MODEL BASED COST ENGINEERING AS A BASIS FOR THE MANAGEMENT OF CONSTRUCTION PROCESS

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The traditional design and tender process without the integration of design - manufacturing - construction hampers innovations in construction. The implementation and the use of product and process models will enable the simulation of buildings and allow their performance to be predicted before they are build.

The building industry in all consists of several parties representing design, engineering, construction and systems, materials or components industry. Because of organisational segregation there is a great need of process integration in construction. In this paper is a description of new approach for the construction process and its key player, model based cost engineering. Also the pilot environment for total product model usage in design & construct project is descriped.

It is proved that there is a waste of money and time caused by non-integration of design and construction. The potential savings between a non-integrated process and a complete optimized process is theoretically calculated on 10 - 20% of the investments.

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1. PROBLEM DEFINITION

Overall productivity in building construction sector has not enhanced as in other industrial sectors. A main reason for this is the lack of abilty to really plan, manage and control the whole construction process.

Compared to other sections in society, information technology is not used very extensively in the construction sector. It only exists today in isolated areas within the companies. Large existing manual procedures have often just been transformed to the new electronic media. This has resulted in a rationalization compared with the manual procedures but has not utulized the full potential of the new media. Companies involved in the same building process have their own individual procedures and systems. Even in the same company the individual systems are often not compatible. The construction industry have to rethink the total production process from prelimary design to maintenance (Lundegord 1993) In modern industry we recognize three stages of development; the phase of craftmanship, the phase of mass production and the phase of lean production (Davenport 1993). - The construction industry is in general still in the craftmanship phase.

The building industry in all consists of several parties representing design, engineering, construction and systems, materials or components industry. Because of organisational segregation there is a great need of process integration in construction (Howard 1989, Miyatake 1992). Generally, in mid-size to large building projects, tools for managing the information process as a whole does not exist. The problem is worst in case of multi-user buildings, since information flows to and fro between several client sources and several design/ management/ construction parties.
In all there is a lack of systematic methods concerning the areas of

- Establishing customer or user goals and discovering real needs,
- Transfer of user or customer needs into building performance requirements,
- Transfer of customer's goals and needs into architectural solutions,
- Transfer of architectural and design solutions into economically feasible technical solutions, are a severe limitation regarding the degree of customer-orientation in traditional design process.

2. BUILDING PROCESS

There is a lack of systems that are able to integrate the process both horizontally and vertically: horizontally in the sense of managing the creation, revision and interchange of information carried out simultaneously by several parties, and vertically in the sense of transferring information from one phase to another.

Traditional methods of design and detailed engineering prior to bidding usually tie the hands of constructors and building systems industry to offer only products that already are familiar to designers and engineers. This prevents the industry from product innovation, and limits most of the innovative potential within production processes. Poor interaction between design, engineering and production results in non-optimised technical solutions and high investment cost. This could be improved greatly with systematic application of performance concept with approved technical solutins through the whole design and construction process.

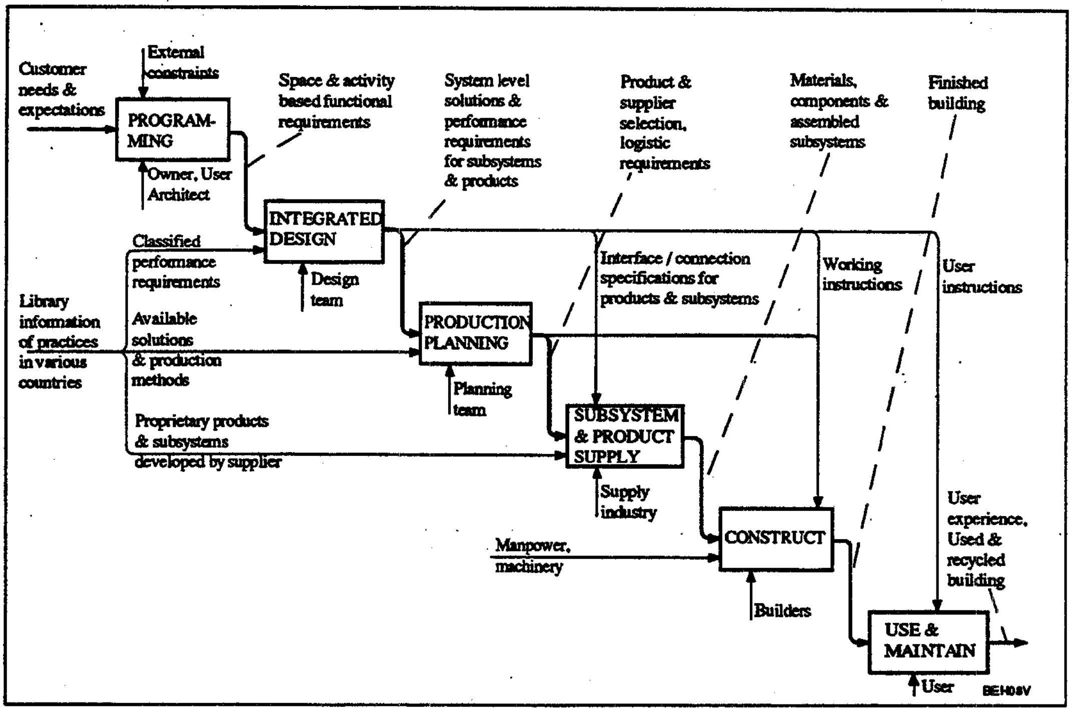


Figure 2.1 Schematic activity diagram of the proposed building process based on stepwise refined performance requirements

