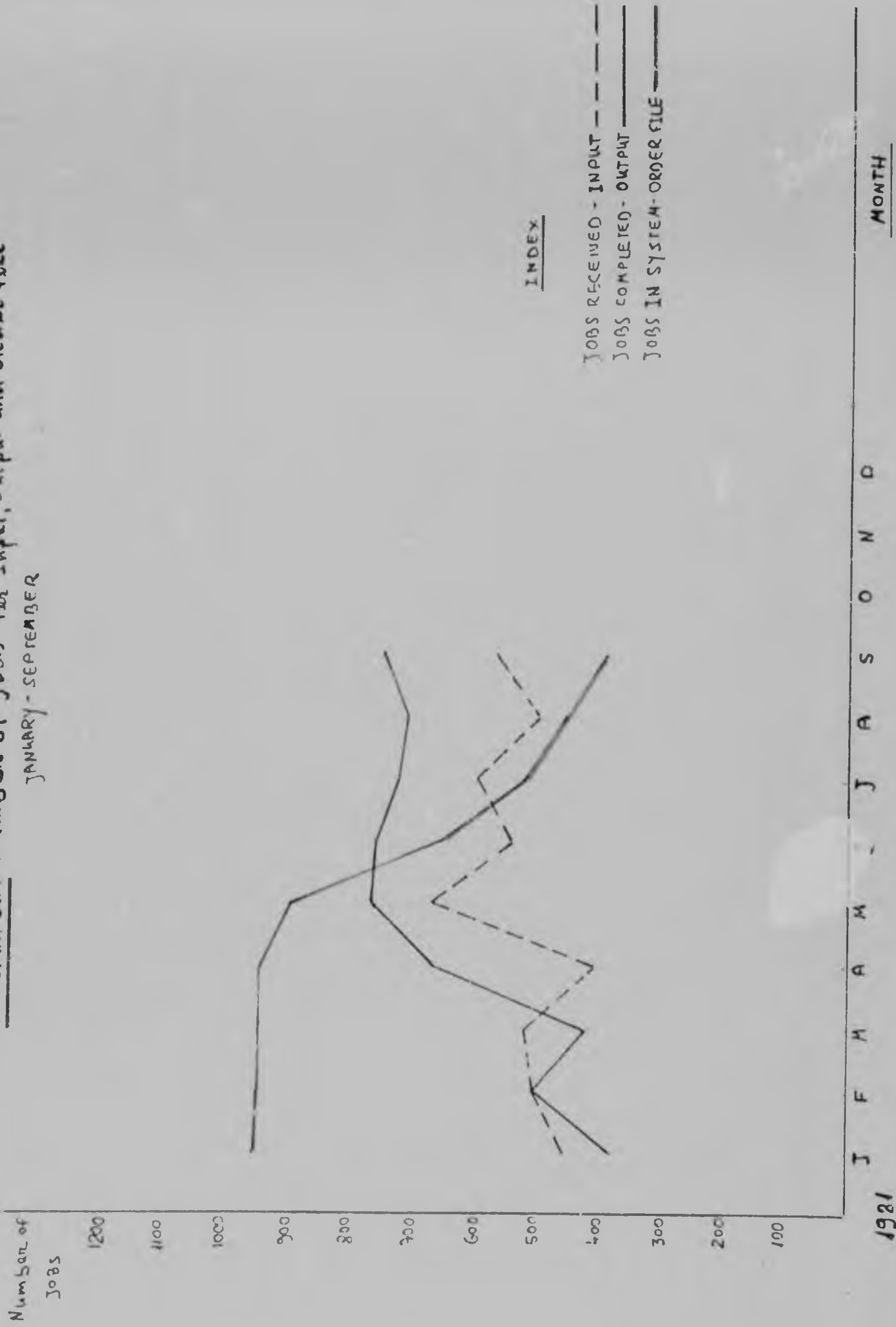
CHANGES OF CFD'S DUE TO THE NEW APPROACH

CAPOSS NO	REQUEST DEL DATE	ADJUST DUE DATE	FCFD	CFD1	CFD2	CFD3	CFD4	CFD5	CFD6
113825300	1146	2005	1213	1213	1208	1204	1208	1223	
113906100	1158	1175	1171	1171	1175	1181	1187	1191	
113912200	1140	1150	1154	1154	1159	1164	Comp	1158	
113915300	1162	2006	1203	1203	1211	1211	1202	1209	
114107300	1146	2007	1207	1207	1209	1209	1209	1209	
114115900	1145	1166	1162	1162	1166	1172	1165	Comp	
114117200	1157	1150	1150	1150	1151	1160	Comp	1156	
114205200	1150	1169	1166	1166	1151	1161	Comp	1154	
114303300	1162	2009	1206	1206	1206	1206	1206	1210	
114328200	1155	1190	1169	1169	1169	1169	1174	1179	
114406300	1155	2008	1209	1209	1209	1209	1205	Comp	
114425500	1165	1206	1165	1165		1160	Comp	1157	
114501900	1153	1182	1168	1168		1165	1168	1172	
114501901	1153	1181	1177	1177		1165	1169	1171	
114507300	1147	2008	1206	1206	1206	1206	1206	Comp	
114508900	1187	1208	1178			1178	1171	1174	
114508901		1205	1178			1178	1170	1174	
114518900	1163	2022	1234			1234	Comp	1155	Emergency
114608000	1161	1192	1187			1187	1173	1178	
114609900	1168	1183	1170			1170	1166	Comp	
114609902	1168	1184	1170			1170	1166	Comp	
114609903	1168	1185	1173			1173	1178	1172	
114616400	1161	1182	1157	1157		1162	1167	1190	
114618500	1168	1180	1156	1156		1160	1165	1170	
114702500	1169	1217	1173			1173	1168	1173	
114704700	1152	2022	1220			1220	1220	1220	
114705300	1148	2011	1211			1211	1211	1214	
114707900	1157	1176	1163			1163	Comp	1158	
114709300	1167	2021	1223			1223	1224	1224	
114710700	1158	1220	1177			1177	1178	1183	
114727000	ASAP	1191	1169	1169		1159	Comp	1157	
114803300	1167	2010	1213			1213	1210	Comp	Emergency

APPENDIX 6b: Number of Hours per Input, Output and Order file
JANUARY - SEPTEMBER



APPENDIX C: Number of Jobs Per Input, Output and order file
JANUARY - SEPTEMBER



APPENDIX 5:

RESIDENCE TIME OF JOBS IN SYSTEM - C. W/S

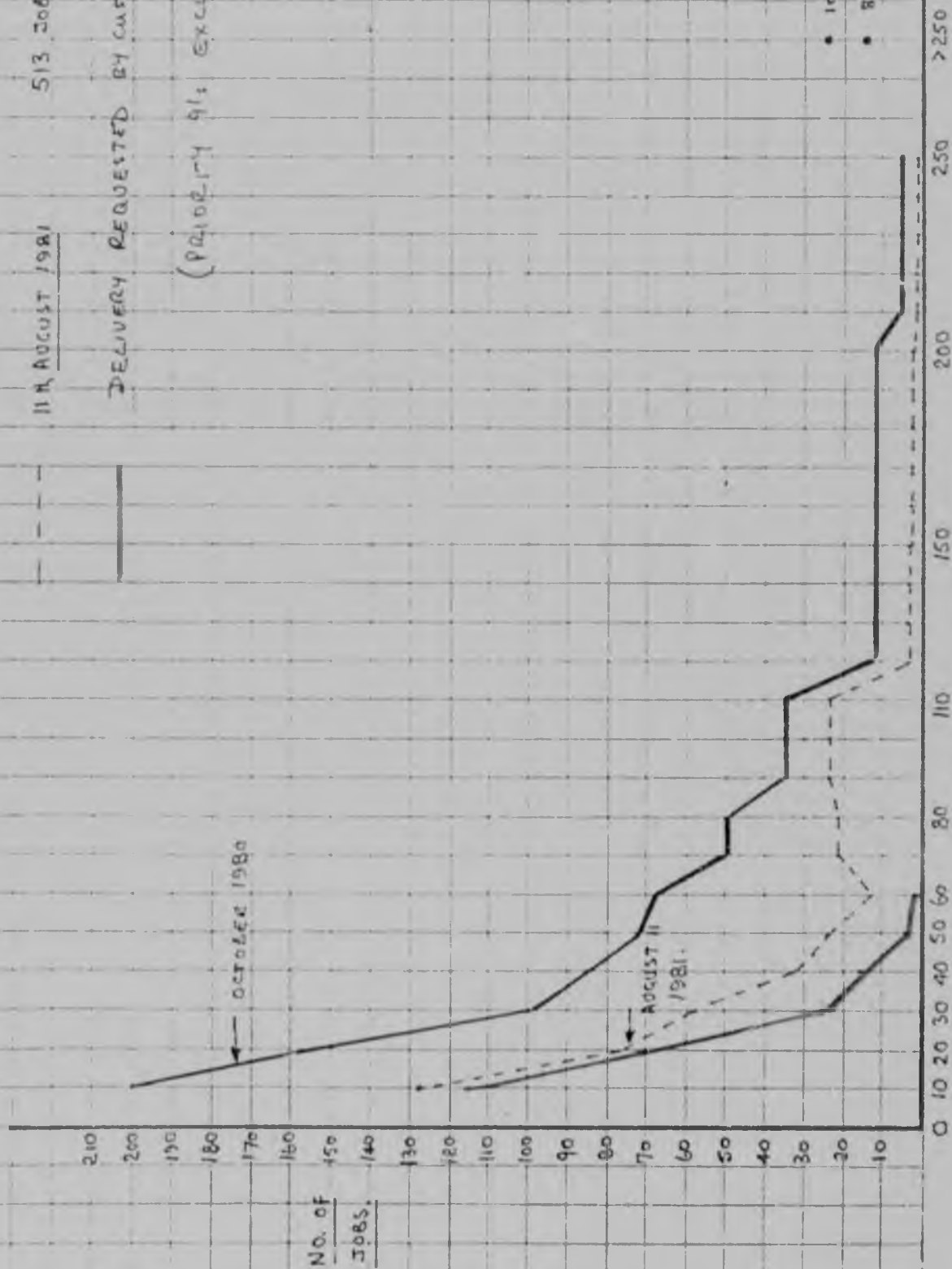
OCTOBER 1980 1053 JOBS IN SYSTEM

11 AUGUST 1981 513 JOBS IN SYSTEM

DELIVERY REQUESTED BY CUSTOMER - SAMPLE OF 233 JOBS

(PRIORITY 91: EXCLUDED)

SOURCE: CAPSS



RESIDENCE TIME - DAYS. (5 WORKING DAYS PER WEEK)

JOB SHOP PRODUCTION PLANNING & CONTROL - CASE STUDY
(AECI Modderfontein - Central Workshops)

Part E

Production Planning and Control - Literature Survey

Part E

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PREFACE

This report is a final following a series of 5 reports to my project for the MSc degree in Engineering.

The report presents a literature survey on the various views and approaches to Production Planning and Control and other subjects concerned with my project such as Management Information Systems and the operational research - Queues theory.

