

**Organisation and project management of a major industrial
engineering and construction project**

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A. General

This paper aims at describing the organisation and project management of a major engineering and construction project. Reference is made to a real case.

We shall demonstrate that, in complex projects, it is not enough to consider separately the organisation of each Contractor, while it is most important to study how the various organisations interact each other in order to create a single, multiple and complex organisation to run the construction site.

B. The referred project

B.1. Main data

The project referred to was relevant to the engineering and construction of a major, integrated petrochemical plant in an extra-European country, whose development was at a medium level and whose economic system was mixed. In this country, the oil and petrochemical sector was part of the planned, centralised and state-owned economy.

The complex was composed by:

- process units (ethylene, hydrogenated gasoline, low density linear polyethylene, high density polyethylene, polypropylene, poly butadiene, etc.),
- service units or utilities (power generation, steam generation, cooling towers, etc.),
- piping interconnection and storage system,
- auxiliary buildings and civil works (roads, office building, workshop, warehouses, canteen, gatehouse, etc.).

The project was studied to be completed in different phases, in order that phase one could have been put in operation while phase two was still under construction and phase three still through the engineering process.

In order to have an idea about the magnitude of the project, reference could be made to the following data:

- concrete: 370.000 m³ (cubic metres)
- piping: 1400 km
- electrical cables: 2060 km
- imported material: 145.000 Mg (tons)
- standard man-hours: 16.500.000 Smh
- actual man-hours: 28.000.000 Amh about
- construction time: 4 years (phases one and two)
- manpower on site: 6000 people (average), direct manpower 4500 people
- value of the construction works (1985-90): 900.000.000 ECU

B.2. Contractual organisation

At the beginning, the purpose of the Owner has been to assign the whole of the project, engineering and construction, to a major European General Contracting company; the bidding process, however, was open also to U.S. and Japanese companies.

The first bidding process did not give any result: at that time, no one of the General Contractors in the world was willing to assume the whole responsibility of this project. To be noted that, at that time, the political risk of the country was still high.

The Owner decided to manage the works by itself, assigning to various contractors the engineering and the construction works, separately. In reality, the Owner's structure was able to manage plants in operation, while they had no experience at all in engineering and construction, so co-ordination problems started. Initially those problems were due to discrepancies between engineering of different companies.

The Owner then decided to put in charge a Project Managing Contractor. They called a major engineering company with a wide experience in general contracting of refineries and major chemical and petrochemical complexes.

B.3. Parties involved

a) Owner

The Owner was actually a National Company, whose scope was the management of one petrochemical complex already in operation as well as of the complex under construction.

The National Companies were institutionally organised as follows:

- The property was belonging to the State itself and was managed through the Ministry of Industry, whose functions were the general co-ordination as well as to appoint and recall the members of the Boards of Directors of the Companies. The Ministry itself was acting as the holding company, without an intermediate Holding Corporation like happens in other countries.
- National Companies were actually acting as private companies, under the laws governing the private system.

In the National Company under consideration the Board of Directors was composed by 11 members, three of whom involved in the project, namely:

- the Chairman & Managing Director who was actually a politician without neither specific nor management experience,
- the Construction Executive Director with a wide professional experience, he was actually the Project Director,
- the Planning Executive Director.

The National Company's Representative on site was a top manager whose title was Construction Manager (note that this title was not properly used). The functions belonging to the Owner were the following:

- financial management of the project,
- representation in front of other Government bodies and Authorities,
- management of the complex after its completion,
- purchase of local material,
- transportation of imported material from FOB (Country of Origin) to Site,
- management of site warehouses,
- general site services (camp for workers, offices, power, etc.).

b) Project Managing Contractor (PMC)

The functions belonging to PMC were the following:

- Integrated Project Management, including
 - general management of the project, with all powers to manage the contracts with all the involved parties and without the power of modifying those contracts,
 - operating management of the construction contracts,

- planning, scheduling, progress monitoring and project control,
- cost control (limited to construction),
- co-ordination of head-office activities,
- management of site activities,
- co-ordination of site engineering,
- quality assurance.
- Training of the personnel of the Owner (administrative, management).
- Assistance to the Owner in relationship with other Govt. Bodies or Authorities.

c) Engineering Contractors or Process Units Contractors (PUC)

