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ACHIEVING SUCCESSFUL PROJECT EXECUTION IN A CHANGING WORLD[1]

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SUMMARY

Traditionally, major chemical plant projects were undertaken by a single contracting company, in a single location. Development and market forces over the past 15 years have resulted in engineering offices opening throughout the world. In many cases, clients prefer to use local detailed engineering contractors, whilst still having access to the leading technologies. In other instances, a low cost detailed engineering centre may be selected, even though the technology source and plant location could be in another continent, in order to reduce capital expenditure.

One of the key areas for ensuring the successful execution of such a project is in the technology transfer and interface between each of the offices. This paper discusses technology transfer, giving case studies based upon the experiences of an international contractor, particularly in the fertilizer field. Potential pitfalls, and their prevention, are discussed.

A view of how project execution may be developing in the future is discussed.

RESUME

Traditionnellement, une seule société d'engineering s'occupait de la construction des usines de fabrication de produits chimiques, dans un seul lieu. Le développement et les forces du marché des 15 dernières années ont eu pour conséquence l'ouverture de bureaux de sociétés d'engineering partout dans le monde. Dans de nombreux cas, les clients préfèrent utiliser des sociétés locales pour les travaux de détail, tout en ayant accès aux technologies de pointe. Dans d'autre cas, un centre à moindre coût pour l'engineering des travaux de détail pourrait être choisi, bien que la source de la technologie et la localisation de l'usine puissent se trouver sur un autre continent, afin de réduire les coûts en capital.

Un des facteurs clés pour assurer la réalisation réussie d'un tel projet réside dans le transfert de technologie et l'interface entre chacun des bureaux. Dans cet exposé, le transfert de technologie est discuté. Des études de cas basées sur les expériences d'une société internationale d'engineering, surtout dans le domaine des engrais, sont données. Les pièges possibles et leur prévention sont également discutés.

Un point de vue est donné sur la façon de réaliser un projet à l'avenir.

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1. Introduction

For any client, the two most important factors in a project, once the technology has been selected, are schedule and budget. If a project is completed on time, and within budget, then any other problems which occur during the execution of the project generally lose significance. Traditionally, to meet these two factors, projects were undertaken by a single contracting company in a single location. Development and market forces over the past 15 years have resulted in engineering offices opening throughout the world. Clients now have the opportunity to use local detail engineering contractors, whilst still having access to the leading technologies. In other instances, a low cost detail engineering centre may be selected, even though the technology source and plant location could be in another continent, in order to reduce capital expenditure. However, using local or low cost detail engineering contractors is only attractive if schedule, quality and budget are not impaired.

One of the key areas for ensuring that the schedule and budget are met is in the technology transfer and interface between each of the groups executing the project. This paper discusses technology transfer, giving case studies based upon the experiences of an international contractor, particularly in the fertiliser field. Potential pitfalls, and their prevention, are mentioned.

[1] *Transfert de technologie - Parvenir à réaliser un projet réussi dans un monde changeant*

A view of how project execution may develop in the future is discussed.

2. The Development of Information Transfer

Thirty years ago information transfer involved sending a parcel of documents, which would often take a number of days to reach the addressee, and then attempting to make international phone calls so that the details of the documents could be explained to ensure that the information was understood. If the receiving person was not familiar with the documentation, then misunderstandings could occur.

Fifteen years ago details could be faxed to the addressee, and then telephone contact made to explain the details of the document. This was generally satisfactory with small documents, so long as the receiving person was familiar with the documentation that was sent. However, for large drawings, e.g. P&IDs, etc. this method was not satisfactory.

Today, with the information highway in operation, and teleconferencing allowing 'virtual' face to face meetings to take place, computer derived documents can be sent to any location in the world in a matter of seconds, and people can clarify on a screen the exact meaning of the documents. Thus the hardware required to allow easy transfer of information now exists and is readily accessible for most companies, at least to some extent.