As many books were written on the various aspects of Production Planning and Control the survey given is an overall summary of the important points about the subject envisaged on these books and others not appearing on the reference list as well.

The few notes on the Queues basic theory are given as the significant point of the overall project is "Real-Queue" approach to job shop production scheduling versus "Priorities" approach.

Another issue discussed in the survey is the Systems Engineering view to production planning and control as I found it one of the major factors contributing to the development and advancement of the planning and control systems since the last 15 to 20 years.

A. FRANCO

1. PRODUCTION PLANNING AND CONTROL - GENERAL INTRODUCTION

1.1 Definitions

Short and overall definition for Production Planning and Control based upon APICS is :-

"Co-ordination among all the production facilities in order to produce products as per schedule and optimum cost."

It means that the planning and control function must look after regulating of materials supply and all the production operations in the plant for producing products by means of methods and certain processes in order to meet the commercial department programmes and customer requirements.

The activities should be directed in such a way that the equipment, the machines, manpower and the capital available to the plant will be used and fully utilized.

1.2 Tasks of production planning and control

- i) To ensure production of the right product.
- ii) Meeting customer's requirements on determined delivery date.
- iii) Producing the product in the most suitable work centre and the adequate equipment.
- iv) Producing the required quantity.
- v) Production with minimum scrap and rejects.
- vi) Maximum utilization of machines and equipment production capacity.
- vii) Maximum utilization of plant available resources.
- viii) Co-ordination between contractors if required
- ix) Achieving the above in such a way to enable minimum cost.

2. PRODUCTION PLANNING AND CONTROL DEPARTMENT FUNCTION AND POSITION WITHIN THE ORGANISATION

The position of the Production, Planning and Control department within the organisation structure of the plant of which it applies, is of utmost importance. Success in achieving most of the above tasks depends essentially on the authority and responsibility definition provided to the function by the firm.

Based on Production and Engineering Control to F.E. Bullet and on APICS there is no universal recipe which suits all the plants. The above give examples of the various possible ways of planning applicable in many organisations, depending on production type, size and organisational structure. A recommended 4 steps to treat this matter, when introducing the function, due to the above, is as follows :

- a) To determine and match the Planning and Control function tasks to those of all the plant.
- b) To determine the relative importance which the plant gives to every one of these tasks.
- c) To determine the amount of knowledge, the information, the technical reliability and the personal character required from the function incumbents for achieving the tasks.
- d) To determine the duties, the authorities and responsibilities of the function, and to appoint right people based upon their character to the above position.

Another article analyses the position of the function in the plant; and the possible organisational relations with other functions. Due to the article, Production Planning and Control is a function which correlates the sales, the purchasing and the production functions. The relations among these are strong or weak, upon the position of the Production Planning and Control Manager in the organisation structure.

The author gives examples for the position of the Planning and Control Manager in 6 different possible organisational structures.

- i) Usual structure in industry where the responsible man on production planning and control has direct and immediate connection to the production manager, as shown in figure 1. This type of organisation structure has advantage when Long Term Planning is being determined by the high level management and the plant has flexible production capacity. Under this type of organisation there is not connection between the sales programme and the production programme.

The conflict between the production departments to sales is sorted out in the high level of the plant management; which determines policies. The Production Planning and Control function has a duty of production progressing in this case.

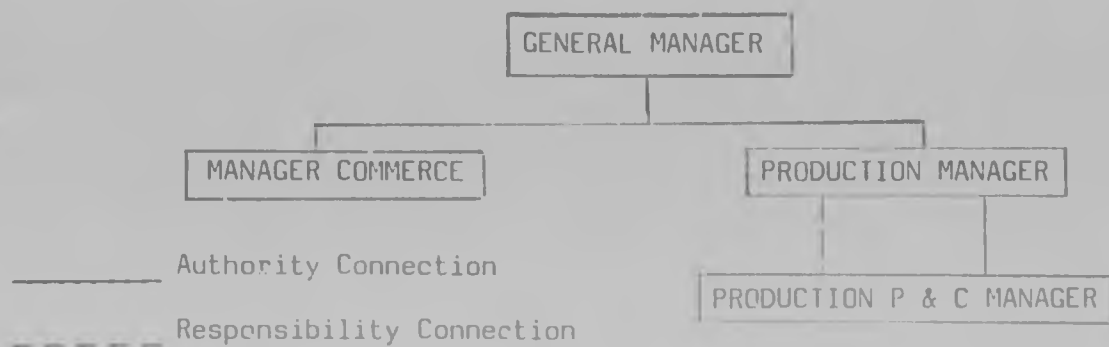


Figure 1. Usual position of P & C position in Industry

ii,iii,iv) There are various variations where the status of the men responsible for planning and control is independent on the production manager and on the commercial manager. The variations are shown in figure 2. This enables him to have influence on both of them and to balance between the contrary interests of the production and the sales.

The justification to such an organisation structure is where a balance between maximum fulfilling of customer requirements to most effecient production is required.

Everyone of the above three variations is applicable in a plant producing a wide range of products and having limited production capacity.

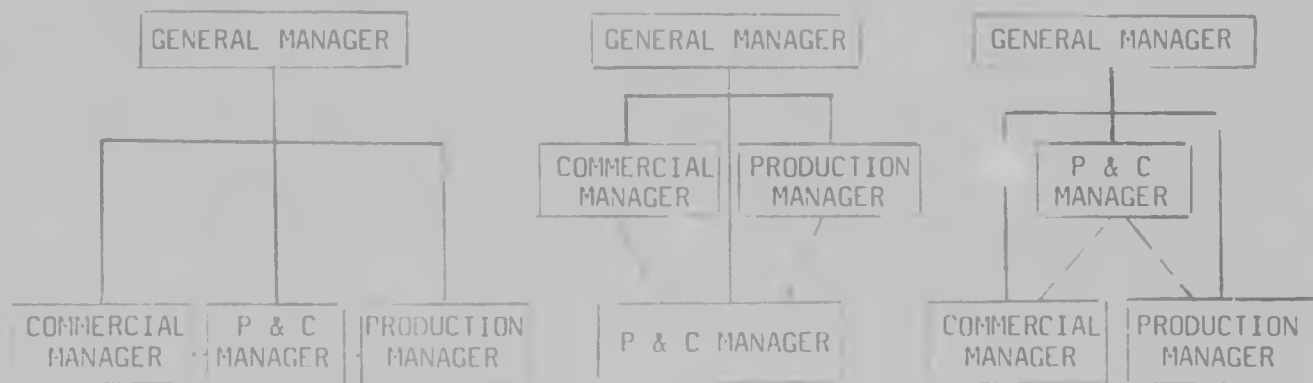


Figure 2. Various variations for Production Planning and Control Position

3. INTERNAL DIVISION OF THE PRODUCTION PLANNING AND CONTROL FUNCTION

Based upon the classical approach which can still be found in the literature, Production Planning and Control Function consists of the following four main activities :-

- i) PLANNING - Production planning through machines. Load and manpower available.
- ii) ROUTING - Determination of the place where job should be done. Where once this activity consisted of the preparing of drawings, detailing for production tools required and determining of the work centres, today it is condensed to the determination of machines and work centres required for a job.
- iii) DISPATCHING - Issue of work orders due to schedule and issue of orders for materials and tools required.
- iv) SCHEDULING - Determination of work programme in each one of the work centres.
- v) EXPEDITING - Determination of work progress as per programme, when exercising deviations from it.
- iv) CONTROLLING - Control of carrying out the work programme as per schedule.

Essentially, the relative importance of each one from the above activities depends on the way in which production is organised.

Production can be organised in one of the following four ways :-

- a) Flow mass production.
- b) Batch production.
- c) Job production.
- d) Group Technology production.

a) In flow mass production Routing and Timing problems do not exist. Single orders are not connected to the production programme. The customers should wait for meeting their requirements based upon the plant production programme. The main problems in such a plant are of dispatching and control. Planning and Control Function should ensure continuous flow of materials and items on the right rate to the production lines, and rational stock levels in stores and in process as well.

b) In the Batch production plant the production facilities are used for producing a wide range of products as per customer requirements, or to stock.

In this case all the activities of the Production Planning and Control Function are directed to ensure the best utilisation of these facilities and at the same time meeting the customer's required delivery dates.

- c) In job production the same problems as in the case of b) exist. The Production Planning and Control Function has in addition to ensure completion of design and drawing before planning.
- d) In group technology production the same problems exist as in the previous 3 production types. Production Planning and Control has in addition to co-ordinate and balance between the groups.

4. CONTROL SYSTEM

In Production Planning and Control to J.H. Green a more modern approach to the Internal structure of the Production Planning and Control Function is given :-

The author envisages this function as a control system. The type of system depends only on the sort of production technology being used. In other words the type of control system used indicates the production technology of the plant.

The author differentiates between 3 types of control systems :-

- i) Order Control System - which is defined as control system for progressing every customer's order or stock order through all the activities in the production cycle.
- ii) Flow Control System - which is defined as a system for control on production flow of production orders for groups or blocks of product which is processed through the same production processes, for instance : Clothing Factory.

* Comment : The above definitions are based upon APICS dictionary.

Every Control System immaterial of production technology type includes 3 stages :-

Planning
Action
Compliance

All the activities concerned with production in every plant are connected to these three stages.

When comparing these three stages with the four tasks which presented the classical division of the Production Planning and Control function we deduce that there is an analogy between them as shown in figure 3.

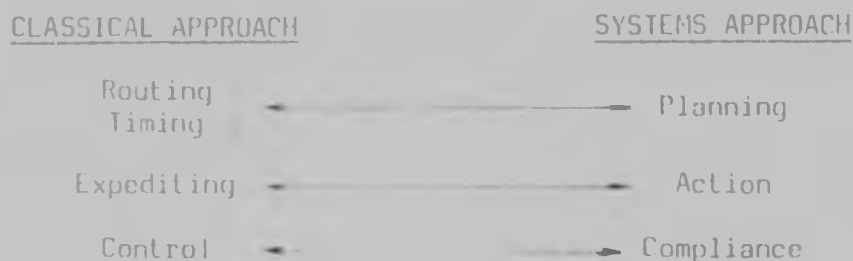


Figure 3 Comparison between the approaches

Today there is a tendency to limit the control activity which should build a bridge between the production and the planning up to replacing it by data captured and worked out in the EDP System.

Indeed, there is an analogy between the production control system to the Servo Control System based on the fact that production control has the duty of a production regulator as shown in figure 4.

