

THE COST ESTIMATING AS THE INTEGRATOR BETWEEN DESIGN AND PRODUCTION

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ABSTRACT

Generally, the cost estimating is the first process where the design information meet the production information. It is very important that this integration succeeds; otherwise the same procedures are carried out several times while wasting resources. If the cost estimating processes and tools are well designed, the production planning, the procurement, the purchasing and the management tasks can both utilise and enrich the information produced on the design and the cost estimating phases. The focus of this paper is on the conceptual models of cost estimating tools and it is based on the research work and experiences collected during the last decade in Finland.

Keywords: Conceptual model, product model, production model, cost estimating, production planning, activity planning

1. BACKGROUND AND STATE-OF-THE-ART

The cost estimating is the first process in production planning. The meaning of cost estimation is examining the designs. Therefore cost estimators get acquainted with specifications, drawings and other documents, and transfer them to bills of quantities and cost estimations. The cost estimation is the basis not only for tendering and the budgeting but also for the production planning and the management (Talo 90 1994).

Generally, the cost estimating process is divided to two sub-processes. The first of them is quantity surveying and the other is pricing the bill of quantities. Some studies in Finland proved that the quantity surveying takes 50...70 % of the whole cost estimating effort (Myllymäki 1991).

In the following text are some of the main cost estimating techniques explained. The focus are on the conceptual models; how the cost estimating tools have developed and what is the existing basis of the future development efforts.

1.1 The Bill of Quantities and the Cost Item Based Pricing

The basis of cost estimation is always some kind of bill of quantities. The detail level of bill of quantities depends on the cost estimating methodology used. Item of bill of quantities can be equivalent to component or element in cost & value engineering or work section in traditional cost estimating or even resource. The most simple method to price the bill of quantity is multiply the quantity of every item with unit price and then sum up these numbers.



More detailed method for pricing is cost item-based pricing. Every item of the bill of quantities has several unit prices, for example for labour costs, material costs, subcontract costs etc. The quantity of item is multiplied with these unit prices and results are summed up. This method tells more about the content of every item but not very much. Cost item-based pricing is used in experience-based one-of-kind cost estimation, without any knowledgebases.

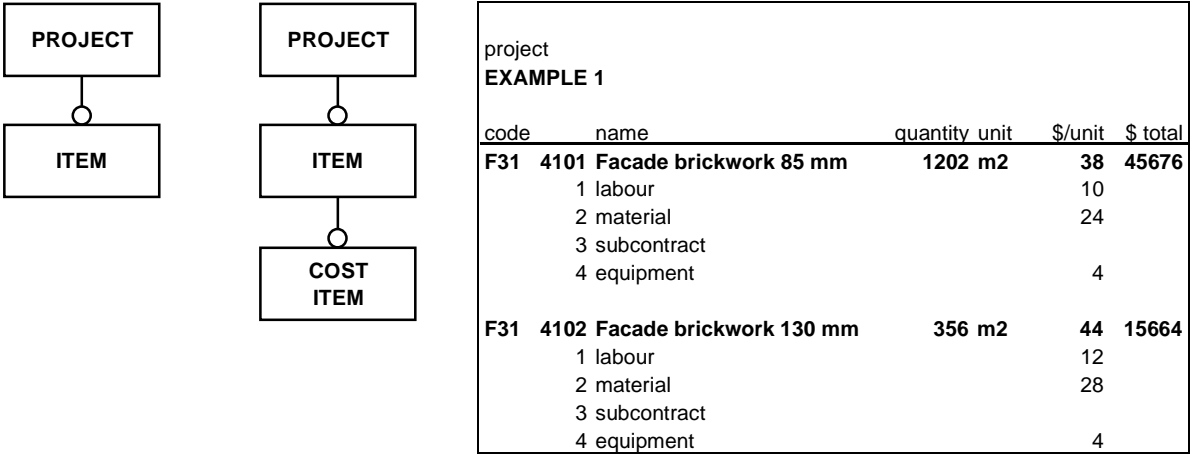


Figure 1. The conceptual models of bill of quantity (left) and the cost estimating tool based on cost item pricing. The example (right) shows how every cost item is priced by using cost items.

1.2 The Resource Based Pricing

The need of more reliable and knowledge-based cost estimates led to the resource based pricing. The resource structure, "recipe", was composed for every item in the bill of quantities. This kind of operation needs the resource libraries, which include labour, material, subcontracting and equipment resources. The source of the labour cost was the payroll calculation, the material and the subcontracting costs came from the long or short term contracts, the offers and the supplier's product price lists.