The needed changes in the process will cause a change in the structure of the building firms. The sub-contractors from now will be the co-makers in the future. The proportion of a project contracted out may be up to eighty percent. In the future the relationships between the main contractor and it's subcontractors will presumably be closer and co-makerships agreements will become increasingly important. Due to this the ability in managing the construction process is vital.

The new strategy for the building sector is to change the nature of the entire building process so that:.

- Fully integration of the design and production planning (Eastman 1993) becomes reality
- Customer demands will be clearly defined and fulfilled
- Conflicts between total and sub-optimisation by actors will be reduced
- Competition will be extended to include the guaranteed performance characteristics of the products

The traditional contracting bid & build will be changed towards design & construct contracting by developing and implementing of:

- Competition is not based on selling volume. Contractors are able to provide alternative solutions which meet customers' functional and performance requirements
- Integration of information technology. Implementation and use of product and process models. This will enable the simulation of buildings and allow their performance to be predicted before they are build
- Product package procurement system
- Open design and module production system, included the performance requirement system
- Integration of quality assurance and quality control systems

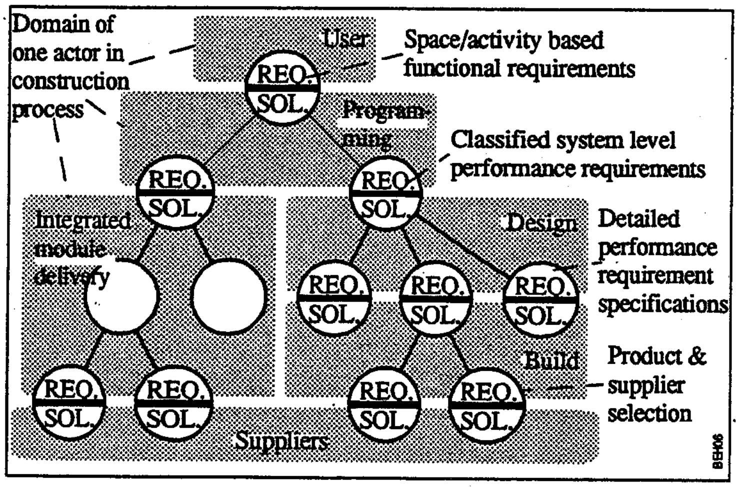


Figure 2.2 Principle of performance requirements in the building process

3. COST ESTIMATION, THE KEY ISSUE

From the main contractors viewpoint the cost-estimation/tendering is the key issue (Laitinen 1992). At this point contractors should add their knowledge into the design information. This forms the basis for further activities in the process; in order to be able to plan, monitor and manage the process. The information should be available for different purposes; tendering, cost estimating, scheduling, module procurement logistics and in the future visualisation purposes.

The main problem in carrying out cost and value engineering is the lack of suitable systems and especially kowledge based. There are some systems based on average knowledge of cost levels but there are no direct integration to design and contractors production planning (scheduling, logistics and procurement). The measurement and quantitity take of from design information is gruelling and not standardised.

Nowaday designers are not able to produce product models, so contractors should create company models themshelves from designers' information (paper drawings or CAD-files). In the future situation will change towards real team work between designers and main contractor and even with subcontractors and suppliers.

The other big problem is the lack of reliable feedback mechanism throghout the whole building process. This is vital while creating knowledge libraries and recepies of different building parts.

In Finland the development of model based data transmission started from the RATAS framework (Björk 1994, Enkovaara 1988). At present the development is based on OOCAD (Hannus et al 1994) and the integrated building design on generic product data model (Karstila et al 1994). At the end of this paper there is a description of the paradigm used in the pilot project (full scale product model approach amongst designers and contractor) (Serén et al 1993).