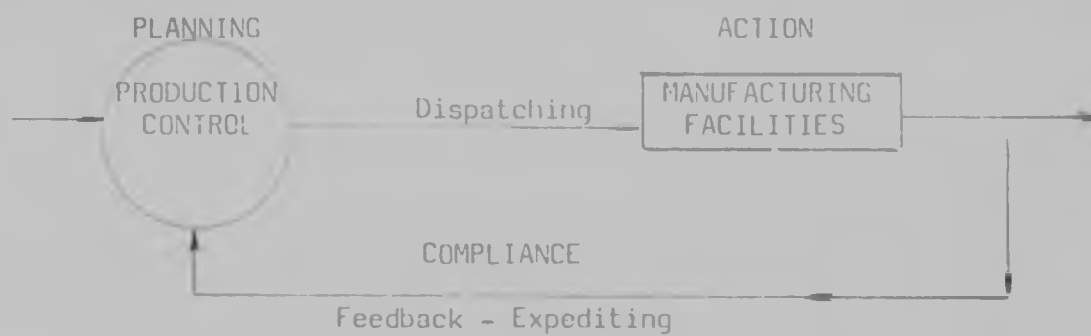


Figure 4 Control - Analogy to regulator

5. PRODUCTION PLANNING

When considering production planning, there is a distinction between two aspects of it :-

- a) Short Term Planning
- b) Long Term Planning

5.1 Long Term Planning

Under this concept of planning all the policy principles and key points are determined for optimisation.

Optimisation size : Stock level, minimum production cycles, etc, subject to demand forecast, market survey, machines and available resources.

Production programmes are being prepared based upon Long Term Planning as well as the capacity requirements.

However, if there is no possibility to extend capacity, the programmes and capacity requirements are reviewed until optimum correlation is achieved.

5.2 Short Term Planning

Usually, the idea referred to procedures for conversion of production order into production programme. In every planning system immaterial of production process it is possible to determine six main activities :-

- a) To determine what to produce - Targets.
- b) To determine how to produce - Production processes.
- c) To determine when to produce - Activities order and timing.
- d) To determine where to produce - Routing and work centre.
- e) To determine who will produce - Manpower.
- f) To determine by what to produce - Production resources.

6. TECHNIQUES USED IN PRODUCTION PLANNING AND CONTROL

6.1 GANTT Chart

The traditional and mostly used tool during many years has been the GANTT Chart.

This is a very simple way to present, in a graphic way, the production stages and that is his most important contribution.

Advantages of this method which do not exist in the other methods are :-

- Forces preparing of production programme which is itself an important stage towards making activities efficient.
- Makes it easier to compare between scheduled work and actual work done. Eliminates the need to remember a great deal of information for comparison.
- The chart is of compact structure - one chart can replace a large cardex of information.
- Simple to introduce : Everyone, after short training, can build up such a chart.
- Dynamic in his feature.

Of course, at the present stage of technology, the GANTT Chart has more disadvantages than advantages.

The GANTT Charts are of two basic types :-

- i) Forward charts - on this chart work schedule is determined from the present date forward and based on it the end date is determined.
- ii) Backward charts - when the end date is known it is desired to start from it backward in order to determine the desired start date.

6.2 Introduction to computers use

As Production Planning and Control department has the duty to co-ordinate between Purchase department, Production, Stores and Sales, various reports about plant activities are required for it.

Based on these reports production planning should be carried out. Since the last two decades as the volume of required information is increasing and due to the quick development of the PERT technique, the use of computers in planning is being extended.

The contribution of the computer is significant when considering capture of large amounts of data, quick processing and the follow up after progressing production.

Today it is applicable to use a joint application of the GANTT Chart, PERT Chart and balance line.

This type of diagramme presents :-

- a) General layout of project and his activities order.
- b) Critical rout and sub-critical routs.
- c) Work state before and now.
- d) Resources requirements.

In addition, the following information is given :-

- a) Execution times.
- b) Start and finish of activities.
- c) Cost control centres.
- d) Completion percentage of every activity execution.

Two tables complete this diagramme :-

- i) Cost Analysis . regarding Normal time and crashed time.
- ii) Manpower Analysis : Supplies the same information but on budgeted work hours.

7. COMPUTER USE FOR PRODUCTION PLANNING AND CONTROL

7.1 General

As it was mentioned before the need to store large amounts of data and activities brings the Production Planning and Control to use the computer.

The computer assists a great deal in the use of many planning techniques, for instance CPM.

IBM was the pioneer in development of new techniques for network planning and for production planning and control (Kraus, Class, CAPOSS, etc).

Later on all the other companies such as CDC, HP, Borrough and others dumped the market with many packages for production planning and control, integrated with other aspects of management in the firms such as Costing, Marketing, Inventories, etc.

7.2 Basic techniques used in computers for production planning and control

7.2.1 PCS 360

This technique provides the user with a technique called "precedence network" or another name "Precedence list".

The advantage of this method over the others CPM/PERT is in the way interactions between various activities are given.

An example which illustrates the difference between CPM/PERT network to PCS network is given in figure 5.

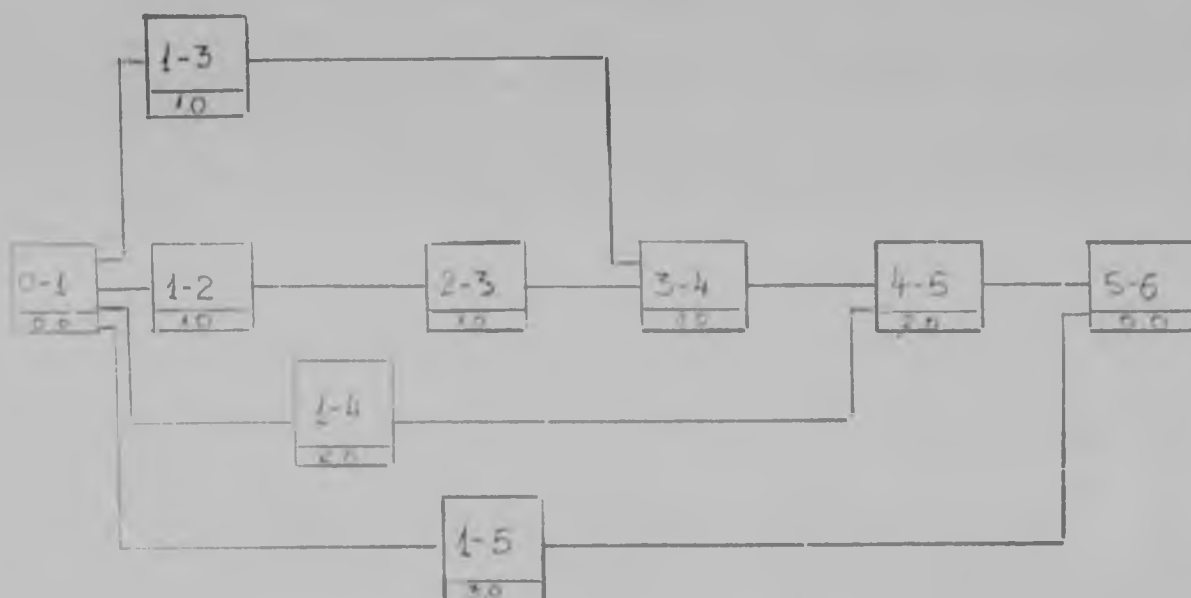
CPM/PERT



Precedence Event | Follower Event

0	1
1	2
1	3
1	4
1	5
2	3
3	4
4	5
5	6

PCS 360



In this case all the relations are :
start of every activity depends on
finish of precedence activities.

Activity	Precedence Activity
0 - 1	
1 - 2	0 - 1
1 - 3	0 - 1
2 - 3	1 - 2
1 - 4	0 - 1
3 - 4	1 - 3; 2 - 3
1 - 5	0 - 1
4 - 5	1 - 4; 3 - 4
5 - 6	1 - 5; 4 - 5

Figure 5 The difference between CPM/PERT to PCS-360

The techniques presented above are available in PERT and are called A-O-A and A-O-N i.e. activity defined by Arrows and activities defined by Nodes.

Other network techniques available : PERT/COST, PERT/TIME, PERT/LOB.

B. ADVANTAGES ON USING COMPUTER FOR PRODUCTION PLANNING AND CONTROL

The larger the plant and the production scale the more the importance to have Electronic Data Processing (EDP) for success in achieving of the organisation goals.

Obviously, computerising only available reports in order to save manpower can result in disappointment and uneconomics.

It should be born in mind that not only saving in manpower is aimed at when introducing computer but his potential possibilities for improvement of present procedures or the introduction of new procedures which are responsible without using computer.

The criteria for efficient use of computer for Production Planning and Control are as follows :-

- a) The system will be assigned to control with exceptions.
- b) The system will not be assigned to eliminate manpower but to avoid clerical work done by technical workers (Technicians, Engineers, etc).
- c) The system will be used for day to day decision making.
- d) The required information for non-usual decision making will be assessed.
- e) Minimum paper work.
- f) Information processing will be of high level i.e. Inputs will have as such quality, layout and timing that no reprocessing for reports is required.
- g) Information processing and reports will be timeous in order not to lose their utility.
- h) The system will be flexible for extension and improvement without essential modification in the system or in the programmes contained.

9. COMPUTER PROGRAMMES FOR PRODUCTION PLANNING AND CONTROL

The first programme developed by IBM in order to enable use of computer in Production Planning and Control is the "KRAUS" programme. The programme can be used by every plant, small and large size.

The programme is built in such a way that her introduction does not require organisational changes in production plant and every plant can process the data based upon his particular organisation structure by means of a leading card and without modification of the programme itself.

The big disadvantage of this programme is not having an optimal cost element. Layout of a "KRAUS" programme is shown in figure 6.

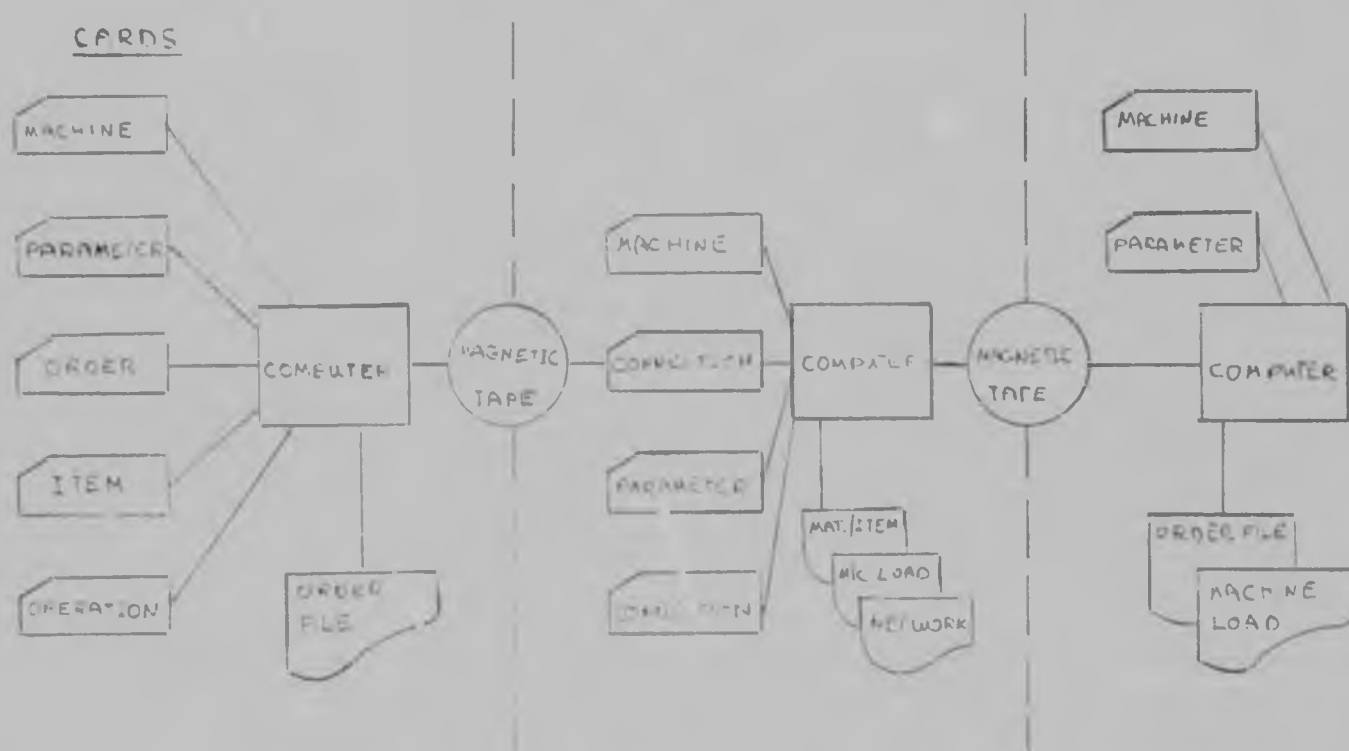


Figure 6 "KRAUS" layout

IBM planning and control programmes archive offers many other programmes for project planning and control. Few of them are :-

