# The general requirements for efficient project management*

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**SYNOPSIS**

A 'project' is defined here as a process in which an idea is developed from its inception until either it is discarded or the product of the idea has been accepted by the ultimate user. The phases in a project, particularly the early phases, are examined, and project organization is described and contrasted with a functional line-management type of organization. Emphasis is placed on comprehensive definition, which is vitally important to the achievement of the goals of time, cost, and quality set for a project.

**SAMEVATTING**

'n 'Projek' word hier omskryf as 'n proses waarin 'n idee ontwikkel word vanaf sy begin totdat dit verwerp word of die produk van die idee deur die uiteindelike gebruiker aanvaar is. Die fases in die projek, en veral die vroeë fases, word ondersoek en projekorganisasie word beskryf en teenoor 'n funksionele lynbestuurorganisasie gestel. Daar word klem gelê op 'n omvattende omskrywing wat van die allergrootste belang is vir die verwesenliking van die mikpunte wat met betrekking tot tyd, koste, en gehalte vir 'n projek gestel word.

## Introduction

A project is a process in which an idea is developed from its inception until either it is discarded or the product of the idea has been accepted by the ultimate user. This definition indicates that a project is finite and often unique by nature, in contrast to the continuous operation of a production company. In the metallurgical industry, such a finite task can involve the modification, improvement, and provision of new production facilities for the beneficiation and refinement of different types of ores.

Traditionally, these tasks are performed by the line management of the production company supported, where the need arises, by specialist groups. Generally, one member of the staff is made responsible for the co-ordination and execution of the task. In turn, he obtains the assistance of other groups within the organization, e.g., engineering and design, financial, administration, and production. These groups are generally part of the existing functional line organization of the company.

Problems arise as the result of a conflict between the need to complete a specific task of a multi-disciplinary nature and the need to perform the functional company tasks required for production. Specialist groups are therefore developed to deal exclusively with these specific tasks, i.e., project management is introduced. This contrast between a project and normal company operation has led to the recognition that different, and indeed new, management and control methods are necessary for project work.

Now that the costs and complexity of projects are increasing and, therefore, the emphasis on time is greater, the control techniques employed in project management have become increasingly more sophisticated. The methods of project planning, cost engineering, drawing production control, material and equipment control programmes, and construction management used by many contractors of multi-disciplinary projects need to be continuously improved and refined.

Furthermore, the staff of a production company do not usually have the experience, and may indeed be uncomfortable, in the task-force environment of project management with its different methods of operation.

Various phases are passed through from the birth of an idea to the completion of the product of that idea. It is of great importance that the special expertise of project management should be introduced in the early phases since it is in the early development of a project that the 'ground rules' should be properly defined.

This paper examines the phases of a project, particularly the early phases, and describes a typical project organization, which is different from a functional line-management arrangement. Each of these types of organizations fulfils its correct function in the appropriate environment.

## Stages in a Project

A project is intended to produce specific results at a particular point in time at a certain cost, and may originate from a need to improve and increase facilities so that the end goal of the company — continuous profitability in its field of endeavour — can be achieved.

A project may pass through stages that involve research and development, feasibility studies, conceptual design, basic design definition, detailed design and procurement, construction, commissioning, and operation. These stages usually overlap to varying degrees, as shown in Fig. 1.

The first three items (research and development, feasibility, and conceptual design) represent the Initiation and Investigation Phase of the project. The third and fourth items (conceptual and basic design) constitute the Definition Phase, and the subsequent items (detailed design and procurement, construction, commissioning, and operation) the Implementation Phase of the project.