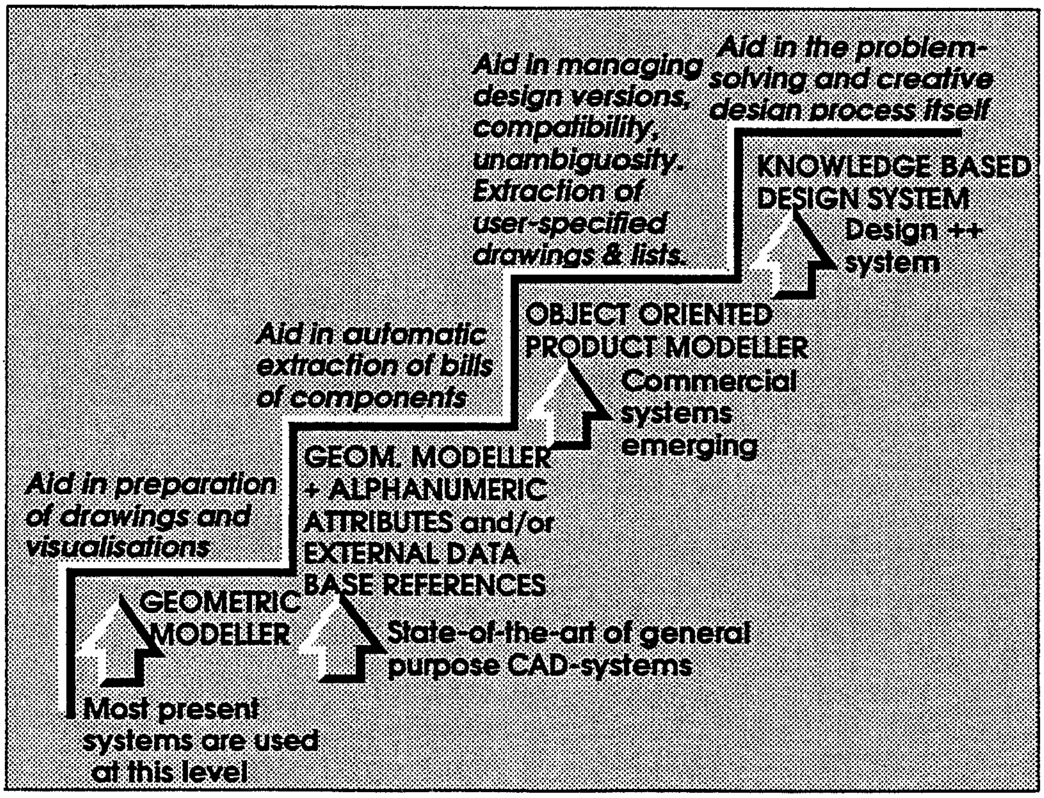


Figure 3.1 State of the art of the computer aided design technology

4. HYPOTHESIS

In the development of construction process management there are two major types of contract; bid & build and the other and more important design & construct. From the viewpoint of cost estimation/tendering the basis is rather similar.

In the new process model (design & construct type agreement) main contractor is responsible of the design also. This leads to team approach where actors should be able to share information (model based) from the very beginnig of the process. The target is to use contractors knowledge to produce reliable cost estimations and schedules already in the programming phase (Fig 2.1 and Fig 6.1).

In the traditional building process we have to make fundamental decisions with very little information. With the implementation of the new methodology we can raise remarkably the amount of information and study more alternatives before we have to decide, which would be the most practical and less expensive way to accomplish the project or a part of it (eg. product packakge procurement) and how the alternative solutions affect on the expenses (Froese 1992).