PCSI/1130 - The programme can process no more than 2 000 activities by IBM 1130 computer. Hence, there are certain limitations on the amount of data processing.

- PMS/I8 - Used mainly for data processing. The system is flexible on input layout, on data included and on the significant way of getting reports.
- The system consists of modular programmes in which each one of them does a significant job, either processing network or managerial data processing.
- The programmes are joined into 4 sub-systems :-
- i) Network processing system (Times analysis)
 - ii) Resources allocation system (Resources analysis)
 - iii) Costs analysis system (Cost analysis)
 - iv) Reports producing system (Output analysis)
- JAS/3 - The system can process between 300 to 736 activities and up to 10 joint networks.
- The programme contains most of the possibilities of the PCS and in addition enables printing of the network itself based either on arrows or on rectangles.
- The system gives the following :-
- List of activities and progress data.
 - List of activities and resources consumption.
 - List of precedence operations.
- APL-Mini Pert - A programme for quick reporting. Can be applied only through terminal No 2741 which is not available in every plant. The programme gives the designer all the possibilities for storing network, maintaining it and reporting on about 200 activities. After then it is possible to incorporate the network to other more complicated networks.
- Class-25 - One of the most developed programmes for Production Planning and Control which is being used in many industrial organisations. The system can be applied through an IBM/360 computer.
- The system is based on CPM/PERT and mainly suits assembly plants and works due to the timing approach.
- Advantages -
- Suitable for assembly plants.
 - Forecasts future events.
 - Besides production programmes and load programmes for the Production Planning and Control Department, it is used by the costing and accounting departments.
 - A great number of activities can be processed through it.
- Disadvantages -
- Complicated to be applied for plant other than assembly.
 - Useful only for large plants as a result of high operation costs.
 - The programme does not keep history.

CAPOSS - Version 1,2,3,4,5

- Programme to use whenever there is a problem of allocating a large number of activities to limited capacity resources based upon job priorities. It contains many features such as overlapping and splitting of operations, use of alternative resources, grouping of similar activities and resources for efficiency.

The system generally is one of the most developed systems of IBM.

Detailed description of the system is given in part B to this project.

Other programmes

- The other companies such as CDC, Borough and Hullet Packard also offer programmes which are sometimes more useful for small plants as the systems offered are of Integrated Management Information Systems approach.

GENERAL

- After more than 20 years of experience in using computers for Production Planning and Control and the increasing number of plants using computers many plants and organisations find it feasible to build suitable self programmes as the big companies offer too general programmes to suit all which cannot be utilized properly by sophisticated users.

10. SYSTEMS VIEW OF PLANNING AND CONTROL

10.1 GENERAL

R.L. Ackoff in his book "A concept of Corporate Planning" sees Planning and Control as clearly related activities.

The main tasks of Planning and Control are as follows :-

- Planning : To co-ordinate various parts of an organisation and to allocate resources according to its objectives and the forecast state of the environment.
- Control : To ensure that plans are implemented so that the desired co-ordination is achieved and the organisation develops in the desired direction.

In terms of a "gap" planning and control can be illustrated as shown in figure 6.

Performance

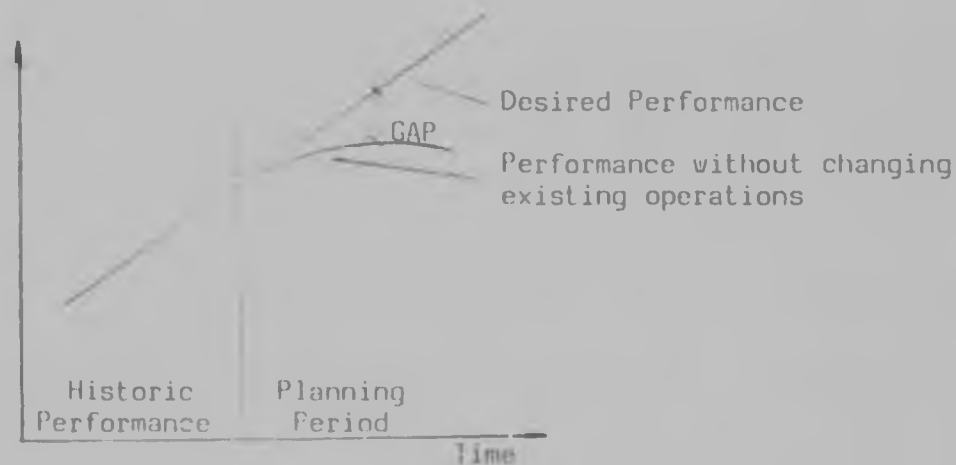


Figure 6 'GAP' term to planning and control

Planning is therefore concerned with identifying where the organisation is going through exploration and evaluation of alternatives and deciding where the organisation should go.

Control is concerned with bringing about the gap closure by maintaining and adjusting the chosen alternative by planning.

10.2 Planning

In any organisation three types of planning should exist in order to ensure continuity : Strategic, Project and Operational. Together they form a hierarchy of the Planning System.

Another way to illustrate the regulator role of Planning and Control given in item 4 can be shown in figure 7.

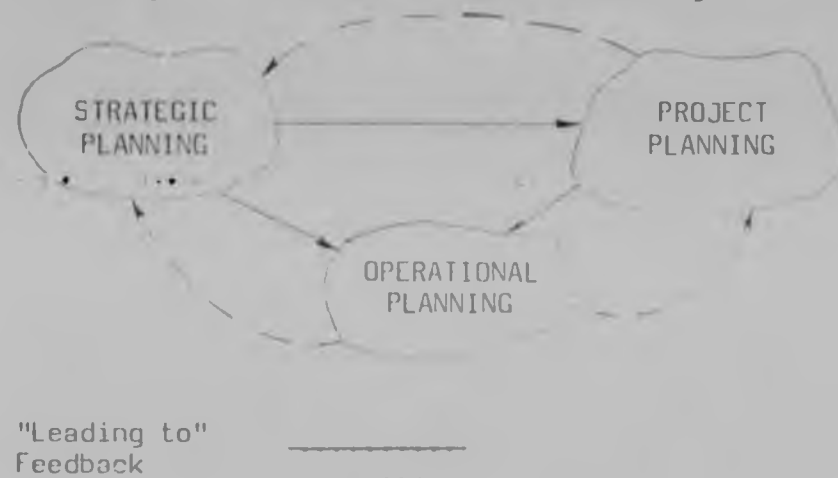


Figure 7. Systems view to planning and control

As all planning systems require a measure of performance feedback is necessary.

Every planning system has to co-ordinate between the various parts within the system and as this is the case systems approach insists on having considered all the properties of the relevant systems such as : objectives, wider system, boundaries, resources, connectivity, decision takers etc.

10.3 Control

Control is a mechanism to ensure bringing about of programmes as per planning programmes.

The results are measured through outputs. It is preferred to have them as quantitative as possible.

In human activity it is difficult to measure outputs quantitatively, thus, in many cases, it is done qualitatively.

When considering a Production Planning and Control System a control consists of meeting daily production programmes, meeting operation estimated time and ensuring feedback which are a few of the interrelated variables composing higher target as x% products delivered on time. This implies they are connected and should be known and clear enough to the system users or incumbents.

Having known all the variables of the system, adjustment of them is required. This is the task of control and it should be done through monitoring inputs, outputs and related variables which affect the systems performance.

A practical example for control in this particular project is the control over the computerised planning and control system in central workshops.

The basic model used is in figure 8 taken from readings on Systems Engineering by J. BICHENO (Wits University).

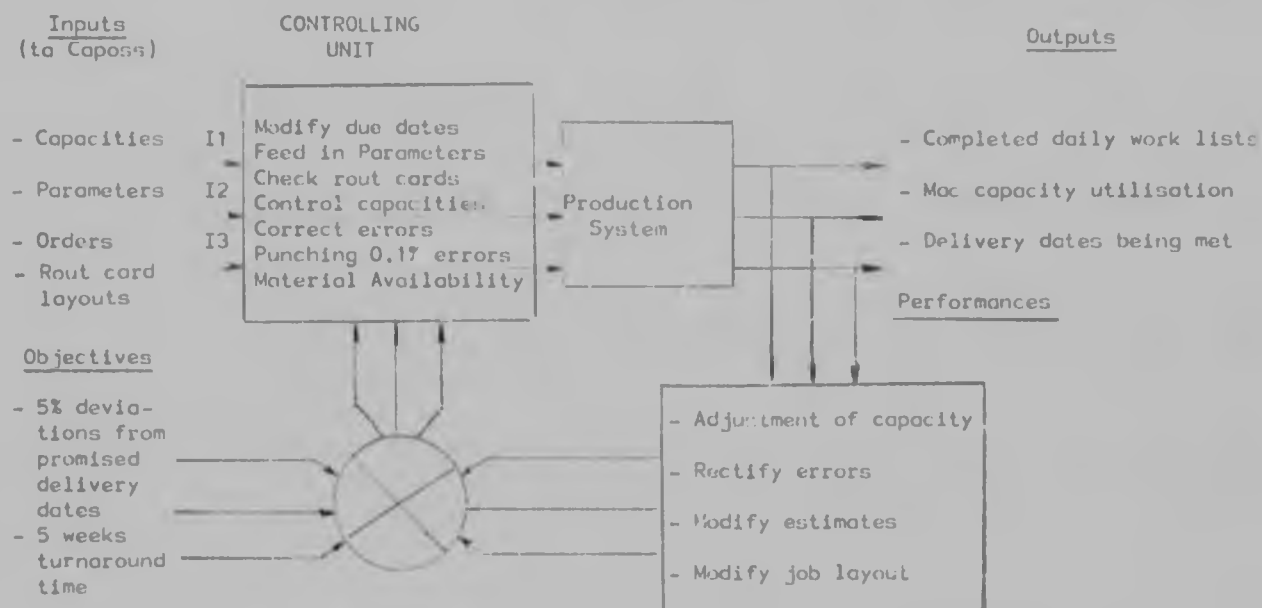


Figure 8. Control Model

10.4 Planning and Control summary

The essential difference between planning and control can be thought of as a difference in system boundaries. Nevertheless there is a large overlap between them, thus it is useful if not essential to consider planning and control as integrated activities. In actual fact that is the case in most of the Industrial Planning and Control units.