The critical importance of the Definition Phase often

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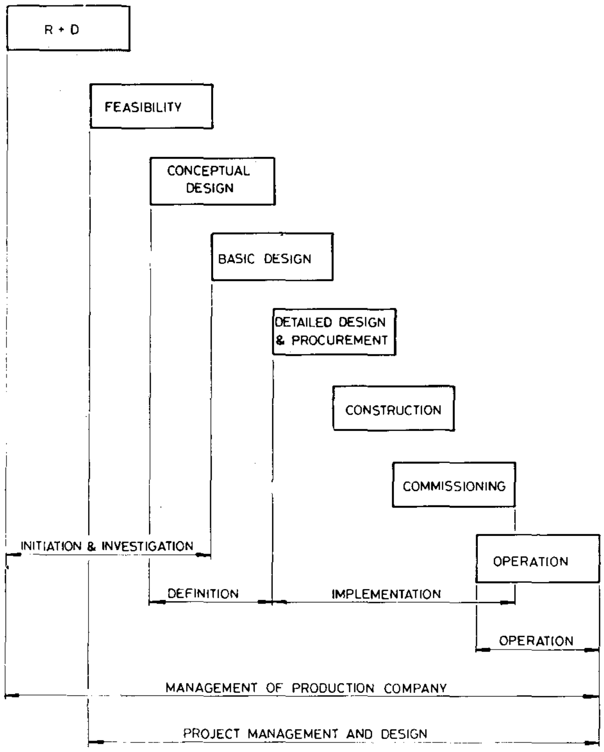


**Fig. 1—The phases in a project**

appears to be overlooked, possibly owing to the 'eagerness' of staff to implement the results of the Initiation and Investigation Phase, which may have resulted in the 'go-ahead' instruction. It is obviously most important that what has to be done should be defined *before* implementation and *not* during implementation.

The first two, i.e., the Initiation and Investigation Phase, and the Definition Phase, are the most critical phases of any project, and require the expertise of a multiplicity of specialists.

In the traditional approach, the first two phases, and even part of the Implementation Phase, may have been done by specialist groups and the functional line management of the production company by appointment of a task force. The other part of the Implementation Phase, i.e., construction, was then done by a contracting company, which was called in only at the stage when the first two phases and part of the Implementation Phase had been completed.

However, experience has shown that construction and commissioning expertise *inter alia* should be brought in during the first two phases so that the most economic solution in terms of both capital and operating costs can be achieved within the requirements of the quality and technical specifications.

### Initiation and Investigation Phase

When a production company has decided to investigate the need for increased manufacturing capacity, its research-and-development, together with the operating experience of the company, may decide the basic plant principles.

A feasibility study is then undertaken on the cost and probable return on investment. At this phase, or even at the start of a research-and-development programme, a project manager is appointed to co-ordinate this effort within an agreed period. This is a difficult phase owing to the conflict between the need to achieve the ultimate end-goal at a specific time, and the freedom and time required for the production of good research results.

The task force required is democratic in nature, depending on the personalities involved, but requires firm leadership to generate as many ideas and/or solutions as possible, to ensure concise reporting of successful developments, and to decide when to abandon, stop, or continue specific lines of such developments.

Usually, this phase of a project is undertaken by the production company, possibly with input from specific process consultants. It may be decided that, for the feasibility study, a project management organization or consultant should be brought in to ensure, *inter alia*, a minimum of bias in the feasibility report and to reduce the effect of the conflicting interests of the various functional groups within the production company.

At the conceptual design phase, the task force should consist of senior staff drawn from the production company, consultants, project management organization, etc., who can effectively contribute to the alternatives available for the achievement of the selected approach from the previous phase. Experienced cost engineers, as well as senior engineers of other disciplines, are required to provide cost data and valid cost comparisons. It is at this early stage that experienced project management, as well as operational staff, can make meaningful contributions.

### Definition Phase

In the Definition Phase, the design parameters, quality standards, project programme, definitive estimate and project procedures are firmly established. The importance of this phase must be stressed since it is here that the basis of the Implementation Phase is fixed.

It is highly desirable that project and construction management, in addition to the usual process and other engineering disciplines involved, should be utilized fully in this phase. The contents of the basic design make this clear, since they include the engineering flowsheets, the general arrangements, and the general specifications for each engineering discipline. These specifications must establish, for example, the required load factors of the major items of equipment (e.g., crushers, screens, and belt conveyors), angles of repose of various materials, types of chute (e.g., Langlaagte), bearing life, painting and insulation standards, fire fighting and detection, electrical voltages for distribution, and, at different motor kilowatt ratings, the general electrical and instrumental standards. The specifications may also mention particular makes of equipment that are recommended by the production company as a result of their experience with such equipment.