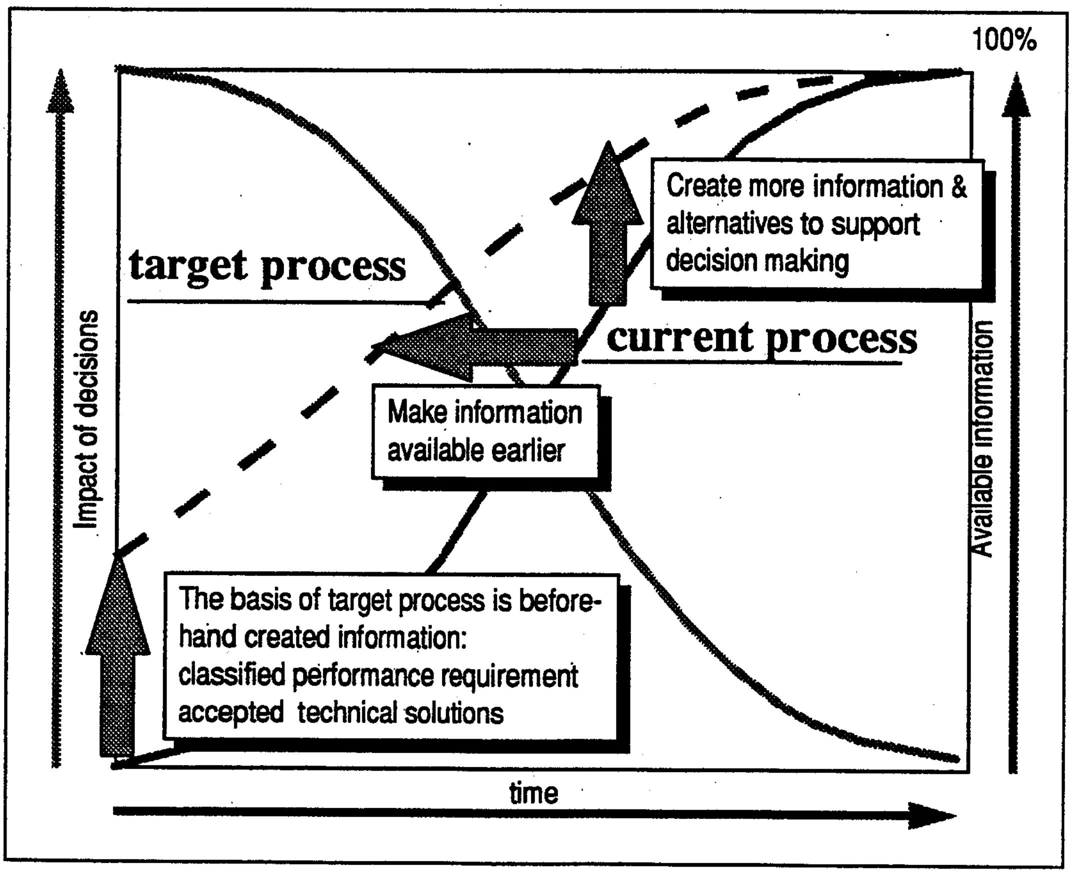
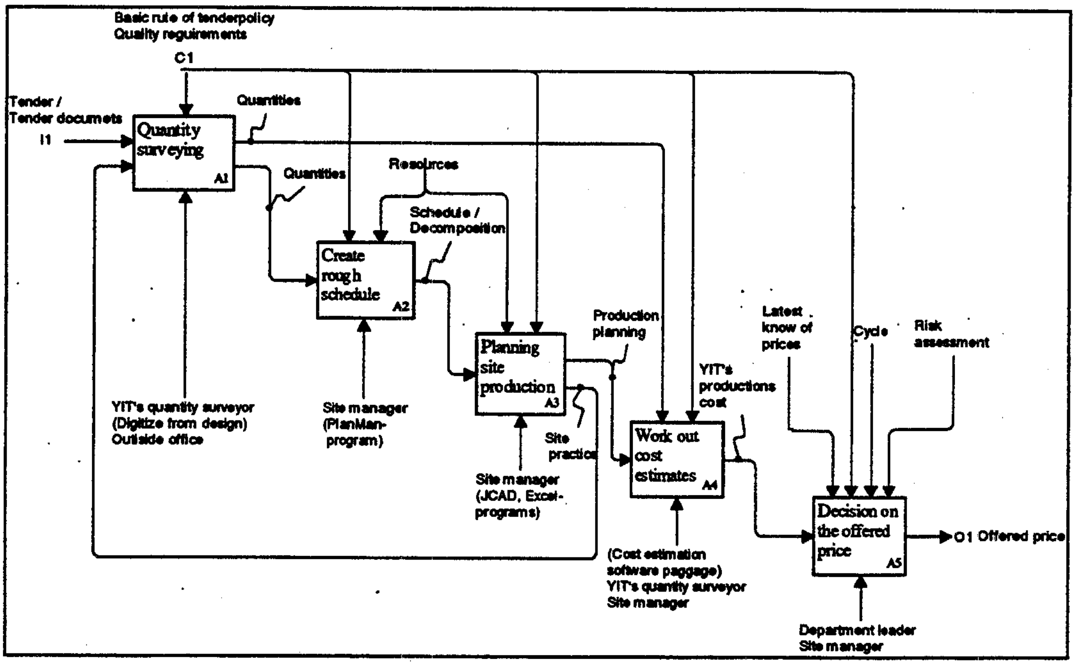


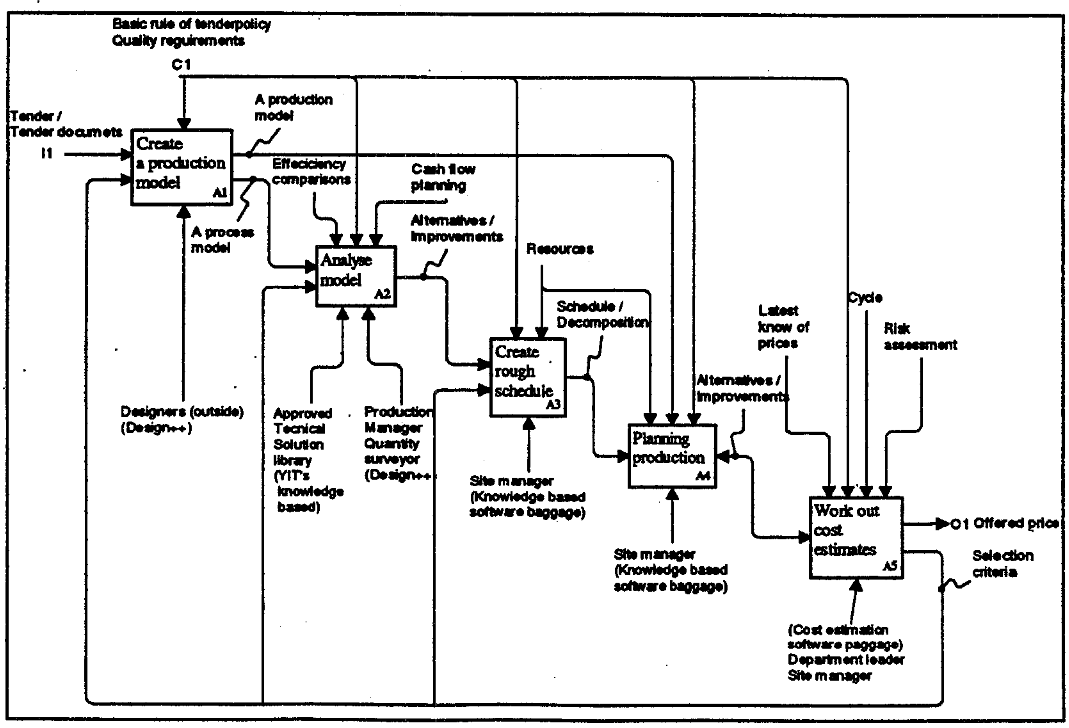
Figure 4.1 Decision making versus available information