11. MANAGEMENT INFORMATION SYSTEMS

11.1 Systems view to MIS

Many books and notes have been written about management information systems. This chapter will present selected topics in view of the above subjects. The basic rule for information is "Information has no value unless it causes us to change our course of action".

Change in course of action implies from a stand point of Information : Relevance and interpretation.

Computer output data does not imply an information system but mean oriented.

Since every system does not consist only of operations but is also concerned with planning, control and with bringing about change, these variables are interrelated and require information to allow its system-continuity.

The information required for each part can be unique or common to few parts. As these parts overlap to a greater or lesser extent. Schematically it can be looked as in figure 9.

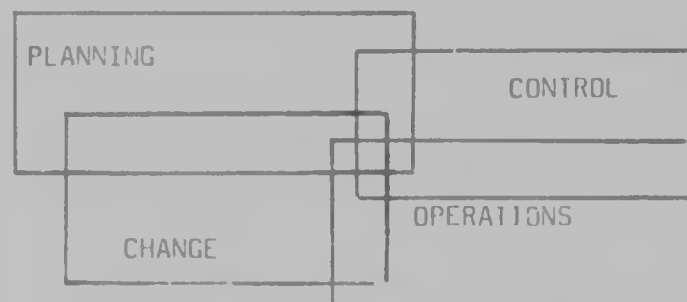


Figure 9 Planning, control, operation and change overlapped

Good information system considers the above overlap, tailored to different people in different levels within the organisation and is being used by them for decision making procedures, on a continuous basis.

11.2 Building a MIS

11.2.1 Introduction

For several years, qualified systems and data processing personnel in a great number of companies have been devoting a substantial amount of effort to the design and installation of so-called "management" information systems of "total" information systems. Raymond J. EPICH draws the following conclusions about these efforts :-

- The systems being designed do not deal with actual "management" information.
- The systems are not "total" in any sense of the word.
- Most frequently, the cost of systems design and computer programming is several times greater than it should be.
- Companies that have automated too much, too soon at too great a cost, may be at greater disadvantage in the long run than those that have automated relatively little thus far.

11.2.2 Management information

"Management" information can be defined as the information needed to manage. Management itself is the allocation of company resources to the accomplishment of predetermined objectives, a process requiring strategic and tactical planning, factoring of these plans to smaller scale objectives, assignment of these objectives to subordinates and control of subsequent progress. Using this definition, management is distinguished from the actual accomplishment of the smaller scale objectives which will be referred to as operations.

Discussing management information requires sorting executives into two groups : management and personnel, which as a practical matter is extremely difficult.

Sorting activities is equally difficult, since few, if any, are readily distinguishable by the planning, factoring, assignment and control features of the definition.

If we take planning for example : Is an executive "planning" when he reacts to stiff competition by cutting his price? In some respects he may be. The price cut may be the initial action to a whole series of factored smaller scale objectives, responsibility assignments, control processes and follow-up activities. The decision to make the cut may require access to more data, require more penetrating analysis and entail greater computational activity than a formal plan to build a new factory or market a new product.

Having arrayed management activities as carried out by management personnel further question have emerged : Do we know how these are carried out? Do we know what management information is required to carry out a particular activity?

Actually, we know relatively little about management decision making. Herbert A. Simon in his book "The new Science of Management Decision" focused attention on the actual process itself rather than to specific examples of management decisions. The conclusion from it is that information system should deal with the overseeing of operations and not with management itself.

Thus, the fundamental stage is to make management a programmable activity before management information can be much more than a loosely used term, not at all descriptive of the information truly needed to manage resources.

11.2.3 "Total" information

Whoever coined the term "total" information systems certainly gave it little thought. Those who use it are guilty of gross overstatements. So-called "total" systems, as presently conceived do not convey 0,0001% of the information needed to manage a company, and probably 0,001% of the information needed to operate one.

Use of the word "total" for information may prove embarrassing to systems personnel for two reasons :-

- i) Your management may actually expect a total system and you may be hard pressed to explain why the system as designed falls short of work.
- (ii) Your management may accept your system as "total" looking at it for the totality of management and speaking information.

Indeed, the use of this term has greatly diminished and it may soon leave the vocabulary altogether.

11.2.4 Costly design and programming

During his work on design and installation of computers, the author found that design and programming are being carried out in a manner that is astonishingly inefficient.

- i) At the outset, while systems are being conceived, too little attention is paid to sub-system integration. Often systems are heedlessly proliferated when a more thorough examination of the objectives would have eliminated them entirely.

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- i) At the outset, while systems are being conceived, too little attention is paid to sub-system integration. Often systems are heedlessly proliferated when a more thorough examination of the objectives would have eliminated them entirely.

- ii) At the next level of effort, run flow design (the specification of run to run computer processing flow), has observed the greatest waste.

It is not unusual for several computer runs to be eliminated entirely when run flow concepts are examined by experienced and imaginative people. Failure to perform such a review could represent a needless great deal of increase in total installation cost.

- iii) At the detailed systems design and programming level it is likely that much of the work proceeds in an undisciplined manner. Accuracy is left to stochastic processes, which can increase costs by an additional hundred of percents.

The reasons for such a phenomenon are as follows :-

- i) The personnel assigned the responsibility for systems design fail to make full use of the experience of operating management.
- ii) Personnel having responsibility for systems design do not have the necessary intelligence or creative imagination to conceive of suitable systems.
- iii) Operating management has not actively participated in the installation of the systems.
- iv) Basic scheduling and control devices are not used to monitor progress.
- v) Surveillance is inadequate on both the quantity and the quality of the output because much routine work is erroneously classed as highly creative labour not susceptible to measurement.

11:245

Safeguard against costly failure

At the end of the article, the author gives a list of recommendation for improvement which might be usefully adopted by companies building large scale information systems.

While these seven recommendations may not become as noteworthy as Mr Lisk's Seven Deadly Dangers in EDP (Harvard Business Review : May-June 1962 p88) they are offered nevertheless :-

- i) Place the information system design project under the direction of an executive whose ability is commensurate with the scope of the project, measured in terms of either payout or cost.
- ii) Take a good look at all of the systems and data processing personnel participating in the project. Use whatever criteria you wish but weed out sub-standard personnel before the project is too far along.
- iii) Take full advantage of the experience of operating management by assigning several as principal members of the installation team.
- iv) Look at the opportunities for computerised operating systems more completely before approaching Management System.
- v) If you really know how management decisions and procedures are made and what the information requirements will be - try an improved manual management information system first.
- vi) Formulate an overall concept but do not try to install it all at once. Factor the project into several integrated sub-systems and rank these in priority sequence. Tackle each sub-system separately, in series or in parallel, yet provide for overall integration.
- vii) Do not hesitate to defer the design and installation of true management systems for a few years until we all understand it a little better; it is quite possible that this may put you ahead of your competition.

12. PRODUCTION PLANNING AND CONTROL INTEGRATED

Introduction

In his article Production Planning and Control Integrated William K. Holstein discussed the identifying and tying together of the various parts of Production Planning and Control System in order to achieve the above goal.

12.1 Toward better control

The author gives in detail the 2 major ranges of planning and aims required of them. Long term planning which commits the company to adopt the right strategy on manpower, skills, plant, production approach, machinery and equipment.

These require information to be analysed and within the guidelines formed by long term plans, tactical control must be exercised over the uncontrollable variation in product mix and productivity in the short term.

Control in the short term involves : Meeting daily production programmes, meeting standards times, allocating resources, controlling stock levels and meeting required delivery dates.

The performances required can be measured through the key result areas of the above targets.

12.2 Need for Flexibility

A task of utmost importance in designing a Production Planning and Control System is the flexibility. The boundaries and guidelines drawn up by the long term planning should be followed by the short term planning operators.

This can be achieved through the right information system and feedback from the bottom to the top to update programmes and give indications on deviations and modification required. An example to this procedure can be a standard time for the production of a certain product; long term programmes about quantities is based upon this standard time. If the standard time is wrong the programme cannot be met. Having flexible MIS that give a feedback on meeting of standard time will bring about either change on the long term programme or investigation why the time cannot be met.

Action will be taken in due course given by high level management.

12.3 Long term capacity planning

Since production programme in the short term cannot be carried out with short notice of high level management long term planning programme must be prepared in the right timing and is the starting point for production planning and control.

12.3.1 Forecast of future demand

Demands can be forecasted through analysis of available data for trends, market survey and competition.

This will lead to knowing the capacity, machinery, technology required, etc for drawing up long term planning.

In make to order shops future demands are being analysed through available data, the state of economy and its impact on the company's future business.

An example of this type of forecasting is this project case : Central workshop job shop production.

We used to collect data as per units within the various plants Ammonia, Explosives, etc. We learn the trends in the maintenance state through the data and based upon know where to increase capacity or in the case of new plants or machinery through maintainability studies to a certain extent.

12.3.2 Continual adjustment

Capacity requirement planning is not a one-shot operation after getting the forecasts.

This should be updated in predetermined frequencies and established procedures. Adjustment consists of building new plants, purchase of new machinery, acquisition of knowledge and technology, recruitment of skills, engineers etc. Again, this can be achieved through elaborated management. Information System Computer can provide data but cannot do it by itself. This should be done by the users.

12.4 Master scheduling

Master scheduling includes the production programme for the next several months ahead. When establishing the schedule, consideration is given to the plant load, leveling of load where required, manpower, machines, stock level, etc.

The master scheduling establish deadlines for orders considering customer requests and internal factors as stated above.

12.4.1 Estimating shop loads

Accurate estimating of shop loads is the key area for accurate master files. This can be done through having accurate estimates of job duration, analysis of past data available and other methods.

Today as the computer can store large volumes of data it is being used for measuring loads as per department, work centre, or even machine load.

12.4.2. Inventory Control

Inventory control is not a separate entity, but rather it is a pervasive factor which runs throughout any Production & Control System.

A lot has been written about inventory control systems and all that they entail; re-order level, lead times, economic order quantity etc. Briefly, as stated above, inventory control is a part of Planning & Control and, as such, it should be used for master scheduling and capacity requirements.

12.5. Short-term Scheduling

As mentioned before, this is derived from the Master schedule. It can be a one week or even a one day programme. This includes; capacity loading per work centre, area or machine, based on the schedule period or on infinite capacity (i.e. queue of jobs based on priority type job or ordinary job).