Procurement standards must also be agreed, the procurement of certain long-delivery items must be initiated (such as large crushers and process computers), and prices must be obtained for major items. The definitive estimate to within an accuracy of 10 per cent can then be established, and the financial and project co-ordination procedures are agreed and approved.

The additional expertise of project management and construction management can make an important contribution to the determination of the best combination of time, cost, and quality in design, plant layout, and construction methods.

Thorough work done in this phase will ultimately save money by ensuring proper execution and smooth progress during the Implementation Phase, in which the bulk of the project cost is usually expended. Senior experienced staff of both the production company and the project management must be involved.

### Organization of the Project

As stated previously, the requirements for the management of projects differs from those for the management of production companies, which are organized essentially on a functional-line basis. Some of these differences can be stated to be as follows.

1. A project has a specific life cycle, whereas a production company has a continuous life.
2. A project can be subject to an abrupt termination if the goals cannot be achieved, and is always terminated when the project is completed, after which there may not be further continuous use for the project team. The different functions of a production company have continued existence, even though they may be re-organized at intervals.
3. A project is often unique. A production company performs a known function, which remains basically the same, even though continuous improvements are made in the execution of those functions.
4. A project must be completed within a fixed cost and time schedule, whereas a production company sets budget and performance targets on an annual basis.
5. Prediction of the completion time and the final cost of a project is difficult owing to its unique nature. The prediction of the annual expenditure of a production company is simpler because historical factors are available.
6. A project involves a team of many skills and disciplines that are brought together for a short time. This team changes during the various project phases. The skills of a production company are continuous, are well-defined, and operate in a stable organization.
7. The rate of expenditure, and the type of expenditure, on a project are constantly changing, whereas they are much more constant in a production company.
8. A project is basically dynamic in nature, whereas a production company is basically steady-state.

These are some of the major reasons for the difference in approach to the management of projects and production operations. Because of this need, project management is organized differently, often on a matrix basis, according to which a dedicated group of people work together to perform a specific task with a limited amount of direct authority. If the end-goal of a project, with its associated rewards of achievement and recognition, is to be reached, the work has to be performed in a disciplined fashion and to a large extent by persuasion, and by acknowledgement of the expertise of other team members.

The concept of a task force under the leadership of a project manager has been found to be the most successful to achieve the objective of multi-disciplinary projects. The whole team should, as far as possible, be located together in one area to increase the effectiveness and speed of communication, and the task force, with its sole concentration on one project, tends to engender the essential requirements of team spirit and dedication to a specific object.

### Organization of the Task Force

Fig. 2 shows a typical task-force organization during the Definition and Implementation Phases.

The task force is under the leadership of the project manager, who has the total responsibility for completing the project within the agreed time at a cost and quality that satisfy the production company.

The production required to achieve the objective of the project is performed by the design, procurement, and construction elements of the task force, as shown in Fig. 3.

The definition, coordination, and control functions are performed by the project-management elements of project engineering, project control of planning and cost, quality assurance and control, and project administration.

The functioning of the task force is along horizontal and vertical lines in a matrix organization, as shown in Fig. 4.

The size of a project determines the number of project engineers, who are made responsible for all aspects of a particular area of the plant under their control. These areas may be specific plant areas, off-site and service facilities, other common facilities, etc. The project engineering is therefore essentially a 'vertical' division of the project, and the construction is similar. The other task-force elements of quality assurance, quality control, design, project control, material control, and administration are horizontal functions across all the project areas and construction of the project.

There are many variations in such an organization, but the general concepts are the same. The size and nature of the project define the type of organization for the task force.

The following are some general guidelines.

1. The management organization of a project should be simple.
2. The size of a project defines the need for sophisticated techniques. In large projects, the response times of manual information systems become too long to be effective. The total duration of the project also influences this requirement. A short project (say, up to 2 years) needs faster response times than a project of long duration (say, 5 years and more).
3. The organization should not become bogged down with too much detail; effective yardsticks should be used for control.
4. The organization of the task force may also depend on the personalities of its proposed members. In a