As an example of the use of product model approach in cost engineering the next figures illustrate (Zhong et al 1993, Marca 1987) the difference between traditional and new way of doing it. This example of setting the proce for tender is similar in both types of contracts (bid&build versus design&construct).

TRADITIONAL, STRAIGHT AHEAD



MODEL BASED, ALTERNATIVES AND ANALYSIS



5. MIGRATION STRATEGY TO MODEL BASED COSTE ENGINEERING

Development path

The basis for accurate cost and value engineering is accurate measures of the site activities; materail, labour and equipment. This work must be done before development any software package. Actually this is very hard task to do and requires quit a lot manpower. In that sence even construction companys can be called reseachres. The result is recepies for buildig parts and modules. This development started in 91.

Model based cost and value engineering development started in 93. The chosen environment for YIT was Design ++. By that time we started also to create the library of approved technical solutions. This tool is suitable for both types of contracts, but more useful in design&contract.

In COCON (Eureka 1077) project, a full scale pilot using the product model approach started in 94. The environment is descriped later in this paper. This is the first time (at least in Finland) when all actors are using product modelling (Design ++ as a basic system). The target for YIT is to achieve capabilities to use the cost estimation package already in the early phases of the building process (Fig. 6.1).

There are plans how to utilize the product model in later projects. This is illustrated in figure 5.2. This is another viewpoin to case based reasoning (Schmitt 93). In this approach different types of buildings are starting point.

Figure 5.1 shows the migration towards the total integration of design phase (in future the product data model will be produced by designers) and production planning (tendering system is the basis of model based production planning, see also fig. 6.1) (Tarandi 1993)

