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M. Jacques TERRIN (20/8/30)  
President of the Republic, ...

18068

Technical Review on  
Agenda for UNIDO Actions on Engineering  
Design and Consultancy (EDC) Services Proposals

01. The main reasons to develop EDC services in developing countries have been recorded by MARIWALLA's<sup>(1)</sup> report (page 9). Four of them can be highlighted:
- Catalysts for increased use of local equipment and construction skills, and efficient turns between investment and production.
  - Human resource development with multiplier effect
  - Generation of hard data which remains in the country for use in future planning exercise
  - Reduction of foreign dependency
02. To build-up a programme development of EDC services in developing countries, twelve propositions have been checked (pages 12-15). Three of them seems more important:
- Consulting services does not occur in vacuum. They contribute to and derive sustenance from industries and industrial infra-structures (Proposition II)
  - Human resource is the most important resource in a country and EDC services nurture human resource development (Proposition VII)
  - Government has a major role to play in this area (Proposition III)
03. Some of the specific features of EDC services have been noticed by this report. It is worth focusing two of them:
- EDC organizations, for their very existence, depend heavily on technological, industrial and environmental information (page 24)
  - There is no better means for development of local EDC than by learning through doing (page 24)

(1) Kan D. MARIWALLA. Strengthening engineering design and consultancy services in developing countries. A basic study for Programme Development UNIDO, IPCT, Sept. 1989

## 1. The main characteristics of EDC Services

1.01 The objective of engineering design activities is the conception and the construction of artifacts (product and plant). For this objective, designers use current technical knowledge and sometimes produce new technical knowledge. The outputs of engineering design activities are both new artifact and new technical knowledge.

The purpose of technical knowledge is to build a new artifact, while the purpose of scientific knowledge is to know the laws of nature. The production of a new technical knowledge is always involved with the design and the construction of a new artifact. The production of a new scientific knowledge is always involved with the conception of a new hypothesis of research concerning the laws of nature.

The production process of technical knowledge inside engineering design activities is therefore very different from the production process of scientific knowledge inside the research activities. Engineering design activities and research activities should not be integrated in the same approach and we have to differentiate the two areas to understand the production process of technical knowledge. The E.D. concept is one of more confused concept.

The EDC organizations, and more precisely engineering design organizations, play the same role in the production of technical knowledge as the laboratories in the scientific knowledge.

1.02 All the design activities (product design and plant design) carry out a lot of technical (and economic) choices. But only few of them are explicit choices. Indeed, each new design study of an artifact (product or plant) re-integrates most of antecedent technical choices. Even in the case of the design of a new artifact, a lot of technical choices are implicit and linked with antecedent artifacts. Continuity is the main feature of the evolution of artifact and technical knowledge. The improvement of technical knowledge is the result of an accumulation process, while the scientific knowledge is more involved by scientific revolution, by changes of scientific paradigms (Kuhn).

1.03 The EDC services can be defined as a set of all the methods and organizational structure, which make it possible to apprehend correctly the interdependence of technical, economic, social informations and data which are necessary to the study of engineering design and the optimal realization (construction costs and time allowed, operation costs) of capital within a coherent productive unit as a whole.<sup>(1)</sup> The EDC services are information activities and, for that, they use specific methods.

1.04 The factors which have given rise to the autonomy of these services and particularly of engineering design and to the creation of engineering design firms, are, when first analysed, quite numerous and diverse - growing complexity of construction techniques, development of continuous production processes, growing size of industrial complexes - But the determining factor which is at the root of autonomy of the function of engineering design (and of other related functions) with regard to the production function is to be found in the process of division of labor which is induced by the economic development. More economic development is growing, more division of labour is important, that is to say, more number of different autonomous specialised firms is important.

The history of engineering design firms in developed countries shows that, before the creation of specialised firms, the function of engineering design was the result of a first phase of development inside the capital good firms, construction building firms, continuous production process firms. The history indicates the division of labor has not operated in the same way in all the industrialised countries. In some countries (e.g. U.S., U.K., Norway, Sweden, Denmark) the tradition of a liberal profession, of (independent) consulting engineers has strongly influenced the creation and development of engineering activities for industry. In other countries (e.g. France, Germany, Japan), production firms and capital good firms have played a more determining role in the development of engineering design activities.