The basic idea under this category, is that short-term production programme should be met in order to fulfil the Master schedule programme.

12.6. Control & Progress

The author gives other important factors for meeting the short-term programme, such as, despatching, progress, and control over the shops which have been discussed already in previous items.

12.7. Scheduling Approaches

The author gives a few possible approaches to scheduling:

- Real queue
- Priorities; Pre-emptive, ordinary
- Profitable payoffs

As this issue is discussed in detail in parts B, C and D of this project, it will not be discussed here.

Something new, is the use of Hot/Cold terminology for job priorities. However, this is another literal version of the pre-emptive priority approach.

The profitable payoffs approach is a scientific one and I do not think that this can work properly, as sometimes, an expensive project which pushes back small jobs can be of a one-off customer type, while the small jobs are incoming on a continuous basis and from constant customers.

However, every case should be considered separately, but, generally, every priority scheduling system is too scientific for practical application and does not fulfil what is required of it.

12.8. The Integrated System

The various parts of a Production Planning & Control System as described in previous items, should be tied together, in order to achieve an integrated system. An integrated system is necessary to achieve better management, making decisions and continuity, in the long run.

The information flow and the feedback are the most significant factors in tying these parts together.

Long Range Forecasts are transformed into capacity plans to guide Master scheduling. Master scheduling supplies a load programme. From this Master scheduling, we derive scheduling, despatching, capacity adjustment and inventory control. It can be seen as a closed system in which all parts are interrelated.

At present, progress towards this approach is being made to a large extent, as computers are becoming more and more an integral part of many organizations.

13. ANOTHER VIEW ON PRODUCTION PLANNING & CONTROL

13.1. General

Another approach to Production Planning & Control, is the early Fifties Approach, which involves having 3 major functions:

- i) Pre-production Planning & Control - equivalent to Long Range planning.
- ii) Production Control - equivalent to Middle Range planning.
- iii) Despatching and follow-up - equivalent to Short Range planning.

This approach emerged from experience gained in small and middle size companies, before the computer revolution. Nevertheless, today many industrial plants, including large ones, although using computers and sophisticated management information systems, are following exactly this approach, thus I found it useful to give readings on this approach, based on old literature on the subject. Moreover, it appears that, in many large companies, including the multinationals, subsidiaries and companies within the large ones, are working as per this approach. One could say that the large companies should have the sophisticated system in order to survive in the long term, which is more difficult for the middle size and small companies, which is correct, but obviously, the present approach for an integrated Planning & Control System emerged from it.

13.2. Pre-production Planning

This consists of taking a new (or changed) material, part, product or line of products and organizes, in advance, the men, materials, machinery and money required for a pre-determined output in a given period of time

While the responsibility for pre-production planning is one of sufficient importance to reside directly with top Management, nevertheless, the actual steps are performed by a variety of key personnel in the organizations, co-ordinated, almost invariably, by a committee. Since the activities are so broad and transcend divisional lines, the committee approach seems to be the most successful way to good planning, something like co-operate Management.

In the usual sequence of steps, the production control specialists and the plant and industrial engineers "explode" or breakdown the product or part into its components and materials. These groups, together with the purchasing buyers, determine next what is to be made and what is to be purchased. If not already in existence, the physical facilities must be acquired and organized by the plant and industrial engineers, for the level of production desired.

These same people also develop and detail the operations and their sequence, prepare time standards or estimates, determine process quality standards and plan the tools, jigs and fixtures as to both type and number necessary for the anticipated production quantity.

Pre-production planning then proceeds to a consideration of the manpower needs by the personnel division. The required skills and number of people are determined from the sales forecast plus the operation and time data mentioned previously. The procurement planning of materials and supplies from external sources, including the setting of time schedules, is performed by the inventory control and purchasing functions. Yet another section, that of cost accounting, estimates the cost of making the product in the forecast quantity.

In summation, it can be said that pre-production planning is a series of related and co-ordinated activities performed by a number of different departmental groups, each activity being designed, in advance, to systemize the manufacturing effort in it's area.

Organization of the physical facilities is, of course, one of the principal activities of pre-production planning and it's starting point, in the case of new facilities, is selection of the plant location, designing of plant buildings, layout, machinery, equipment etc.

13.3. Production Control

13.3.1. Function & Duties

After pre-production programmes and activities are completed, someone should carry out the production programmes. This is the duty of the production control unit, which is also called Production Planning & Control in many plants. Small plants do not need the elaborate and detailed production control systems which may be required by their larger counterparts. However, the same control principles apply for all plants, large or small. Plants with 50 or more employees, for example, may have a one-man production/control system operating under the wing of the factory superintendent. During the course of his work, this man is engaged in all the production/control activities - but in a more simplified manner - which are performed by a battery of specialists and clerks in large plants. Briefly, the activities of the production manager and his specialists embrace the development and operation of the production/control techniques, procedures and paperwork used in manufacturing the products of the enterprise.

They co-ordinate the various production/planning activities of the manufacturing divisions and the other staff functions.

Since product designs, production methods, manufacturing requirements and work priority are continually subject to revision, the production control routine is seldom stabilized for long. Thus, the work of the production manager and his specialists is, at times, as hectic as it is varied.

13.3.2. Routing

Fundamentally, routing determines what work will be done on a product or part, as well as where and how it will be done.

It establishes the operations, their path and sequence and the proper class of machines and personnel required for these operations.

While routing is a major responsibility of the production/function, it is also connected with the field of product development in beginning a product which can be readily manufactured. Likewise, it is closely allied with plant and industrial engineering, in setting up the most efficient operating methods and establishing a materials flow through the plant for a minimum of handling and backtracking. Thus, at one time or another, each of these departments may have a hand in product routing.

Routing Procedures

- i) An analysis of the product to determine what to make and what to purchase: A decision is made; what to produce and which parts to purchase outside. This is based upon technology, machinery, skills and capacity availability of a particular plant.
- ii) An analysis of the product to determine what materials are needed: Drawings, specifications, standards of quality and identification symbols are usually condensed by the routing section, into a parts list. This is used for preparing a "Bill of Materials" which indicates: part name, identification number, quantity required and application of the product.
- iii) Determining the manufacturing operations and their sequence. The engineering standards office or Industrial Engineering uses data on files, to establish the operations necessary to manufacture the product and lists them in proper sequence on a route card/sheet. This card will be used in production, when transferring the product from one work centre to another. The route card/sheet includes standard times for operations as well as which are used for bonus schemes, costing and scheduling.
- iv) Determining Lot Sizes: The number of units to be manufactured in any one lot or order as established by routing, depends primarily on the type of manufacture involved. If it is a product to be manufactured strictly to a sold order, the quantity to be made will usually equal that required by the customer plus a certain average or allowance for rejections.

Where manufacture is to stock, the lot size is usually based on the economic lot quantities.

- v) An analysis of the cost of the article: Based on established time to produce, direct materials cost and specific and general indirect expenses.
- vi) The organization of Production Control Forms: The type of manufacture exercises considerable influence on the forms required by the plant departments. In production line manufacture, work is organized around a form known as a schedule. For job order manufacture, a manufacturing order, sometimes called a work order, is required.

13.3.3. Scheduling

Scheduling is that phase of production control which rates the work in order of priority and then provided for it's release to the plant at the proper time and in the correct sequence.

The function of scheduling closely resembles that branch of railroading which schedules the use of railroad/track facilities. The aim in railroad scheduling is to run as much traffic over the same tracks as safely as possible without interference or collisions. Similarly, the aim in industrial scheduling within the limits of the customer orders available, is to schedule as great a volume of work as the plant equipment can conveniently handle, without similar interference or "collisions" resulting in material stoppages along the route.

Scheduling establishes the begin and finish dates of a job, machines and labour required for doing the job.

Sequence of Scheduling Procedure

Scheduling usually starts with the Master schedule. This schedule is simply a weekly or monthly breakdown of the production requirements for each product for a definite period of time (such as, per quarter, 6 months or per year). As new orders or requirements are received, they are scheduled on the Master schedule, with due regard to the available plant capacity. If no capacity is available, (in that particular week, month or year), it is obvious that the new requirements must be carried over to a subsequent period or the present schedule for the capacity period must be re-arranged to accommodate the additional orders.

Scheduling of serialized manufacture is primarily a matter of translating the sales or programme requirements into a schedule of the amount of material which can be manufactured on the production line in any given period. The length of time required for the production cycle of a serialized production line is usually established when the line is set up and material entering that line usually finishes the cycle without a change of sequence.

Semi-serialized manufacture on the other hand, usually does permit some storage and re-shuffling of the orders along the production lines, particularly if a range of products or parts, with varying process times, are fabricated on a single production line.

When dealing with scheduling of job order manufacture, particularly where a range of parts is required for one assembly project, it becomes infinitely more difficult, for the fabrication of each part and the assembly of each group of parts must be scheduled with due regard to the availability of equipment, personnel and materials.

In the scheduling of several component parts of a job order assembly, each with a different process time, theoretically, each part is scheduled so that it will be completed just prior to it's being required for assembly.

An important factor to remember in scheduling is that it is being made in order to be revised. After all, a schedule is based on the priority or relative urgency of the work involved and as conditions and customer requirements change, so also does the relative urgency change. In summary, a schedule must be flexible to meet changing conditions.

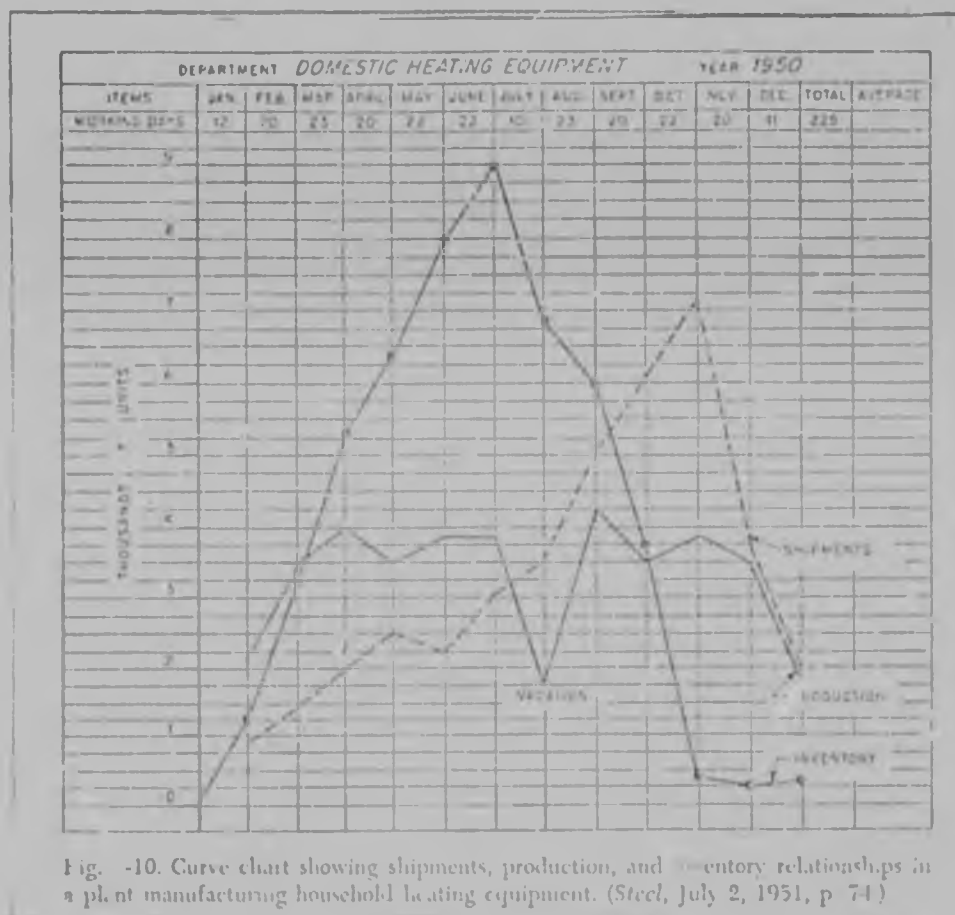
13.3.4. Control Charts

Charts are widely used in industry for control purposes. Particularly in the field of production, scheduling charts often constitute the foundation on which all scheduling activities are based.