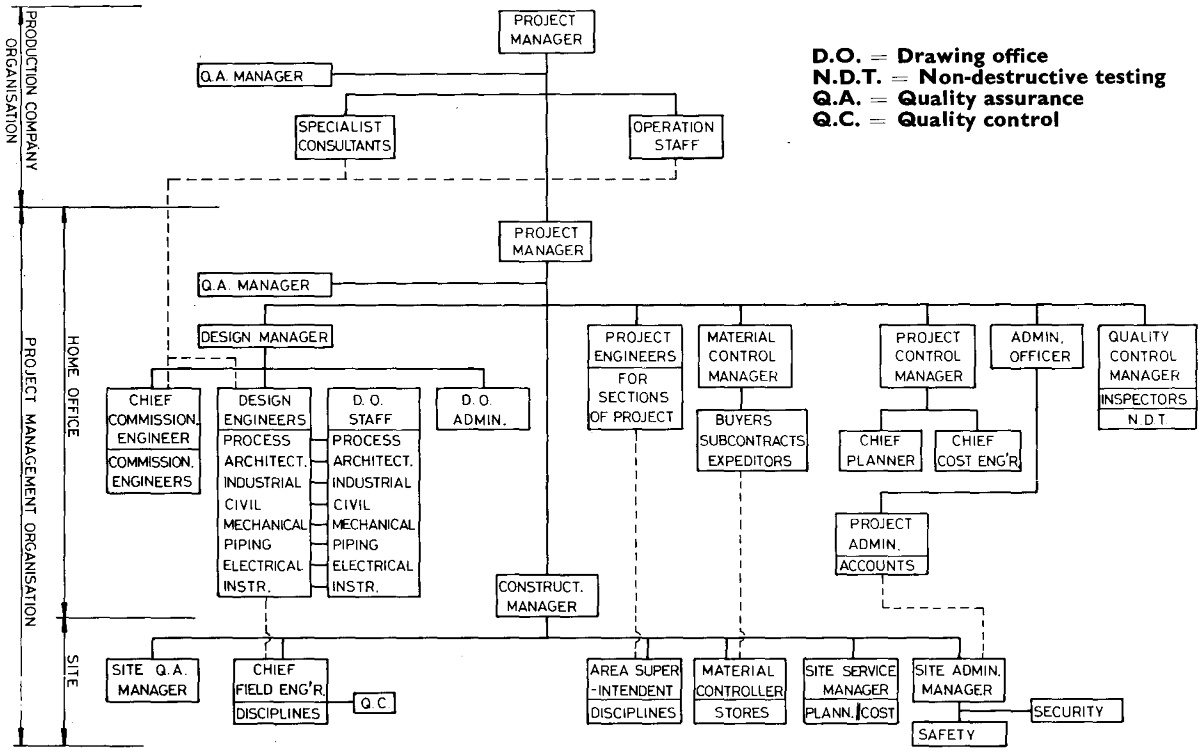


**Fig. 2—A typical project organization**

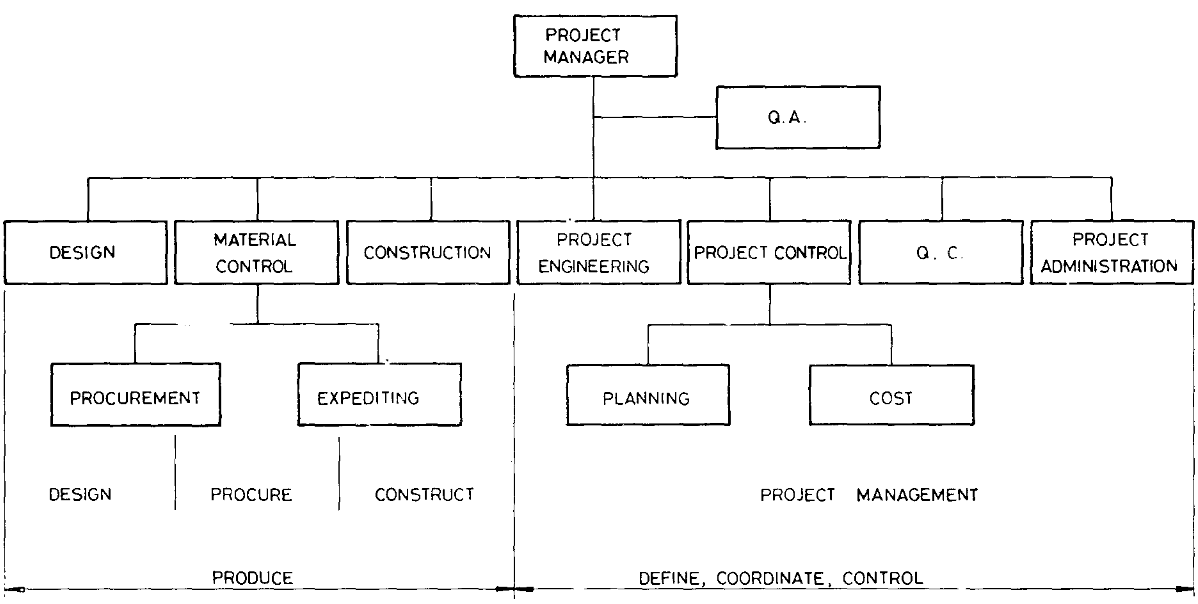


**Fig. 3—Functions and responsibilities of the project task force**

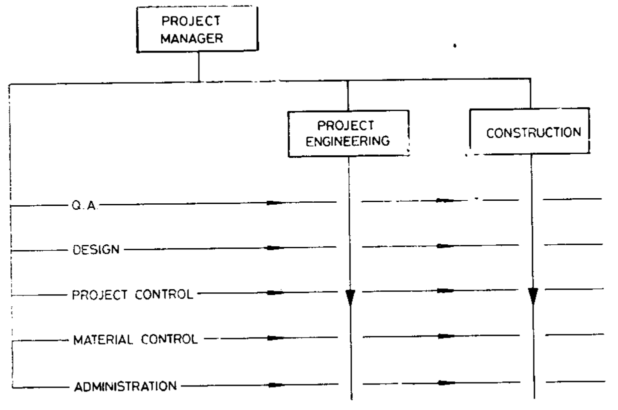


**Fig. 4—Operation of the project task force**

matrix organization it is essential to get team work.

5. The organization of the task force should be adapted to suit the phase of the project.

## Elements of the Task Force

The project management services are performed by planning, cost engineering, and administration. Briefly, it is essential that the programmes formulated should be realistic. These can be either simple barcharts, or sophisticated PERT or CPM techniques involving thousands of activities. Progress must continually be measured against the programme, and action taken to remedy any adverse variances.

In essence, cost engineering involves cost prediction, trends, and cashflow forecasts, rather than the collection of the costs incurred to date. This is also necessary to provide a base for the predictions. The system must be kept simple, based on a suitable cost code.

Project administration involves all the elements of conventional administration that are required when a group of people perform a work task. In addition, it includes the accounting function and insurance administration. Other functions might be the fulfilment of legal requirements in foreign countries, and the housing and welfare of the construction-management staff.