(1) Jacques PERRIN. "Engineering - Terminology and Economic Function" OECD Development Centre, 1976 (CD/TI.(76)1)

From this brief economic and historical comment, two main conclusions can be drawn:

- The way of creating and developing EDC organizations in developing countries can be different from one country to another. There is not one model of development of EDC organization.
- In the first phases of development the EDC services will be integrated in existing firms (construction firms, capital good firms, other production firms). Strengthening EDC capabilities is not always similar to creating new EDC firms.

1.05 As an information activities, EDC organizations have to collect different kind of informations<sup>(1)</sup> from economic and social environment, production activities, capital good industries, construction enterprises, R&D and they have to produce technical and economic informations - drawings, specifications, tenders, planning, economic evaluation, ...

EDC services are at the centre of a network of flows of technical and economic data and know-how between the different poles of activities which constitute an industrial system: production activities, equipment manufactures, financing activities, research laboratories. These data and know-how flows are not one way, exclusively to the benefit of EDC organizations. In return, EDC services poses new questions to research laboratories, new performances and other requirements to equipment manufacturers and construction firms.

1.06 Every pole of activities can influence the development of EDC services and can increase the demand of local EDC services. For instance, Banks can provide low rate loan if the project "owners" use local EDC organizations. The standardization of equipments by local capital good industries can improve the local engineering design studies.

1.07 The EDC services, being at the centre of exchanges of technical and economic informations, are fitting a function of integrating the different poles of activities (production, equipment manufacture, construction, financing, research, ...) which make up the industrial system. EDC organizations play also a role of accumulation memorization and valorization of industrial experience.

It is worth recalling that accumulation, memorization and valorization of industrial experience have played and play an important role for the developed countries.

- In the XIX<sup>th</sup> century, at the beginning of industrial development a lot of scientific societies, and technical reviews were created (especially in England, the first country which had experimented the development of machines) to improve the exchanges of informations between the new industrialists, artisans and to try to explain the new events.
- Today, the creation of quality circle and lot of articles in management review try to explain the new forms of work organizations involved with the diffusion of information technology.

## 2. The Tools of EDC Services

- 2.1 From the main features of EDC activities and from observation about the way of working of the EDC organizations, one can define three main tools used by these organizations to perform their results:
- recrutement of skilled manpower
  - formal and administrative procedures
  - accumulation of experiences and knw-how
- 2.2 All information exchanges inside the EDC organizations and with its partners are formalized and codified through written procedures which vary according to the importance of each project,. These codified procedures identify the various tasks to be carried out together with their sequence, determine competence, and responsibilities, plan all project development phases and evaluate data-processing requirement.
- Even if most firms tend to develop some original and individual procedures, some tasks have always to be carried out, whatever the project (project definition, co-ordination and planning, quality control, manufacturing and commercial ability, interim and final evaluation).
- The recent development of Computer Aided Design (CAD) is a new way to implement and to increase the use of formal procedures.

Formal procedures have been also created in order to improve the efficiency of individual tasks.

2.3 Know-how is a form of knowledge, i.e. a set of technological procedures which are memorized and transmitted. This set is always the product of a specific time period, of individual or social groups and of organization.

Know-how results from an accumulation over the years not only of positive experiences but also of difficulties and mistakes. It is based on knowledge which cannot be easily formalized and codified in a simple medium for transmission. This specific knowledge can only be transmitted in the course of joint activities and over a long period of time. The know-how is the capital of an EDC organization and before EDC organization can become operational there has to have been prior accumulation of experiences.

### 3. Proposals for Action

It is not possible to implement, in a country, all EDC activities at the same time. Some priorities have to be defined. The criteria to define these priorities are the economic and social impact of each EDC activity. These priorities can be different in a same country, for different industries.

#### 3.10 Pre-feasibility and feasibility studies

These studies usually consist of:

- a market analysis
- a study of alternative processes
- a study of the viability of alternative technical proposals (site, raw materials, communications, etc.) in technical terms and in terms of cost.
- an initial cost benefit study in financial and social terms.

These component parts are interdependent - the market study's conclusion on product and quality may affect the choice of process. The indirect bearing of a project on the wider economic context needs to be considered. Particular attention needs often to be paid to raw materials and consumed utilities, the particular local nature of which may necessitate changes in design in comparison with normal practice abroad.