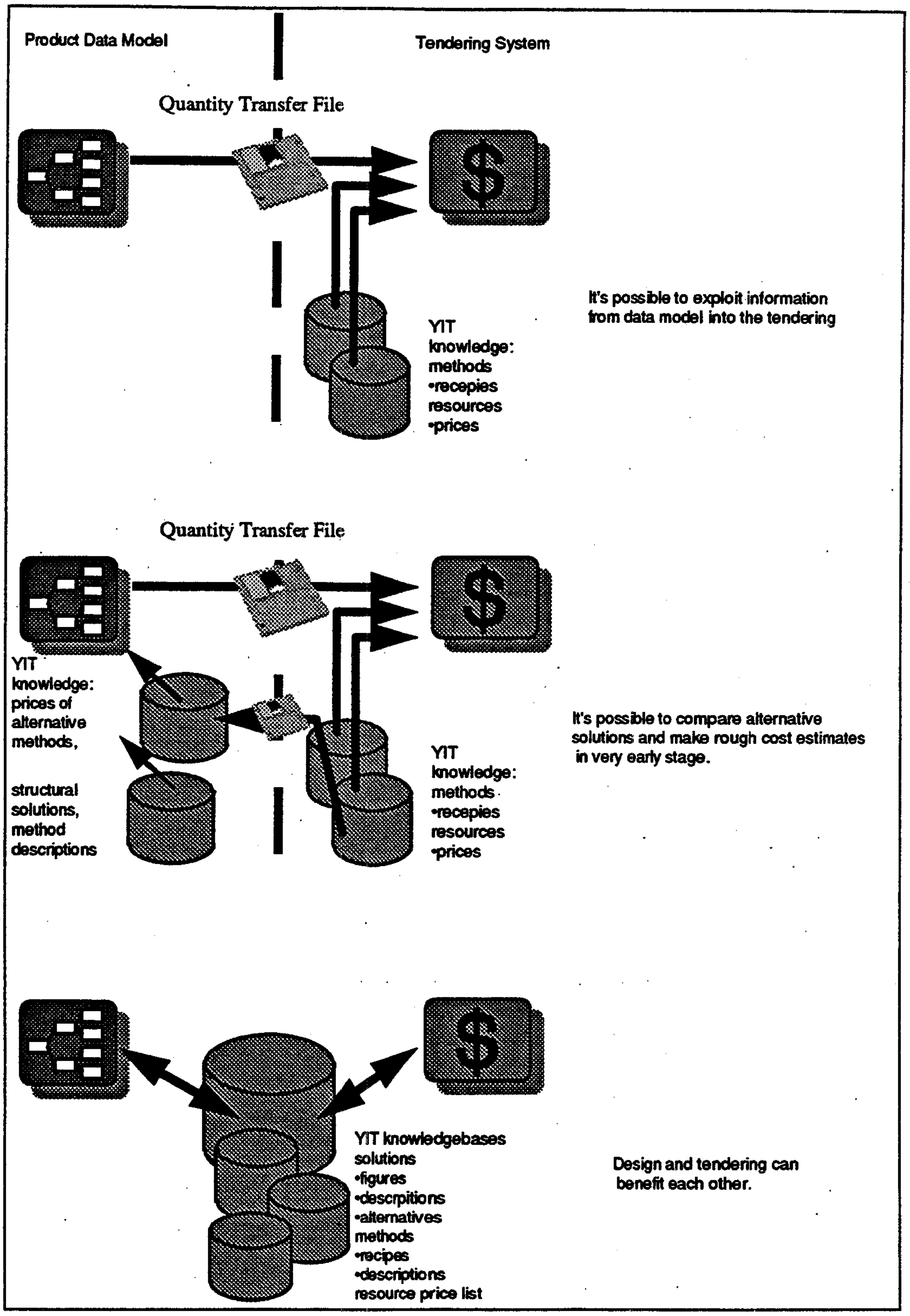


Figure 5.1 Migration strategy towards model based cost engineering and production planning