The existence of today's methods of communication and electronic data interchange has made the world smaller, and has opened up new opportunities for project execution giving Clients access to both the latest technologies and the lower costs available in the developing world for performing part of the project. However, information transfer is not the same as technology transfer, as some elements of technology know-how cannot be encoded or written down.

Care is needed to ensure that information which is transferred from one group to another is not mis-interpreted, and that all the elements of the technology know-how are successfully passed over.

The potential for problems in the transfer of technology is dependent upon the project execution strategy adopted. Three strategies normally adopted are discussed below, along with the methods available for ensuring that the technology know-how is correctly interpreted.

3. Project Execution Strategies

There are 3 main strategies available for project execution for any major chemical plant installation. These are:

A - Single contractor / single location
B - Single contractor / multiple location
C - Multi - contractor / multiple location

A. Single contractor / single location:

Other papers giving details of this approach are available, and hence only a brief discussion is given here.

The obvious advantage of this contract strategy is that the Client is dealing with a single company at all times. The people working on the contract will (normally) all be working in the same office, and hence discussions between various groups can take place easily. The potential for misinterpretation of the information which is provided by other groups within the company should be minimal, and technology know-how should be easily transferable. Good methods of controlling the information as it flows through a company must still be closely managed. Any modifications by one group must be passed on to the other groups who use this information, otherwise abortive work or errors will occur. Contractors each have their own methods of controlling documents / information, these methods having been developed over a period of years and proven to be successful. This control of information flow is most important during the detail engineering phase of a project.

The obvious disadvantage in using a single contractor based at a single location is, if the contractor is based in a highly developed economy, all man hours spent are chargeable at the high rates that these companies incur to cover their costs and overheads. Although these high costs can be easily justified for the high value parts of a contract, particularly the basic design, they can be more difficult to justify on the higher volume / lower added value detail engineering and construction activities where companies in the developing world, who have much lower costs, are equally capable of performing the tasks in question.

B. Single contractor / Multiple location:

This method of project execution again keeps contractual responsibility within a single company. However, the company which takes on the contract will use a number of different offices to provide the manpower for various parts of the project. This has the advantage of allowing the contractor to use the skills available from specialist or indigenous companies, thus optimising the design and cost of the contract. There is however a greater potential for problems to occur during the project execution particularly at the interface between the various companies.

The project phases normally applicable are as follows:

Licence and Process Package from Licensor
Basic Engineering
Detail Engineering
Procurement of Equipment & Bulks
Construction
Commissioning

Organisation:

One of the key requirements to ensure that a project will be executed successfully is that each of the parties involved in the project must have a clear definition of their responsibilities, know what information will be inputted to them, and know what information they are required to deliver. Lines of communication, documentation requirements and procedures for document reviews and approval must be agreed. Once each party's responsibilities have been specified, systems can be put in place to plan the project activities. Tools such as Gantt charts and critical path analysis allow monitoring of the project to ensure that all the requirements of the project are being met. A detailed list of the project activities, source of responsibility for each activity, and the required completion dates must be developed. This allows a well defined start and end date for each activity identified. The work in each location should be concentrated into logical packages wherever possible.

Having a small amount of work passing through an office over a long time period ultimately increases the cost of a project, since the support services must be maintained for a longer time period. An example of this is during the final stages of detail engineering. It has been found that transferring the key detail engineering personnel to site once detail engineering has been 95% completed can reduce overall costs. This is because the final 5% of engineering is spread over a fairly long time period. Maintaining the support services for the final 5% becomes a significant cost factor. These support services can thus be made available on site, where they may be used more effectively by both the detail engineer and the construction company. Moving the key personnel to site also gives them greater responsibility and understanding of their work, gives an incentive to achieve completion and improves the interface between the detail engineers and the construction company.

There must also be no weak links within the project organisation. Productive work carried out by one office can be impaired by poor work carried out in another office. It is important that the Client or Managing Contractor checks the various offices that the contractor nominates to be involved in the project. Aspects such as each offices' history, relevant experience, scope of work, and the number of times the offices have worked together previously, all give an indication of capability and likely compatibility. There is more likelihood of offices having worked together, and there being a good mutual understanding, if they are all from within a single organisation. Where there is the potential for one office within the organisation to perform poorly then it is important that the work which passes through that office is project managed well. This often involves engineers from other parts of the organisation making regular visits to review and approve the work produced by the weaker office, or even taking up full time residency.