The feasibility study stage leads to the taking of some crucial decisions and it is desirable that local technical expertise ("owner" technical expertise if it is possible) is called into play as much as possible. The efficiency of a project at micro and macro point of view, to a great extent, depends on the feasibility study and the way this study has been managed.

- 3.11 In a survey<sup>(1)</sup> on industry in Africa concerning 343 industrial projects, a French research centre, The "Institut de l'Entreprise" recorded 275 projects which were not running properly including 74 which had been completely halted. When attempting to identify the causes of this situation, the authors of this survey adopted three main categories matching the major phases in the realization of the projects.
- circumstantial causes relating to the programming of the projects: absence of serious economic reasons for launching the project in the first place, inaccurate evaluation of the market, lack of industrial integration
  - circumstantial causes relating to the realization: mistakes in the choice of technical processes, insufficient training.
  - circumstantial causes relating to the running of the plant: absence of industrial culture and traditions, maintenance

All these problems have to take into account in the feasibility studies in order to decide if the plant will be built-up, and which technical and organizational adaptations have to be introduced without forgetting the evaluation of the financial consequences of every adaptation.

- 3.12 The actions to improve the feasibility study capabilities in developing countries could be:
- organization of training session
  - diffusion of specific methodologies to manage feasibility studies
  - diffusion of case studies

(1) North-South Centre of the Institut of Entreprise. Pour un vrai partenariat industriel en Afrique. Bilan et perspective l'industrie africaine. Paris May 1985.



3.13 It is important to remind that in every developing countries, a lot of feasibility studies has been done by foreign firms or by local firms. Several of these projects have been built, some of them do not work, others work with a low utilization rate. Nevertheless, developing countries are going on to create new projects and to rehabilitate plants. It is very urgent to memorize all these experiences (positive experiences and mistakes) and to analyze the reasons of success and the reasons of failure. This kind of inquiry will produce:

- economic and technical data, useful for new feasibility studies, and for the planification of industrial development
- new idea to improve the methodologies of feasibility studies and know-how to manage these studies
- new informations to increase the integration of individual project inside the global economy.

UNIDO could promote this kind of approach by building up a framework of analysis, by supporting some case studies and by organizing exchanges between countries inside the same region or between countries on the same development level

3.20 Basic and detailed engineering design studies

Basic and detailed engineering design studies are assumed by specialised departments inside capital good firms, construction firms (enterprise), or other production firms or by autonomous firms. According to the countries and according to which kind of work they are in charge, these autonomous firms are different names: design firms, consulting engineering firms, contractors, constructor engineering design firm, societie d'ingeniere, entreprise generale...

3.21 Problem for the specialised organizations which are in charge of this kind of studies, is to obtain the specific methodologies of work (organization, standards, software, and mainly to build-up a team work know-how).

Methodologies are not very different from one firm to another, but every firm adapts these methodologies according to its history, its specialised field of industry, and mainly according to the level of training, the previous experiences and the social behavior of its

manpower. The collective engineering design know-how inside a firm is very closed with the specific methodology used by this firm. This kind of linkage between methodology and know-how has to be on account to manage training and transfer of technology programmes.

3.22 Some developing countries, such as Algeria and South Korea, have accumulated a lot of different experiences to try to catch the engineering design methodology and know-how. It would be very useful to collect, analyse all these experiences. This kind of research cannot carry out without a closed participation of all firms and all people who were involved in these experiences.

3.23 Construction and fabrication studies inside construction firms and capital goods firms.

EDC organization determines and specifies the necessary equipments, participates in the drawing up of invitation to bid and in the choice of equipment. EDC organization provides the main specifications which serve as a basis for the construction firms.

To manufacture capital goods, the design departments of capital good firms have to prepare detailed design or fabrication drawings. In developing countries only a few capital good firms have equipment design facilities or the necessary equipment design know-how. As a result of this, most of them decline tenders.

To build infrastructures, the design department of construction firms have also to prepare detailed design and construction drawing. In some developing countries, construction and building firms miss design capabilities for important project.

3.24 The actions to improve construction and fabrication studies inside construction and capital goods firms are:

- organization of training session
- diffusion of specific methodologies and "standard" used to manage these studies
- promotion of transfer of technology.