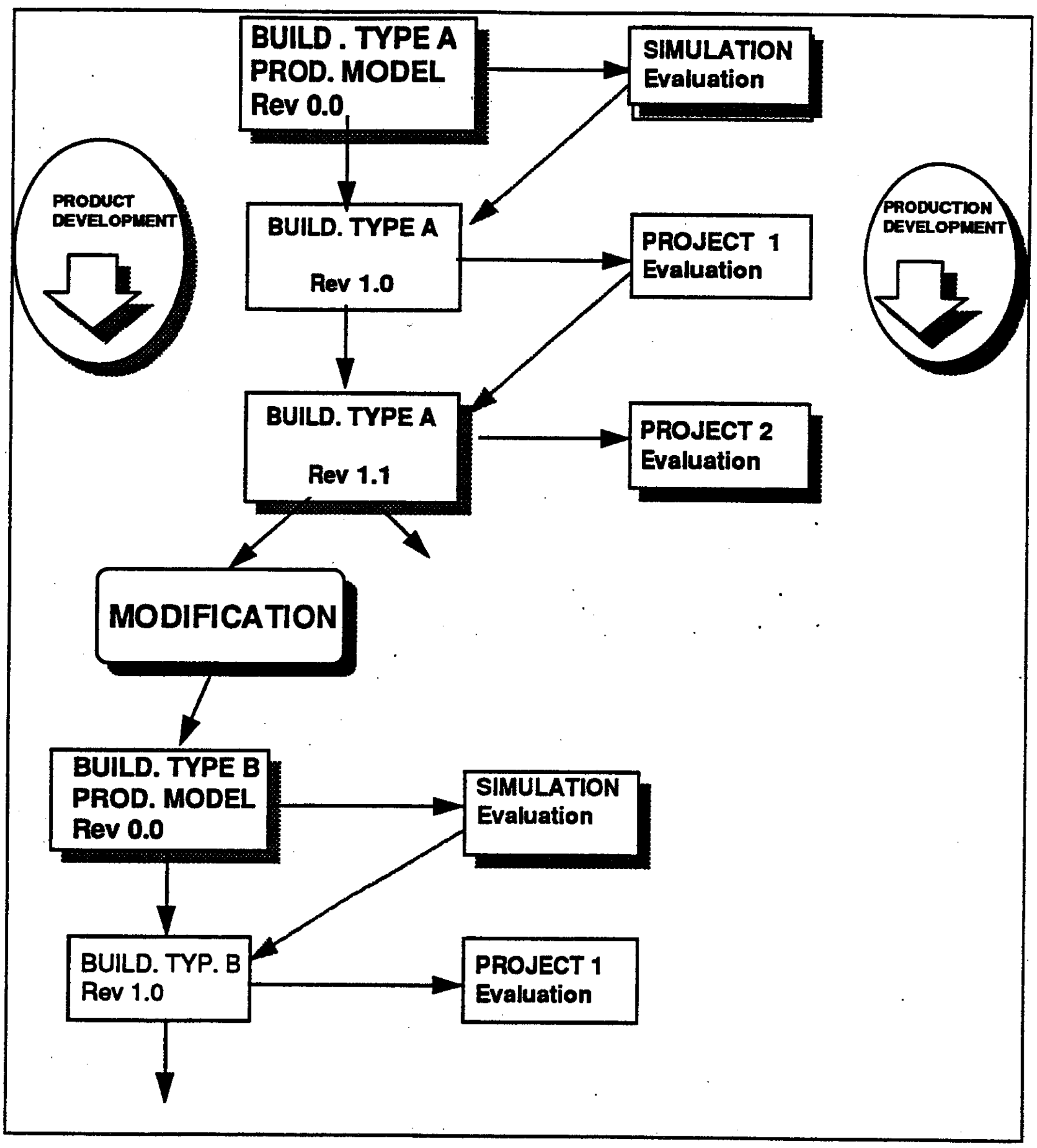


Figure 5.2 Evolution process of building types and the use product model after modification.

6. PILOT ENVIRONMENT

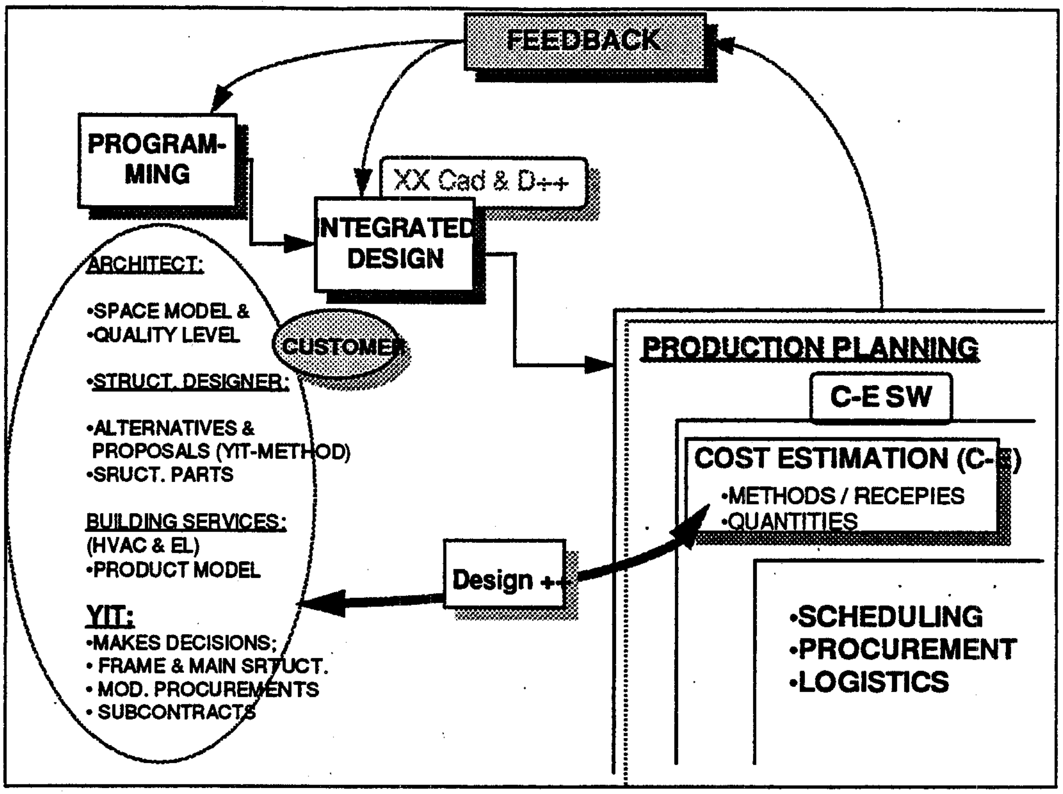


Figure 6.1 Illustration of the target situation in the COCON-Eureka pilot project

At this point (6/95) the models of designers have been built and transferred into contractor's (YIT) production model (Fig. 7.2). From there the information have been transferred directly to the cost estimation package.

The development work have been difficult but so far the results seems to be positive. In the next pilot we try to use the same product model as a basis and measure what we have learnt.

7. THE DATA EXCHANGE PARADIGM

The data exchange paradigm is based on the following principles (Hannus et al. 1994), see figure 7.1:

1. The focus of standardisation should be shifted from specific, application-dependent definitions to the fundamental architecture of AEC product models (generic data structures, etc.).

2. A common core model should be defined and be a small set of tangible entities shared by "several" AEC applications.

3. A built-in mapping mechanism is needed to map application specific entities to the core.

4. The application domain models and the core model should be based on a common meta-model which provides all more specific model with common generic data structures.