IT Services:

A few years ago there was an abundance of software packages available on the market. This often resulted in different offices using different types of software, even within the same organisation. Software within one office was often not compatible with software used in another office. Conversion programs were normally available, but these often contained bugs and would cause some corruption of the file. This may not be a major problem for written documents, but for documents such as P&ID drawings the corruption may for example convert one valve type to another, and this may in an extreme case remain unidentified until operational difficulties in the plant occur

Today, the packages being used tend to be restricted to a few major, globally available packages ie Microsoft Excel or Lotus for spreadsheets, Microsoft Word or Wordperfect for word processing packages, and AutoCADD or Intergraph for the drawing of P&IDs, PFDs, etc. Some companies do use other software packages, but the conversion software available today is more reliable.

Whether a project is being implemented in a single location, or in a number of different locations, it is important that the information which is transferred from one party to another is accurate and consistent. The accuracy comes from having control systems in place to check that the information produced is correct, such as all work being independently checked by a second party. The consistency can also come through control checks, but the potential for inconsistency increases if the same information is repeated in a number of different documents. A system of providing information in a single document, and then cross-referencing to this elsewhere in the documentation, ensures that inconsistency is avoided.

Interfaces:

It is important that there is good general co-operation between the parties involved in the project. In past years there has often been a feeling of mistrust between clients and contractors - if one party is pleased with the way a contract is developing, then the other party must be losing out. However, over recent years more and more companies are starting to accept that if all the parties involved in a project work together, then all the parties can benefit. If all the members of the contractor group come from a single organisation, then a working relationship should already be established.

Whilst the basic engineering is being performed, a close relationship between the licensor and the Basic engineering contractor is required. Ideally this will have already been established in previous projects. As the Basic Engineering approaches completion there can be advantages in allowing some of the key detail engineering personnel to come to the Basic Engineer’s offices to review the documentation. This allows the detail engineers to gain an understanding of the design philosophy before their work starts, and helps to build relationships.

The contents of a typical Basic Engineering Package depends to some extent on the experience and capabilities of the receiving party i.e. the detail engineering contractor. A typical package is summarised in Table 1. Whilst there is a temptation to reduce the scope of this package in order to reduce costs, experience shows that it is counter-productive to reduce it below a certain minimum.

Table 1 - Typical contents of a Basic Engineering Package

Project Design Basis
Process Description
Process Flow Diagrams (including heat and mass balances)
Equipment List
Utility Flow Diagrams
Utility Consumption List
Plant Effluent Data
Equipment Process Data Sheets
Critical Equipment Drawings
Piping and Instrumentation Diagrams
Utility Piping and Instrumentation Diagrams
Line Designation List
Special Piping Items Data Sheets
Design Philosophies
Special Design Information
Piping Specification Data
Battery Limit Schedule
Plant Layouts
Preliminary Foundation Plots
Hazardous Area Classification Schedule
Hazardous Area Diagram
Instrument Schedule
Instrument Process Data Sheets
Preliminary DCS Specification
Process Trip Schedule
Motor List
Single Line Electrical Diagrams
Hazard Study Data
Analytical Manual
Process Operating Manual

When the Basic Engineering Package has been completed a smooth transfer to the detail engineering contractor is vital. Experience has shown that after issuing the basic engineering documentation and allowing the detail engineering office to review the documents, it is appropriate and effective to hold a 1 week meeting so that the documentation can be discussed in detail by all the parties, and any clarifications which are required can be made. Once the meetings are completed, the detail engineering contractor can proceed with confidence with their work. This step-wise progression is sometimes short-circuited in so-called “fast track” projects, but there is a potential for an increased risk of deficiencies or re-work, which will increase the project costs and can result in delays.