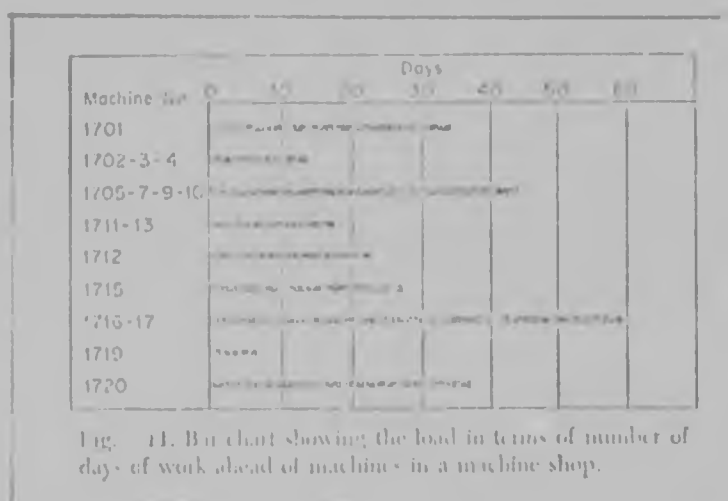
Control charts offer a quick, compact and visual means of recording information. Charts are useful in establishing control by exception. The exception is the area of poor accomplishment compared with the original plan readily stands at when charted and thereby points out the need for investigation and possible correction. Control charts are usually dynamic. That is to say, as conditions change, the charts are successively revised so as to furnish a moving force for current as well as for future action.

Control charts used as a tool of production control include:

- i) The project layout chart (the curve chart): This schedules, in advance, the work ahead of either men or equipment, or both, and determines the relative importance of the work and hence the sequence in which it should be performed. Figure 10 would be representative of such a chart.



- ii) The load chart (the BAR chart): This indicates by number of hours, days or job, the work load ahead of a particular machine, battery of machines, department or plant, as shown in figure 11.



- iii) The progress chart (The GANTT chart): This compares the progress or accomplishment made against a prescribed plan. It directs attention to failure, thus making possible the appropriate investigation and action, as shown in figure 12.

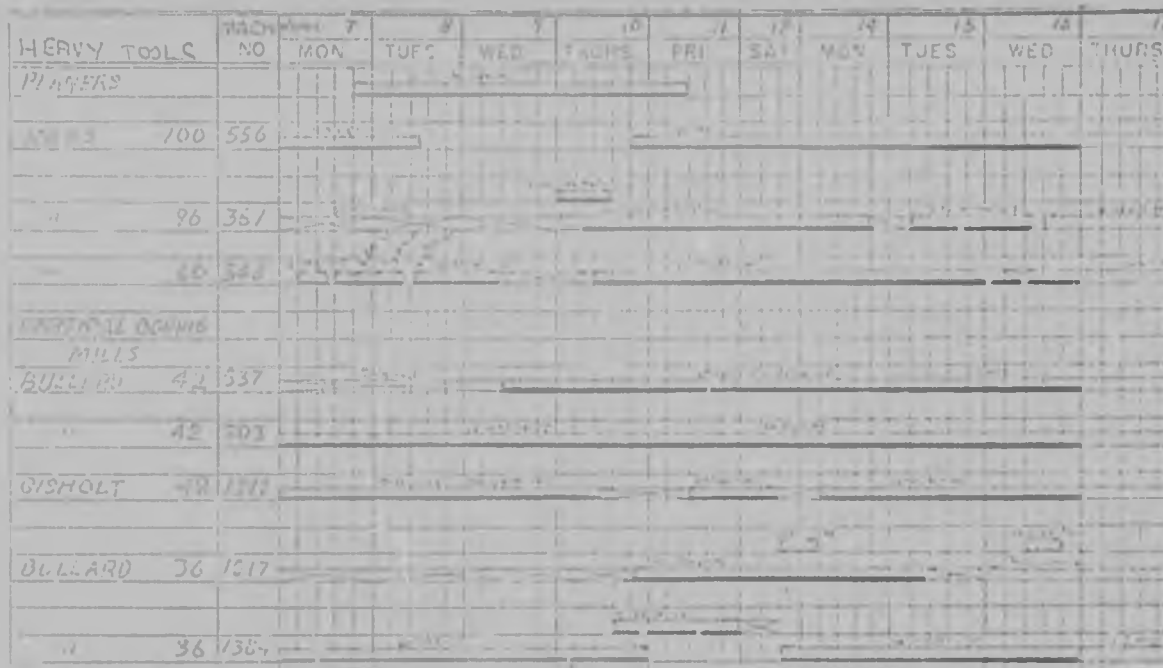


Figure 12 - GANTT Chart

- iv) Mechanical charts: These are charts which include visible index files, various wall charts and scheduling boards which are available from manufacturers of production control equipment. These charts are enlarged adaptations of one of the foregoing three chart forms, with the addition of mechanical clips, pegs, strings and other signalling devices.

Dispatching and Follow-up

Dispatching is the initial action element of production control, consisting of the issuing of orders in terms of their priority, as determined by scheduling. It includes the assignment of work to the operators at their machines or work places. Thus, dispatching affects, determines by whom work shall be done.

Follow-up or expediting is that branch of production control procedure which regulates the progress of materials and parts through the production process. Although it is the agency charged with the responsibility for production orders after they are despatched, it is, nevertheless, closely interrelated with dispatching.

The various types of follow-up are:

- Materials
- Work in process
- Assembly and erection

14. QUEUES

Since the core of my project is the Real Queue approach in job shop production versus the Priorities approach, a few selected readings on Queues Theory will be given.

The notes are based mainly on the books of D.R. Cox and Walter L. Smith and the book by Philip Morse.

14.1. The investigation of queueing systems

Generally, mathematical solutions for queueing systems can be implemented for relatively simple situations.

If numerical results are needed for a complex system, these have to be obtained by sampling experiments, which nowadays can be aided by computers and other high speed computing facilities.

The practical approach for investigating a queueing problem as recommended by Cox, is as follows:

i) A preliminary survey consists of the following steps:

- a) In a complex system, the construction of a flow diagram for customers and a listing of the points at which there is a restriction on service.
- b) The approximate measurements of arrival rates, service times and queuing times at the main points of congestion. This will give a general idea of the main points at which excessive congestion occurs, or at which there are service facilities which are idle for a high proportion of the time.

ii) Rough assessment of possible modifications

At this stage, we determined the possible changes that are reasonably likely to lead to an increase in efficiency or quality of service.

iii) More detailed data

In this stage, the statistical properties of the input and service time are estimated in sufficient detail to help in selecting an appropriate model and enables the giving of numerical values to the parameters in the model.

In a simple single-server queue, in which arrivals are thought to be random, it might be enough to obtain data to estimate the arrival rate, to provide a rough check on the randomness of arrivals and to estimate the frequency distribution of service time. In a complicated system where the priority approach is applied, it is necessary to make a detailed record of the behaviour of the system.

iv) The effects of modifications

At this stage, we carry out an experiment to test the effects of different types of modification. This can be done by factorial design or simulation. Few of the parameters will be assumed as remaining unchanged after modification. Parameters can be arrival dates and service time.

v) Formulation of practical recommendation

At this stage, the best solution will be chosen, based on predetermined criteria. A criterion can be a customers' waiting time exceeding say, W_0 is not to exceed say, W_0 or service time M equal or less P_0 .

vi) Small-scale trial

Having decided in v) on a selected solution, a small-scale trial is required. This will be done in order to find those snags that could not be identified in the theoretical model. This study should be detailed as much as possible, as it will be the foundation for a final decision on modification.

vii) Full-scale practical action

The final step is the full-scale introduction of the new system. Observation of the modified system from time to time may well be advisable.

14.2. The modification of queueing systems

In bringing about a change, we aim at having gained a clear and practical advantage. In a complex system in which each individual phase passes, in turn, through several queueing points, it may be possible to re-organize the flow pattern.

Simple modifications are as follows:

i) Modification to arrivals

We may

- a) Modify the total mean arrival rate by, for example, excluding some customers from service.
- b) Control the arrival times of individual customers by an appointment system designed, usually, to produce regular arrivals.
- c) Even-out systematic variations in arrival rate by considering more uniform flow of groups than of individual customers.
- d) Arrange that customers are encouraged to join or discouraged from joining the queue, depending on the number of customers currently in the queue.

ii) Modification to service mechanism

- a) Decrease the mean service time.
- b) Reduce the coefficient of variation of service time.
- c) Arrange for the service times to be reduced during periods of more than average congestion.
- d) Increase capacity of servers.
- e) Increase server availability, either on the average or by arranging that service is more likely to be available when customers are present.

iii) Modification of queue discipline

We may

- a) Give priority, pre-emptive or non-pre-emptive, to "important" customers, i.e. to one for whom the cost per unit waiting time is high.
- b) Give priority to customers whose service times are expected to be short.
- c) Introduce into a system in which the queue discipline is not "first come, first served", a device to ensure that the probability of very long queueing times is reduced.
- d) In a multi-server queue, modify the arrangement by which customers are allocated to a particular server.

NOTE FROM A. FRANCO

Giving priority to customers whose cost per unit waiting time is high, seems to be a total failure in practical application, as it leads to a situation where the majority of customers are of high priority, a situation which hurts them in the end. However, priority to customers whose service times are expected to be short, can work properly, provided that having control over the time service is given. This is implemented at present in Supermarkets ("quick counters"), Production Control and Government Offices giving a service to the people.

14.3. Notes on some sample queues

14.3.1. Basic Queues

- i) Queueing System: A system where customers arriving for service remain some time in the system.

1 - server, 1 - customer - M/M/1 system

arrivals  SERVER

A - time between arrivals

S - service time in which every customer is served

Assuming that arrival rate is of a Poisson Distribution, with mean time between arrivals λ and service time is of exponential distribution with expected mean $1/\mu$.