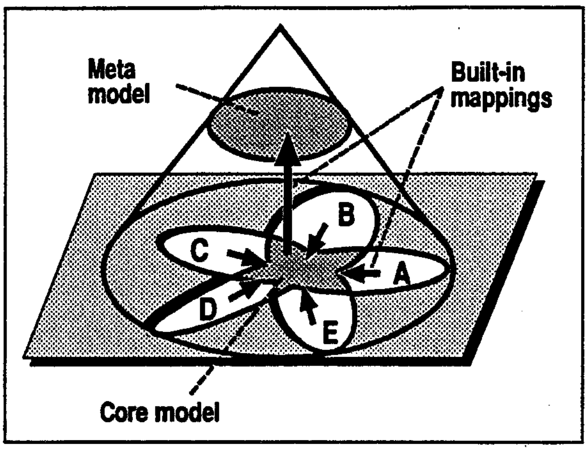


Fig.7.1. Data sharing via common core and meta-models with built-in mappings (Hannus et al. 1994).

The data exchange paradigm of the COCON project complies in general well to the principles described above. However, it should be noted that the compliance is still on a quite project-specific low level. In COCON the system architecture works as follows (see also figure 7.1):

- A common core model: Each partner uses class libraries common to all of the partner-specific applications. The individual applications use specialisations by incorporating super-class links of a dynamic nature, i.e. these may be incorporated on instance level. In the data exchange situation all partner-specific super-class links are disconnected and only data compatible with the common class-libraries is exported.
- Meta model: the model data is in the data exchange situation mapped to the data structures in accordance with the meta-model. The mapping is implemented in the export and import routine parsers of each partner's application.

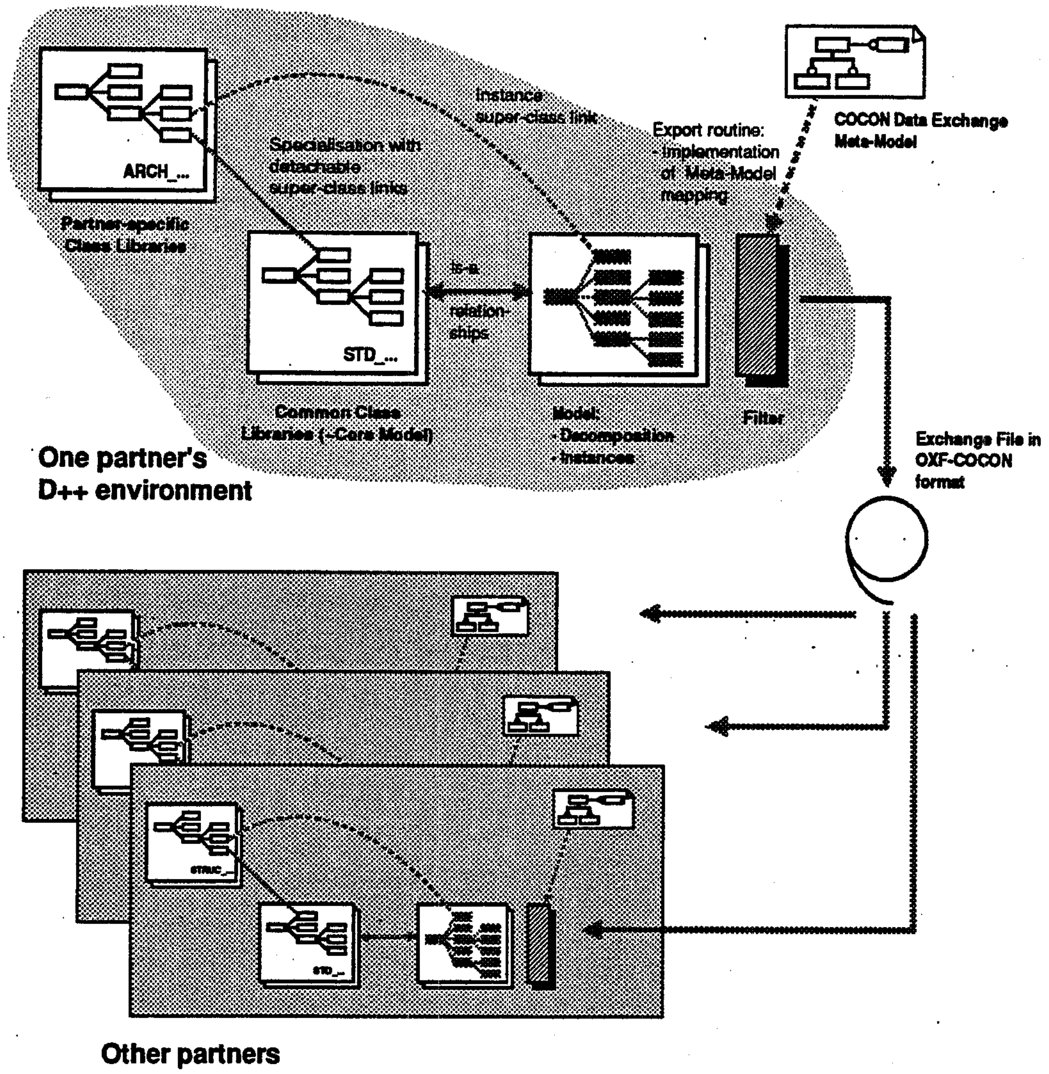


Fig. 7.2 The data exchange architecture used in the COCON project.

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