The functions belonging to PUC were:

- Process Engineering, Licenses, Technology.
- Engineering, purchase of material to be imported, transportation to FOB.
- Technical supervision to site warehousing.
- Technical supervision to the construction works (to assure that the works were executed as designed and engineered), site engineering.
- Technical supervision to precommissioning and commissioning.
- Training of the personnel of the Owner (technical).

d) Construction contractors

Major national or international contractors with a proper organisation, their task was construction, installation of the imported material, precommissioning and commissioning of the petrochemical plant properly so said. They were using its own manpower and equipment, while construction material was given by the Owner.

e) Civil contractors

Minor local civil contractors whose task was engineering and construction of the ancillary building, roads, fencing works, etc.

B.4. Planning and project control

Planning and project control were very sophisticated, based on PMC's technologies, extremely advanced at that time.

The planning and project control procedure included:

- a master plan and a detailed scheduling,
- a weekly progress monitoring procedure and report,
- a monthly complete project control procedure and report,
- a monthly cost control procedure and report,
- updating of scheduling whenever needed.

The master plan was modified twice to cope with a general delay from 48 to 66 months and once to cope with the decision of starting the so called phase three.

B.5. Organisation of PMC

PMC was a major engineering and construction company, whose scope was to act as consulting engineer and general contractor, with several thousand employees.

The company was organised by functional departments with co-ordination and integration offices (weak matrix organisation), in detail:

- the Board of Directors was composed by 7 members,
 - the Chairman was acting as Chairman of all companies belonging to the same Group (so he was actually the Chairman of the Group),
 - the Vice Chairman & Managing Director was the real Chief Executive of the company,
 - directly under the Vice Chairman:
 - the General Manager,

- Administration and Finance Dept. (accounting, bookkeeping, treasury, finance),
- Human Resources and Organisation Dept.,
- Technology Dept. (technologies, patents, licences),
- the General Manager would have been correctly defined as Operating Manager, since a lot of general management functions were belonging to the Vice Chairman; under the General Manager,
 - the Engineering Manager (project co-ordination, planning and project control, engineering, purchase, marketing and proposal),
 - the Construction Manager (site management),
- the organisation of every single project was composed by
 - Project Manager (under the General Manager), with full power of representation, regarding the project, towards external parties, but without strong internal powers,
 - Project Co-ordinator, (under the Engineering Manager), who was the real governing authority of the project,
 - Project Staff (project engineers, contract manager, business manager, project comptroller),
 - Site Manager (under the Construction Manager) and Site Staff (construction manager, site engineers, etc.),
- in each country a Resident Manager (under the General Manager) and his Staff were in charge for all local administration, representation and legal problems.

It was actually the normal organisation structure of a major engineering and construction company, with some peculiarities. The weak points were not enough power given to co-ordination and too much power given to Engineering and Construction Areas. The consequences were a weak project management and a weak general management, in reality the chief executive was the Vice Chairman while the real general management was divided between the Engineering and Construction Managers.

B.6. Organisation of the Project

a) Project Managing Contractor

The Project Managing Contractor's project organisation was as follows:

- Head Office:
 - Project Manager and Project Co-ordinator were the same person, as a matter of fact this project was not considered as an important one, if compared to general contracting, but as an experimental project,
 - Project Staff as above.
- Country Office: since the company had several contracts in progress in the same country together with a continuous marketing activity, there was a Resident Manager in the capital town together with his Staff.
- Site Organisation:
 - the Site Manager was the real governing authority of the project, at least locally; he was the manager accredited towards the Owner. He was assisted by a Vice Site Manager. The Site Organisation was composed by:
 - the Office Manager and his staff (accounting, site treasury, personnel, local general services),
 - the Planning and Project Control Dept., composed by the Planning & Project Control Manager, two Planning Engineers, one Cost Engineer and four to five assistants,

- the Contract Administrator,
- the Site Engineering Manager,
- the Quality Assurance Manager,
- the Data Processing Dept. (mainframe on site),
- the Material Manager (transportation, warehouses),
- the Construction Manager, with a matrix construction organisation formed by Area Managers and by functional departments (civil, mechanical, electrical, instrumentation, painting and insulation, precommissioning).

b) Engineering Contractors

Major or middle size engineering companies. The head office engineering was organised in an independent matter and was not under the effective control of the PMC. Locally their structure was limited to the technical staff under the supervision of a Manager.