3.25 UNIDO could increase the exchanges of experiences between capital good industries of different developing countries, more precisely about:

- the way to improve the organizations, methodologies "standards"
- the cooperation agreement with firms from developed countries in order to operate transfer of technology.

3.30 Process engineering design studies

The objective of this engineering design phase is to adapt the process book to a particular plant which will use given raw materials, and which will be erected on a given site. This kind of study needs very specialised engineers team who has accumulated knowledge about process and know-how about engineering design studies.

3.31 Very few developing countries have got the mastering of the process engineering design studies. Republic of South Korea has implemented a very interesting strategy to catch this phase of engineering design. Other countries like Brazil, Argentina, in some particular fields of industry, have also succeeded. It would be very useful to collect and analyze these strategies in order to inform other developing countries.

TABLE - DEFINITION OF MEANINGS

Main recommendations to strengthen EDC Services	Implementation by which kind of activities and methodologies	Means to design	In co-operation with
<u>Feasibility studies</u>			
Memorization and valorization of economic and social decisions involved on feasibility studies	<p>.To collect informations (1) about the economic and social performances of already built industrial projects and about their history and (2) about the means, methodologies used to realize the feasibility studies of these industrial projects.</p> <p>.To analyse the linkages between these two kinds of information</p> <p>.To propose new methodologies and other recommendations to improve the feasibility study efficiency at micro and macro-level</p> <p>.to valorize the collected informations for industrial planification purpose</p>	<p>.Framework of inquiry</p> <p>.Training in LDC people who will be in charge of the inquiry</p> <p>.creation in LDC of expert group who will be in charge of the organizations and the orientation of this memorization work</p>	<p>.expert who use to doing feasibility studies in LDC and to building up methodologies for feasibility studies</p> <p>.Ministry of Industry in LCD</p> <p>.Feasibility studies - Branch-UNIDO</p>

Basic and detailed Engineering design studies

Memorization and exchange of experiences concerning the ways used to catch the methodologies and know-how of engineering design

.To collection information about EDC organizations in LDC (1) have managed to catch and to evolve the engineering design methodologies and and know-how and (2) the kind of co-operation agreement they are involved with similar organizations from developed countries  
-To analyze linkages between these two kinds of informations  
-To organize the exchanges of experiences between EDC organization on a same LDC or from different LDC

.Framework to collect informations

.Training in LDC people who will be in charge of collecting informations

.Creation at regional level expert group who will be in charge of the organization and the orientation of this work

.Expert who use to working with or about EDC organizations in LDC

.Ministry of Industry in LDC

.regional UNIDO organization

Memorization and valorization of experiences of capital goods firms to improve their equipment design capability

The same things are to be done with the capital good firms  
The exchanges of experience should be organized between firms of different LDC countries, manufacturing the same kind of equipment

The same things are to be organized

Expert who use to working with equipment design department of capital good firms  
-Regional UNIDO organization

#### 4. Implementation of Proposals

4.10 Definition of means  
(of Table)

4.20 Training Seminar for memorization of industrial project experiences  
~~linked with~~ <sup>related to</sup> feasibility studies

The participants should have a graduate level and have got experiences of working in industrial sector

Duration: one month

Location: in the concerned LDC

Training Programme:

(a) Economic courses about:

- main characteristics of national economy with historical aspects
- introduction to the industrial sector with emphasis on capital goods industry. (The main firms and description of their production and organization of show round of some firms.)

(b) Industrial project courses:

- The main phases of industrial projects. Organizations in charge of industrial project. Methodologies of work.
- The role of economic integration of industrial system, played by EDC organizations - with examples from national economy.
- The impact analysis of feasibility studies at micro and macro level - with examples from national economy.
- The different kinds of cooperation agreement with foreign EDC firms.