The probability of completing service in time interval Δ is the probability that service time will be shorter than Δ .

$$P(s \leq \Delta) = 1 - e^{-\mu \Delta} = 1 - \left(1 - \mu \Delta + \frac{(\mu \Delta)^2}{2!} - \frac{(\mu \Delta)^3}{3!} + \dots \right) = \mu \Delta + O(\Delta)$$

Our population is the number of customers into the system. The rate of arrival is not the important factor, but the service level. When there are 0 customer $P_0 = 0$.

When $x > 0$, $P_x = P$

The theorem identifies the number of customers into the system only when there is statistical equilibrium.

$$P_0 = 1$$

$$P_x = \frac{\prod_{i=0}^{x-1} \lambda_i}{\prod_{i=1}^x \mu_i} = \frac{\lambda^x}{\mu^x} = \left(\frac{\lambda}{\mu} \right)^x$$

Criteria for statistical equilibrium:

$$\sum_{x=0}^{\infty} \frac{1}{\lambda_x \mu_x} = \infty$$

$$\sum_{x=0}^{\infty} \frac{1}{\lambda \left(\frac{\lambda}{\mu} \right)^x} = \infty = \frac{1}{\lambda} \sum_{x=0}^{\infty} \left(\frac{\mu}{\lambda} \right)^x$$

This expression is so only when $\frac{\mu}{\lambda} > 1$ or $\frac{\lambda}{\mu} < 1$
which means: the average time between arrivals $E(A) = \frac{1}{\lambda}$

the average service time for customer $E(S) = \frac{1}{\mu}$

Thus, the required service time from the system:

$$\frac{\lambda E(S)}{1} \leq 1 \Rightarrow \lambda E(S) \leq 1$$

$$E(S) = \frac{1}{\mu} \text{ thus } \frac{\lambda}{\mu} \leq 1$$

When $\frac{\lambda}{\mu} \approx 1$ the queue will increase to ∞ .

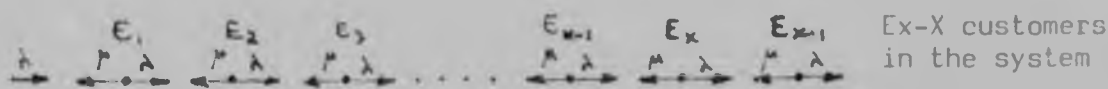
$\lambda E(S) = \rho$ = The server's busy period

$P_0 = 1 - \rho$: stationary probability of having unemployed server

$$P_x = \frac{\rho^x}{\sum_{n=0}^{\infty} \rho^n} = \frac{\rho^x}{1-\rho} = (1-\rho)\rho^x$$

$$E(x) = \sum_{x=0}^{\infty} x(1-\rho)\rho^x = \frac{\rho}{1-\rho} = \underbrace{\rho}_{\text{Average number in service}} + \underbrace{\frac{\rho^2}{1-\rho}}_{\text{Average number in the queue}}$$

Stationary equilibrium can be illustrated as follows:



Average queueing time = Average number of customers into the system $\times$ Mean time between arrivals

11) Arrival rates and service times dependent on queue size

We shall assume for the present discussion, the following:

-($P_A(t)$ = the probability that at time $t + \delta t$ the system is in state A

-Transitions $A_n \rightarrow A_{n+1}$ are associated with a probability differential $\alpha_n \delta t$ and that transitions $A_n \rightarrow A_{n-1}$ (for $n > 0$) are associated with a probability differential $\beta_n \delta t$.

-The probabilities referring to transitions in $(t, t + \delta t)$ do not depend on what happens before t .

From the equilibrium equations giving the stationary distribution of queue size we get

$$P_1 = \frac{\alpha_0}{\beta_1} P_0 \quad P_2 = \frac{\alpha_0 \alpha_1}{\beta_1 \beta_2} P_0,$$

$$\text{and in general } P_n = \frac{\alpha_0 \alpha_1 \dots \alpha_{n-1}}{\beta_1 \beta_2 \beta_3 \dots \beta_n} P_0,$$

We must choose P_0 so that $\{P_n\}$ adds correctly to unity. This will only be possible if the series

$$S = 1 + \frac{\alpha_0}{\beta_1} + \frac{\alpha_0 \alpha_1}{\beta_1 \beta_2} + \frac{\alpha_0 \alpha_1 \alpha_2 \dots \alpha_{n-1}}{\beta_1 \beta_2 \beta_3 \dots \beta_n}$$

converges to a finite value

If $S = \infty$ the customers, on average, are arriving quicker than the server can deal with them and arbitrarily large queue result.

If $S < \infty$ the stationary probability distribution of queue size is then given as:

$$P_n = S^{-1} \frac{\alpha \alpha_1 \dots \alpha_{n-1}}{\beta_1 \beta_2 \dots \beta_n} \quad (n=1,2,\dots), P_0 = S^{-1}$$

iii) Queue with m servers

n - The number of customers

m - The number of servers

if $n \geq m$, $\alpha_n = \alpha$ for all n $\beta_1 = \beta, \beta_2 = 2\beta$

if $\alpha < m\beta$ $\beta_{m-1} = (m-1)\beta, \beta_n = m\beta$

$$S = 1 + \frac{\alpha}{\beta} + \frac{\alpha^2}{2!\beta^2} + \frac{\alpha^3}{3!\beta^3} + \dots + \frac{\alpha^{m-1}}{(m-1)!\beta^{m-1}} + \frac{m^{m-1}}{(m-1)!} \sum_{h=m}^{\infty} \left(\frac{\alpha}{m\beta}\right)^h$$

if $a = \alpha(m\beta)^{-1} \Rightarrow$

$$S = 1 + (ma) + \frac{(ma)^2}{2!} + \dots + \frac{(ma)^{m-1}}{(m-1)!} + \frac{(ma)^m}{m!(1-a)}$$

$$P_n = S^{-1} \frac{(ma)^n}{n!} \quad (n < m)$$

$$P_n = S^{-1} \frac{m^m}{m!} a^n \quad (n \geq m)$$

iv) Queue with limited waiting room

Suppose we have single-server, random arrivals and exponential service time, but there is no room for more than R customers to queue (including the one being served)

$$\alpha_n = \alpha \quad (n < R)$$

$$= 0 \quad (n \geq R)$$

$$\beta_n = \beta \quad (n = 1, 2, \dots)$$

Customers who arrive and find no waiting room leave without service and do not return later. The S is a finite sum

$$S = 1 + \frac{\alpha}{\beta} + \left(\frac{\alpha}{\beta}\right)^2 + \dots + \left(\frac{\alpha}{\beta}\right)^R$$

for

$$P_n = \frac{\left(\frac{\alpha}{\beta}\right)^n \left\{1 - \frac{\alpha}{\beta}\right\}}{\left\{1 - \left(\frac{\alpha}{\beta}\right)^{R+1}\right\}}$$

There are four other implications of the basic queues, but for our discussion, we will refer directly to the queues concerned with the project subject.

14.3.2. Queues with priorities

Sometimes, the queue discipline may be such that some types of customers receive priority because of high cost per unit time of waiting, loss of production in industrial cases, or because of profit consideration. We will discuss here mainly two types of priorities without complications.

i) Non-pre-emptive priority

- Each customer has priority class 1, 2 k
When k priority $> k-1, > k-2, \dots, > 1$
- A customer of class j = a j-customer with priority over j + 1...k
- Customers of different classes arrive independently at random, at rates $\alpha_1, \dots, \alpha_k$ subject to:

$$\alpha_1 + \alpha_2 + \dots + \alpha_k = 1$$

Then: $\alpha_j = P(\text{Particular arrival is a j-customer})$

- Service time of different customers is independent and distributed B(X).
- A single-server system.

'overall' service time distribution is

$$B(x) = \sum_{j=1}^k \alpha_j B_j(x)$$

When $B_j(x)$ is the first arrival time of $B_j(X)$ for instance, $C_j = \int_0^\infty x^2 \alpha_j B_j(x) dx$

Since $\sum \alpha_j = 1$, the traffic intensity ρ is equal to ρ when $\rho = \sum \alpha_j \rho_j$

Now if j=n customer with the same priority, the expected number of n customers in the queue as service was completed and they are going to start being served is

$$1 + \frac{\frac{1}{2} \alpha_j C_j}{\rho (1 - \sum_{i=1}^n \alpha_i \rho_i) (1 - \sum_{i=1}^n \alpha_i \rho_i)}$$

ii) First come, first served approach

If the approach is "first come, first served", then the mean queueing time Q_0 ;

$$Q_0 = \frac{cs}{2(1-s)b}$$

The strategy based on service times is optimum when the service time of each customer can be predicted accurately on arrival and when it is known that future customers arrival rate $\lambda=1$ and the distribution function of service time.

iii) Simple priority system based on service time $b_x = \frac{1}{2}e^{-2x}$

Suppose $s = \frac{1}{2}$ and that:

a) All customers whose service time $\leq \phi s = 1$

b) All other customers $= 2$

Then the queueing time $Q = \frac{c(1-s + se^{-s\phi})}{2(1-s)(1-s + se^{-s\phi} + s\phi e^{-s\phi})}$

If the cost per unit queueing time is equal for all customers, ϕ should be chosen so that it minimizes Q .

By calculation, it can be found that the optimum ϕ satisfies the equation:

$$\frac{1}{s} = 1 + \frac{e^{-\phi}}{\phi - 1}$$

Figure 13 shows the relation between s and ϕ for optimum division into two priority classes

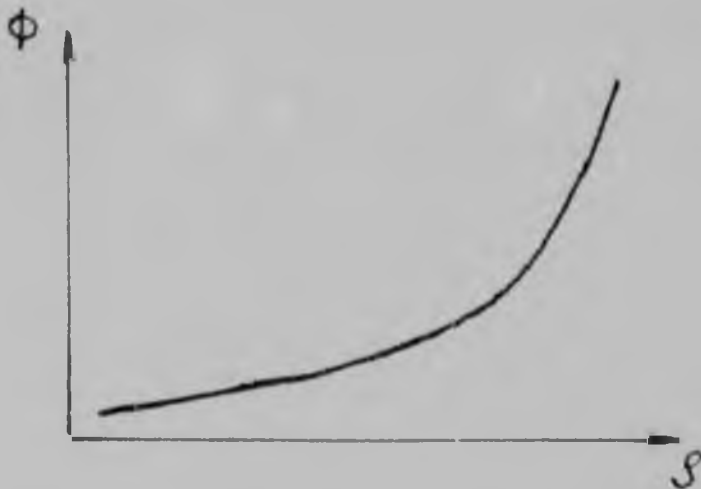


Figure 13: Relation between traffic intensity s and ϕ (parameter determining the optimum division into two priority classes)

vi) Other implications

Other implications of the priorities approach are:

- a) Pre-emptive priority: When a customer of low priority is served and one with higher priority arrives and receives the service instead of him.
- b) Server availability: For a certain period the server should rest, or do other duties.

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