The function of overall material control is concerned with the procurement and expediting of all materials and equipment. It is the link between design and construction. The procurement section is responsible for the issuing of purchase enquiries, establishment of commercial conditions of purchase, adjudication of tenders, and placing of orders, followed by the expediting of supplier's drawings, other documentation, material, and equipment.

The construction-management team is organized along similar lines to the home-office team, i.e., field engineering, construction supervision, material control, and services. Its function is to coordinate and manage the various contracting companies undertaking the installation of plant and equipment.

The field-engineering function is the 'technical' arm of the site management team. It forms the link between the home-office design team and the construction supervision part of the site management team. The responsibilities of field engineering are as follows.

1. The control (i.e., receipt, registration, and issuing) of all drawings and specifications from home office to contractors and *vice versa.*
2. The marking-up of drawings for 'as built' drawings.
3. The control of quality, which includes the testing of concrete strength, inspection of materials and equipment received on site, the maintenance of such material and equipment until start-up, and the arranging, supervision, and interpretation of any non-destructive testing requirements as well as any inspection necessary for the correct technical installation.
4. The resolving, wherever possible, of any technical problems that arise during the construction and installation.

The size and strength of the field-engineering group depend to a large degree on the complexity of the plant, the remoteness of the construction site, and the communication facilities between site and home office.