Typically 4 - 6 months into the detail engineering, a review meeting will be held where the basic engineering contractor will review critical aspects of the work carried out by the detail engineer. This will allow the licensor / basic engineering contractor to ensure that all the process requirements have been met before construction commences and before the final vendor documentation is approved. Of course, between these formal review meetings, the licensor and/or basic engineering contractor will remain in close contact with the detail engineering contractor, answering questions as they arise.

Once all the documentation has been reviewed at the second formal review meeting, the detail engineering contractor should be capable of finishing his scope of work with minimal interfacing with the licensor / basic engineering contractor.

This level of review, and assistance with queries, should ensure that the working relationship is effective.

Of course, the Basic Engineer has to be flexible in his dealings with the Detail Engineering Contractor, and where schedules are particularly tight, specifications for long lead items can be issued early. In practice, the basic engineering documentation is normally released in approximately four stages. This allows the basic and detail engineering to overlap, although this may cause re-work for the detail engineering contractor.

As with all projects, it is important that there is a management system from “cradle to the grave”. Allowing each party to manage their own section of the project is important, but having a single party to manage and co-ordinate the entire project, through each of the stages, is also vital. This management role ensures continuity throughout the project, and enables issues which transcend across two sectors of the project to be effectively managed.

This role can be undertaken either by a company fulfilling one of the roles within the overall project (see case-studies below) or by the Client himself.

C. Multi - contractor / Multiple location

Many of the points raised in the section relating to a single contractor / multiple location, also apply to this section. The definition of each parties’ scope of supply must be clearly established. Any weak links within the group performing the EPC work must be identified, and a suitable management team must to be installed. A check to establish compatibility of the software being used by each party needs to be made.

An area which requires additional attention is the development of general co-operation between the parties. There is a strong possibility that the parties involved will not have worked together before. Thus it will take additional time and effort for a good working relationship to be established. The best method to develop understanding is to give the parties the opportunity to meet and build relationships.

During the proposal phase of the project the licensor, basic engineering contractor, the detail engineering contractor and the project management company will all have worked together to some extent to develop their relationships and indeed the parties may have a long association from previous projects. Once the contract is awarded it is important that the relationships are maintained and improved, particularly as different personnel may well become involved. During the project kick-off meeting, there is an ideal opportunity for team building whilst establishing the detail design basis and procedures for the project.

The provision to allow the key detail engineering personnel to review the Basic engineering documentation as it approaches completion is also important. For convenience, this is normally done in the Basic Engineer’s offices.

One area of project execution where a good working relationship should already be in place, and have been proven to work effectively, is between the main management contractor and the construction company. The construction phase normally involves a number of companies who are local to the plant. These companies will have specific work practices e.g. unions, pay system, working hours, working routines, etc. If the main managing contractor does not have an understanding of these, or a working relationship with a company who does understand these aspects, then there is a strong potential for conflict to arise, which will normally impact upon the project schedule and cost significantly.

It is also important that the working practices of one member of a consortium are not imposed upon another member. Each party will have been selected for a particular task, and they will have been chosen because they have proven skills in these tasks. If the working methods of another company are imposed, then problems may well occur, these problems being caused primarily by the new working methods. The scope of the contract, the schedule, including critical issue dates, and the objectives / documentation required is normally all that should be specified.

Sometimes, for example with the major oil companies and the major pharmaceutical companies, there is an insistence that the contractor adopts the Clients systems, procedures and protocols. In these cases there is an incentive for developing partnering agreements.

A network diagram (Figure 1) showing the linkage of activities during preparation of a Basic Engineering Package is shown below. This is used successfully by one engineering contractor as part of his planning procedures. A similar diagram (Figure 2) shows the interactions between the Basic Engineering Package and the overall project control network.