c) Construction Contractors

They were differently organised. The major between them, whose contract was to make civil and installation works of five process units plus four utilities, was organised with the following scheme:

- the Site & Construction Manager, was the overall responsible for all the activities as well as of the representation and legal problems of the company towards the local Authorities, as well as the full responsible for construction management; under him there were
 - the indirect functions for administrative, financial and legal problems,
 - the Planning Manager, who was also deputy of the Site Manager with some general co-ordination functions,
 - the Civil Work Section,
 - the Mechanical Section,
 - the Electrical and Instrumentation Section,
 - the Painting and Insulation Section,
 - the Road Work Section;
- to be noted that some works were sublet to Subcontractors, creating some further problem and the need of a proper sub organisation within the Mechanical and Electrical Sections.

d) Relationship between Owner and Project Managing Contractor

It is worthy to note that, between Owner and PMC, there was a very complicated network of relationship. As a matter of fact, since PMC was supposed to train the Owner's staff, people from Owner's organisation were assigned, for this purpose, to different PMC's offices or departments.

The relationship between these people, the chief of PMC's office and the chief of Owner's corresponding office can be summarised as follows:

- PMC had the full power to assign duties and to define the level of discretionality for each person to work , to decide start and stop of the various duties, to assign priorities and to check the execution of such duties, while
- PMC had no power about selecting and deselecting people (only limited powers to reject unsuitable persons), moving to an office to another, job evaluation and careers, holidays.

Useless to say that the above could have been improved, it was far from being perfect.

The relationships between two different organisations due to cooperate or, like in this case, the injection of key-personnel from one organisation into a second one, should be carefully studied and contractually defined in detail.

In the case under study, the results were that

- organisation and project control were good, enough detailed and reliable, it was possible to know every week the real progress (planned versus actual) in several aggregated or disaggregated forms, responsibilities for delays were clearly attributed to the really responsible party, while
- delays could not be avoided nor kept under strict control; PMC was able to suggest the proper corrective action but was not enough strong to impose its implementation; the main reasons of delay (transportation, construction manpower) were not actually under PMC control.

At the bottom line, we could say that PMC was really acting as a Project Monitoring Contractor.

C. Project Management and Integrated Engineering

The following terminology starts to be accepted by everyone:

ENGLISH	ITALIAN	SPANISH (castellano)
Cost Engineering	Ingegneria dei Costi	Ingenieria de Costos
Total Cost Management	Ingegneria Economica	Ingenieria Económica, Financiera y de Costos
Project Financing	Finanziamento di Progetto, Ingegneria Finanziaria	Ingenieria Financiera
Project Management	Gestione di Progetto	Ingenieria de Proyecto
Engineering (overall, integrated)	Ingegneria Integrata	

To be reminded that

- the term Project Director (in British terminology Project Manager, lev. 5) identifies the person in charge for the main decisions relevant to the project, including decisions relevant to budget, contracts, major changes, suspensions, scope of works, he is also a key-person in the initial decision, whether to go on with the project or not, while
- the term Project Manager (in British terminology Project Manager, lev. 4) identifies the person in charge to manage the project, within assigned budget and contracts, with full power of interference in the management of all the departments as well as in the operations of contractors and subcontractors,
- the term Project Co-ordinator identifies a co-ordinator with limited or without powers of interference.

The project management does not change if it is done directly by the Owner, by the Owner through a PMC or by the General Contractor:

- in the first case the Owner shall have the whole project management staff, with the functions of planning, monitoring, contracting etc., both Project Director and Project Manager shall belong to Owner's organisation while engineering and construction shall be done by the relevant contractors;
- in the second case the Owner' shall have only the Project Director with a limited staff, while project management with all the involved function shall be given to PMC people;
- in the third case all functions shall belong to the General Contractor, who shall therefore have both Project Director and Manager; the Owner shall have a Director in charge (Project Director, Programme Director) with a limited staff and sometimes shall rely on an external consultant and Project Monitoring or Auditing Contractor in order to keep under control what the General Contractor is doing.

When the project is made under full project financing, the criteria do not change while the organisation could be different. In these cases, in general, a proper project company (special purpose vehicle) is formed, whose study is beyond the limits of this paper.