The area superintendents on the site are there to ensure that the installation is coordinated between the different contractors and that the work proceeds to programme. They form the direct link with the contractors, and are therefore the 'execution' arm of the construction management team. The arrangement of this section of construction management may be along the traditional lines of the disciplines, i.e., civil, structural, mechanical, electrical, and instrumentation; or along multi-disciplinary lines, where one area superintendent is fully responsible for a specific section of the plant. This depends on the size and complexity of the project, as well as on the phase of construction. Initially, an organization according to disciplines may be suitable during the earthworks and civil-engineering part of the construction, but this may have to be modified at a later stage to an area organization to ensure integration, particularly of the mechanical, electrical, and instrumentation installation.

Material control on site is responsible for the receipt and control of all materials and equipment. It may include the operation and control of site stores. This section is therefore linked to the material-control section of the project team in the home office.

The service manager on the site is responsible for planning and cost control on the site, both of which are linked to the project-control manager in the home office.

The responsibilities of the site administration manager range from general office administration and financial administration to safety, site security, insurance claims, staff accommodation, and legal issues. Depending on the location of the site, these responsibilities can be limited or very wide indeed.

## Control of a Project

There are three major areas in which a project is controlled: time, cost, and quality.

The phase and complexity of the project determine the level, degree, and sophistication of control that are necessary. For example, during the research-and development phase, it can be self-defeating to impose a rigid time schedule, which can lead to the adoption of poor solutions. Controls in this phase must be directed to the early recognition of the time at which specific lines of development should be abandoned or continued.

Once a project has passed through the Initiation and Investigation Phase and the Definition Phase to the Implementation Phase, it becomes essential for firm time and cost controls to be instituted. The references of these controls are the major milestone programme, the definitive estimate, and the quality standards that were established in the Definition Phase.

Time control is exercised in the three major sections, i.e., design, procurement, and installation. The sophistication depends on the complexity and size of the project, and varies from simple manual to complex computerized controls. A high degree of sophistication has been achieved in drawing-office production control, even to the control of individual drawings based on drawing hours and manpower levelling by 'massaging' of the programme. Similarly, sophisticated computerized control programmes have been developed to control the material in each programme phase of individual items of equipment from specification to delivery.

The level of construction programmes implemented depends to some extent on the expertise of the contractor concerned. The project management may institute a broad target programme, leaving the detailed programme to the contractor so that he can utilize his manpower and construction equipment in the best possible way. Alternatively, fully detailed programmes can be established that list the tasks right down to those of individual artisans.

The integration of the three major elements of design, procurement, and construction within the overall project programme is a continual requirement. Effects must be analysed based on exception reports so that corrections can be made timeously.

The controls must be forward-looking, and the trends must be identified. However, historical achievements are also necessary to verify the previous forward-looking estimates of time and cost. Therefore, the reporting should be accurate so that the actual project status is known.

Quality as defined in the project procedures during the Definition Phase is the third aspect of control during the Definition Phase. General specifications are required for the various disciplines, as well as for specific equipment. Quality control must be exercised by the setting of manufacturing standards and the verification of manufacturing-quality plans, which describe the sequence of manufacture and the times at which quality controls are exercised during this sequence.

This aspect of quality control also applies to the Construction and Installation Phase of the project.

The quality assurance staff check that all the procedures in all phases of the project are followed, and further ensure that proper procedures are established for all the phases before the start of any work.

## Conclusion

Project management is highly complex and can be implemented in many ways. However, the basic principles are the same, whether all the necessary functions are done by a few persons, as in small projects, or whether these functions are performed by a large team, as in large projects.

The following are some Do's and Dont's that are of significance as projects grow in size and complexity, especially in the present economic climate of rapidly escalating costs, which places even greater emphasis on the importance of time.