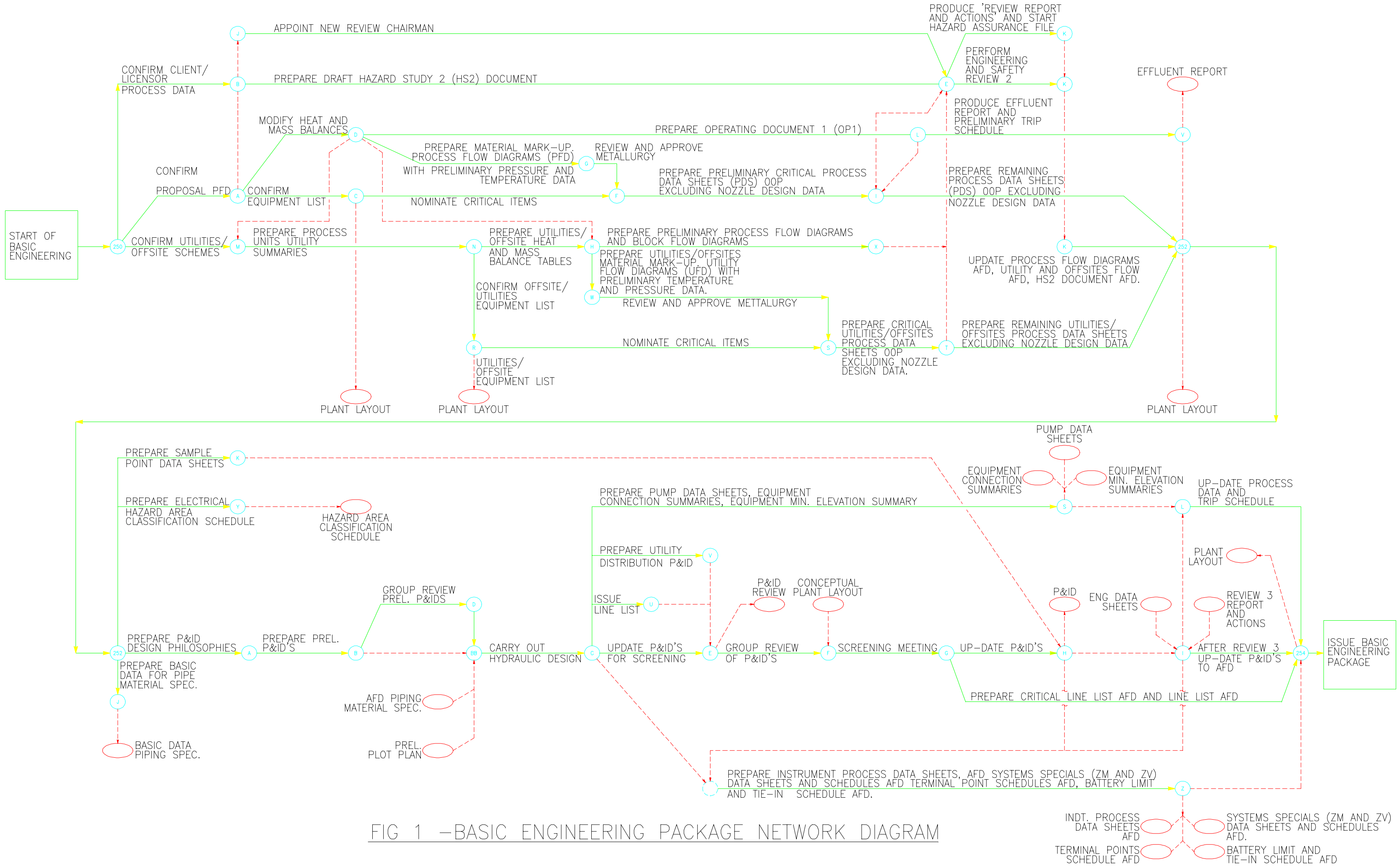

FIG 1 –BASIC ENGINEERING PACKAGE NETWORK DIAGRAM

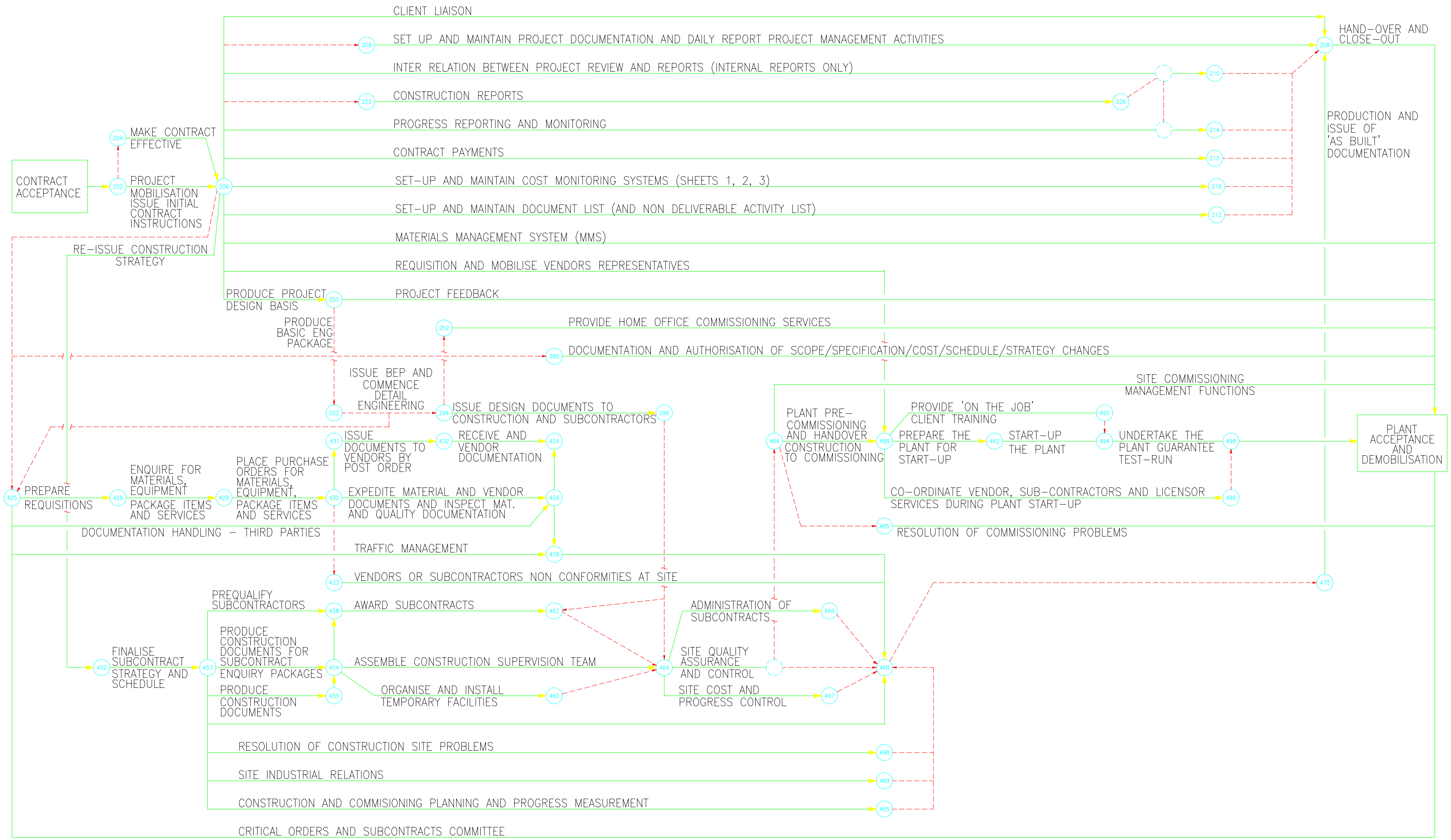

FIG.2 — OVERALL CONTRACT EXECUTION NETWORK DIAGRAM

4. Case Studies

Although there are many principles of project management, the fact remains that every project is different and every project has its own particular challenges and difficulties. Project size, location, finance conditions, complexity, technology and schedule are just some of the more definable variables and there are others, such as the interaction of human resources (people) which are difficult or impossible to foresee in advance. Although we would like to say that all our projects run like clockwork, this is rarely the case because in fact the very function of project management pre-supposes the need to react to unexpected events and to handle risks.