(c) Presentation of inquiry

Objectives

Methodologies to collect, analyze and synthesize informations

Diffusion and discussion of results

4.21 Training Seminar for memorization of engineering design experiences

The participants should have a graduate level and have got experiences of working in EDC organizations

Duration: 2 weeks

Location: In one of the concerned LDC

Training Programme

(a) Economic courses:

- Brief introduction to concerned national economies
- The economic role of EDC organizations (emphasis on the integration of inside industrial system)
- Capital good industries: The main productions in the related national economies

(b) Industrial project courses:

- organizations and tools used by EDC organizations
- the different kinds of cooperation agreement with foreign EDC firm

(c) Presentation of inquiry

Objectives

Methodologies to collect, analyze and synthesize informations

Diffusion and discussion of results

4.22 Training Seminar for memorization of equipment design studies

The participants should have a graduate level and have got experiences of working in capital good industry

Duration: 2 weeks

Location: In one of the concerned LDC

Training Programme

(a) Economic courses:

- Economic role of capital goods industries
- Economic role of design in manufacturing industries

(b) Industrial project courses

- Technical and organizational tools used by design department of equipment firms
- Different forms of cooperation agreement with foreign equipment firms

**(c) Presentation of inquiry**

**Objective**

**Methodologies to collect, analyze and synthesize informations**

**Diffusion and discussion of results**



5. **Production Management Consulting Services (PMCS) and the EDC Organizations**

5.1 In LDC the productivity of enterprises is often very low. In many cases the productivity can be improved by changing some ways of organizing the production and some ways of mobilizing people.

The accumulation of experiences in order to improve production organization and the implementation of organizational innovations can be very useful for EDC organizations which are in charge to design new plants and to design also the organizational structures for these new plants.

5.2 In order to accumulate and memorize the experiences related to the improvement of production organizations, LDC have to create their own capability of Production Management Consulting Services (PMCS) and linkages have to be built up between PMCS and EDCS. That is an example of the reciprocal relationship between Engineering Design activities and Production activities inside the same industrial system. (cf paragraph 1.05)

5.3 It is worth highlighting the role of organizational innovation in the process of technical innovation. In developed countries every important change of production techniques have been preceded by organizational innovation. The first industrial revolution, in XVII<sup>th</sup> and XIX<sup>th</sup> century, was at first, an organizational innovation (the creation of manufactures). The information technology revolution was also preceded by organizational innovation: quality circle, just-in-time. Indeed, these organizational innovations have been implemented in Japan in the fifties.

One can think that, the creation of appropriate technology in LDC will be induced by organizational innovations in these countries.

These observations based on historical analysis of technical changes, focus on the necessity of creating and mastering the PMCS in LDC.

5.4 The means of mastering the PMCS in LDC are the same as for mastering the EDCS, that is to say, the memorization and valorization of experiences (1) of production management and (2) of transfer of organizational techniques, accumulated by PMC organizations and by management departments inside production firms.

The training seminars for people who would be in charge of collecting informations could include:

- economic courses: (informations about national economy, about the economic role of production management)
- production management courses (methods, methodologies)

Analysis of EDCS case studies

Four case studies have been analysed = Tanzania, Mexico, Algeria, Malaysia.

1. Some interesting information have been collected.

- Data base to service consulting engineering profession (Annex 1 of Tanzania case study)
- Table concerning capacity utilization in selected industries (page 6 - Tanzania case study)
- Size of engineering services market on Malaysia (page 5 - Malaysia case study). It would be very interesting to explain the choice of different ratio to calculate the size of engineering market from the amount of investment.
- The analysis of constraints for the development of EDC service in Malaysia (Malaysia case study Page 8)

2. The framework of analysis is not enough well established. It seems the information have been collected according to a few number of sources of information.

The Malaysia case study shows a part of the most interesting information about EDC services are not in statistical documents.

3. Except for the Malaysia case study, the proposals to strengthen EDC services are too general (Mexico case study Page 11, Algeria case study Page 8, Tanzania case study Page 8) - These proposals are:

- Encourage development of product design and process capabilities

Encourage the adoption of modern techniques

- Provide assistance services through design methodologies for product and process, diagnostic techniques for industrial sickness
- Developing consulting information data base and various local consultants
- Developing guidelines and providing promotional assistance in providing consultancy joint venture

In order to implement these proposals it would be necessary to precise:

- Which kind of EDC studies is involved = feasibility studies, basic engineering, detailed engineering, equipment design, process engineering....
- The linkages to build up with capital good industry, the construction firm, the production firm because the EDC organization have to be settled in the industrial system and they cannot be developed in "vacuum".