| *Do* | *Don't* |
|---|---|
| 1. Appoint a project manager with total responsibility for all aspects of the project. | 1. Place the functional manager in the dual role of line manager and project manager, since this results in a situation with conflicting interests. |
| 2. Appoint the project manager and construction manager in the early (conceptual) stages so that their expertise can be used to make the design, procurement, and construction methods much more economical. This applies also to commissioning and operations specialists. | 2. Appoint the project manager, construction manager, and operations staff late in the project, since this may result in less efficient design and construction methods, and thus in increased time and costs. |
| 3. Use the task-force concept to obtain firm commitment and good communication. | 3. Use functional line departments except in smaller projects, since this can lead to a conflict situation. |
| 4. Define the project thoroughly by fully involving the senior staff in the basic design, programme, and definitive estimate, since this forms the basis of the Implementation Phase, when time and costs are expended in vastly increased amounts. Get firm *commitments* from the relevant parties to the basic definition, which is the most important phase and the key element of all projects; with a proper definition it is possible to get a firm price for the Implementation Phase. | 4. Neglect to do a full definition, since such neglect invariably results in increased cost and time, and may also result in poor morale; trying to do the definition during the Implementation Phase usually results in increased costs and time, etc. |
| 5. Realize that project execution needs a dedicated team effort with input from many different specialists, the project manager being the key to coordinate this variety of experience. | 5. Adopt a traditional approach using only functional line management, which may mean that some expertise is not brought into the project, e.g., specialized project and construc- |

tion management; the lack of a task-force team usually means less commitment, and thus increased time and cost.

In conclusion, project management should make early use of all the available expertise, both in-house and external, and, wherever possible, should spend the costly element of time to *define* comprehensively, and then *freeze* that definition so that the goals of time, cost, and quality are achieved. The ultimate objective is to go into production as soon as possible. This should not be delayed by the institution of doubtful refinements with the impossible goal of constructing the ideal plant; instead, everything should be done to ensure that the basic design is sound.

# Surface science

A Symposium on Surface Science and Its Industrial Implications, under the auspices of the Solid State Physics and Materials Science Subgroup of the South African Institute of Physics, the Vacuum Society of South Africa, and the National Physical Research Laboratory of the C S I R, is to be held in Pretoria on 26th and 27th November, 1981.

The Symposium is intended to provide a forum for scientists and engineers of various disciplines and backgrounds who have a common interest in physical and chemical processes taking place on the surface and interface of materials, as well as in thin films and coatings. In ths context, the materials comprise metals and alloys, electronic materials, ceramics and minerals, and glass and polymers.

There will be both invited and contributed papers. Those providing a broad perspective of recent developments and techniques with a description of their future scientific and industrial potential will be particularly welcome. In order to provide a suitably balanced programme within the limited period of the Symposium, papers will be selected both on technical and scientific merit, and for their general appeal to a multidisciplinary audience.

Areas of interest would include

- Surface (including interface) structure, microscopic and macroscopic
- Surface defects
- Surface processes, physical and chemical
- Methods of surface characterization
- Methods of surface creation (e.g., machining) and preparation (e.g., lapping)
- Methods of surface modification (e.g., hardening)
- Surface states
- Thin films and coatings
- Adhesion and adhesives
- Abrasion, friction, fretting, erosion
- Corrosion and oxidation
- Catalysis
- Surface properties of minerals and ore flotation

Those interested should apply to the Symposium Secretariat, S.246, C S I R, P.O. Box 395, Pretoria 0001. Telephone (012) 86–9211 ext. 2077.

# Mineral production management

Royal School of Mines offers one-year full time or two-year part time MSc courses in Mineral Production Management. Both courses include two terms of lectures and seminars in Mine Evaluation and Design, Mineral Production Management, Mineral Economics and options in Rock Mechanics, Ore Reserve Estimation (including Geostatistics), and Environmental Impact. These are followed by a major project in a suitable subject. For further details, including information on possible bursaries, please write to H. E. K. Allen, Royal School of Mines, Imperial College, Prince Consort Road, London, SW7 2BP (telephone 01–589 5111, ext. 1540; telex 261503).

The part-time course requires students to spend only six months in London — two terms of teaching — and allows them 18 months away from the College to complete a dissertation. This also allows them to choose a project that could be closely related to their work.

# Chloride metallurgy

Papers are solicited for a session on the applications of chloride metallurgy to the winning of lead, zinc, and tin to be presented at a session sponsored by the lead, zinc, tin committee of the TMS–AIME at the 1982 annual meeting in Dallas.

The scope of the session will include papers in extraction, purification, and winning, both electrolytically and by other methods, via chloride-, hydro-, or pyrometallurgy.

Please direct all correspondence to: James E. Hoffmann, Exxon Minerals Company, P.O. Box 101, Florham Park, New Jersey 07932, U.S.A.