The case studies below summarise three recent fertiliser projects and give an overview of the different strategies taken as well as some of the difficulties encountered.

Case Study 1 - Wengfu, Ma Changping, China

This project was for a grass-roots 1000 mtpd P_2O_5 phosphoric acid plant. The main contract was taken by the Japanese company Mitsui Engineering & Shipbuilding Co. Ltd. Basic engineering was sub-contracted to Kværner and some of the detail engineering to a Chinese design institute. Prayon was also involved as the technology licensor. The project was thus relatively complex in terms of the number of parties involved but the time schedule was realistic and thus allowed a conventionally structured approach to the engineering.

Kværner and Prayon have worked together on 50 phosphoric acid projects over the last 4 decades and have thus developed a particular way of working which meshes efficiently. In effect, after an initial kick-off meeting to agree the full design basis as soon as the contract becomes effective, both parties start the process design work simultaneously. Both parties have their own highly developed spreadsheets for heat and mass balances and this parallel working acts as an independent cross-check. Thereafter, Kværner generate the process flow diagrams and prepare the detailed text of the equipment data sheets whilst Prayon are sizing the main equipment. After this, Kværner continue to develop the P&I diagrams, layouts and other documentation. One or two key review meetings are held at strategic times before freezing the basic design.

The Basic Engineering Package was transferred electronically and by hard copy from London to Tokyo in three agreed phases, aimed at allowing a logical progression of the detail engineering. At critical project milestones, meetings were held between all parties, for example immediately prior to and during client's review of "approved for construction" P&ID's. Even allowing for different working methods and cultures between the various parties, the project implementation was effective.

Case Study 2 - Confidential Client, South East Asia

The Client had produced single super phosphate powder for many years using belt dens. In 1995 a contract was awarded to Kværner for design and supply of a granulation plant to produce 120 tph of granular SSP based on powder produced from various blends of rock. Basic design was performed in Kværner's London office using in-house technology and detail engineering, procurement and construction supervision in a Kværner office in SE Asia.

Special features of this project were the very short project schedule, severe budget constraint and the fact that the new equipment had to be installed in an existing building which had previously housed a phosphoric acid plant. The project scope included some demolition work to achieve the required space and access, stiffening of existing structural steelwork and the make-good of some excessively corroded steelwork, but even so floor elevations were not ideal for a granulation plant layout.

In order to shorten the schedule, maximum use was made of the JOIN link between the two Kværner offices for the transfer of drawings and other documentation. Unusual short-cut methods were applied to try to advance the order date for major and long-delivery equipment. For example, some of the basic engineering documents were not developed to the usual extent and were transferred early for completion in the regional Kværner office. This was possible because of the compatibility of design standards and working methods across the two companies and also because no licensor was involved. Also, instead of issuing the basic design package as an entity or in discrete phased releases, documents were issued from London to SE Asia as and when available. This strategy involves some risk of re-work but was considered to be the most suitable in the circumstances.

Even with these planned measures, some delay in project schedule occurred mainly due to the need to re-cast the granulator and dryer tyres as a consequence of manufacturing flaws by a sub-vendor and construction problems relating to the use of the existing building. This made for an abnormal start-up period characterised by the requirement to reach full production rapidly due to high product demand in the growing season.

Case Study 3 - Hind Lever, Haldia, India

Kværner had supplied a 27 mtph DAP plant to Hind Lever in 1985. During 1998 the plant is being revamped to produce 60 mtph DAP with the additional capability to make a range of NPK's. This is thought to be the biggest percentage capacity boost on any granulation plant without replacement of the granulator or dryer.

For the revamp project, basic engineering was undertaken in Kværner's London office and detail engineering in Kværner's Mumbai office. As for Case Study 2, extensive use was made of electronic document transfer between the two offices. Procurement of local and imported equipment was contractually the responsibility of the Owner but in practice this was achieved by Hind Lever's representatives re-locating to Kværner's Mumbai office to work in the project task force for the key periods of bid assessments, vendor selection and order placements. Hind Lever's representatives also visited Kværner's London office during the basic engineering phase and similarly staff from Kværner's London office undertook key reviews of the detail engineering in Mumbai.

This project was scheduled to have it's re-commissioning immediately after a statutory inspection of an existing ammonia sphere and this dictated a very short project programme. Considerable planning and client-contractor liaison went into the preparations for the installation of new equipment and detailed tie-in programme to coincide with the ammonia sphere shutdown.

5. Typical Project Cost Estimates

Below, typical comparative costs for a phosphoric acid project are given for two different project strategies, one based in a single location, and the second using different locations. These figures will vary between projects depending upon scope of work, companies used etc. but are presented to highlight typical savings that could be made by the multiple office location approach.

Project:	Single office location	Multiple office location
Process package from licensor	$ 100,000	$ 100,000
Cost of Basic Engineering	$ 640,000	$ 640,000
Detail Engineering man hours	60,000 hours	75,000 hours
Cost of man hours	$ 50 - 80 / hour	$ 10 / hour
Supervision hours	-	8,000 hours
Cost of man hours		$ 70 - 100 / hour
Total cost of Detail Engineering	$3,900,000	$ 1,430,000
Procurement man hours (Basic Engineering Contractor)	-	2000 hours
Procurement man hours (Detail Engineering Contractor)	4,000 hours	3,000 hours
Equipment costs (materials and sub-contracts)	$ 10,000,000	$ 10,000,000
Other equipment (piping, instrumentation, electrical	$ 5,200,000	$ 5,200,000
Total cost of procured equipment	$ 15,520,000	$ 15,390,000
Construction costs (structural steel, painting, insulation, site prep, concrete, piling, buildings, direct labour and field overheads)	$ 12,800,000	$ 12,800,000
Commissioning and start-up costs	$ 150,000	$ 150,000
Total project costs	**$ 33,110,000**	**$ 30,510,000**

Typical savings for strategy II in comparison to strategy I is $ 2,600,000, or approximately 10% of the overall project costs.

6. Future Developments in Technology Transfer

As the engineering skills in the developing world improve, so the scope of work performed in the lower cost centres will be increased. However, as the skills increase, so the manhour costs normally increase, thus reducing the cost advantages. Centres also tend to focus more on their core competencies, reducing the range of projects that they are interested in pursuing. It may therefore become necessary to increase the number of offices involved in a project, so that the costs can be minimised and the core competencies of each office can be utilised to maximum effect. More and more, contractors will need to demonstrate flexibility in terms of global operations, whilst being part of a grouping having substantial capital backing to satisfy clients of their financial stability.

There will be an ongoing commitment to developing engineering and project management tools within an organisation in order to remain competitive. This will include continued expenditure on software development, PC networks and IT support facilities to remain in the forefront of technology transfer effectiveness.

As companies take more of a global presence, and procedures become more aligned between the offices within one organisation, the opportunity for performing project execution 24 hours per day increase. All information will need to be held within a computer network, and this network must be accessible from each office. A virtual management system will need to be established to ensure that all the project requirements are met, and that no details are missed.

This method of working will allow project schedules to be cut, although the time for the equipment manufacturing and construction phases are themselves unaffected.

7. Conclusion

There is more than one way to implement a project successfully. Certain trends however tend to point towards strategies that are appropriate though not necessarily simple. Cost effectiveness is more important than ever. Using the latest technology for information transfer, and having proven systems which will ensure that the technology know-how can also be transferred effectively, allows projects to be successfully executed using a number of offices located around the world. This option for project execution often allows the project costs to be reduced, without having a negative impact upon the project schedule.

To compete in the modern world, a contractor must invest both in capital and in staff training to keep in the fore-front of Information Technology. Equally important though is the realisation that a successful project starts and ends with people - his own and the Client's. The way a contractors personnel, those of other contractors involved in the project, and the Client's own personnel, work together in a constructive and positive manner is critical to achieving a successful project. The way in which a client finds his needs and aspirations satisfied is also vital in achieving a successful project.