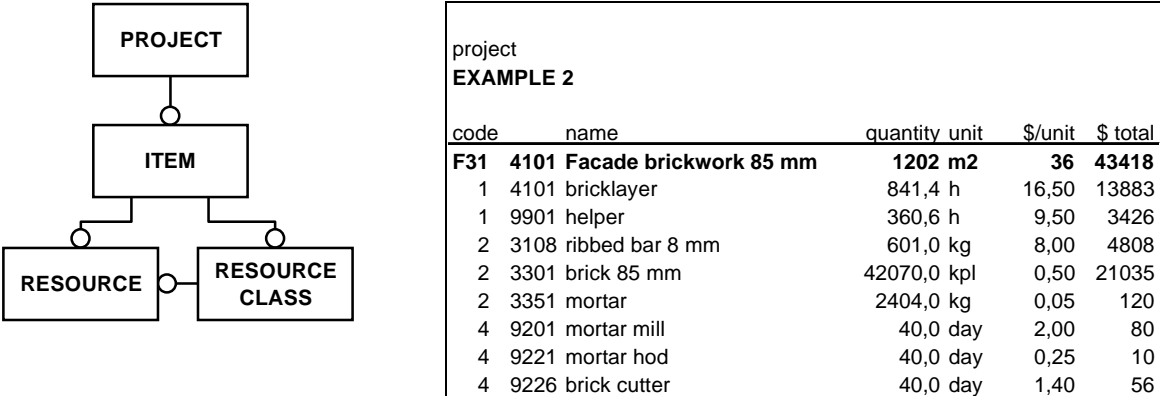


Figure 2. The conceptual model of the cost estimating tool based on the resource pricing (left). The example (right) shows how item is priced by using resources.

In the first stage cost estimators picked resources from the resource library one by one for every item in the bill of quantities. Later they prepared resource structures, "recipes", in the method libraries. Since the detail level of the bills of quantities and the method libraries should be quite same, was the compliance with the existing standards like Rakennus-ATK and later Talo 70 and Talo 80 systems a good idea. These systems standardised both the detailing level of the bill of quantity and the coding of the items in the bill. These systems also allowed the resource based pricing and even the element based cost estimating.

1.3 The Element-Based Cost Estimating

Where the cost items and the resources focus on pricing, the use of the element focus on the quantity surveying. The need for boosting the quantity surveying by developing the design practices led to the element based cost estimating. First the elements and their structures were used to produce the bill of quantities where the detailing was work section because the Talo 80 system was based on work sections. Therefore the value of the element based cost estimating was not very high. With the Talo 90 system the element in the cost estimating got an independent status.

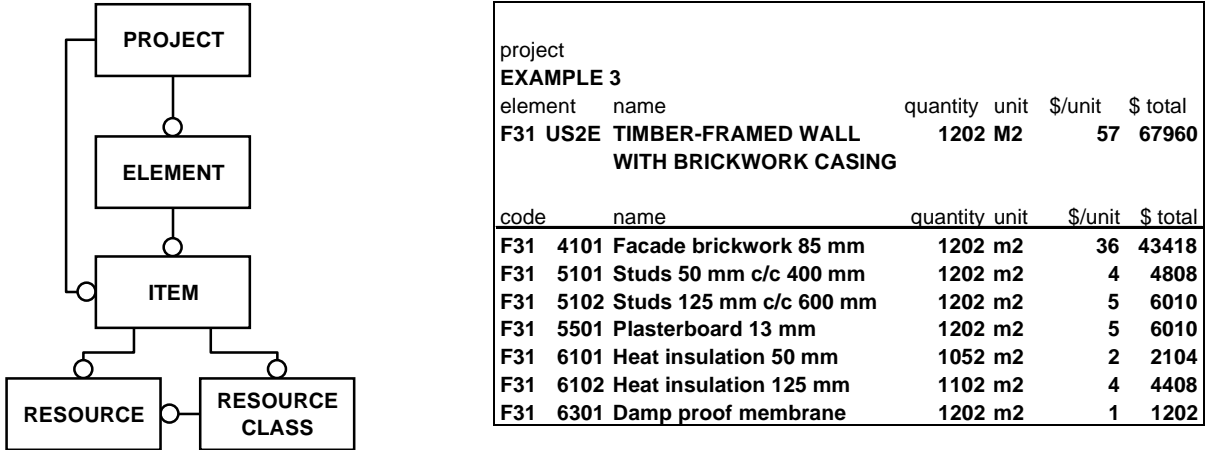


Figure 3. The conceptual model of the cost estimating tool based on the element structures (left). The example (right) shows how an element consists of items (work sections). How an item consists of resources can be shown in figure 2. The element is visualised in figure 4.

Although the range of the elements' technical solutions is very wide it is possible to prepare the element structures in the element library for general use. The direct suitability of the pre-made structures is limited but it is possible to fit them one by one when needed.

In the element based cost estimating the basis of the quantity surveying is the bill of elements. The production structure is build up for every separate element. The production structure consists of the work sections, which symbolize the stages needed for the ready part of the building. Furthermore, every work section can be priced by using either the cost items or the resources.

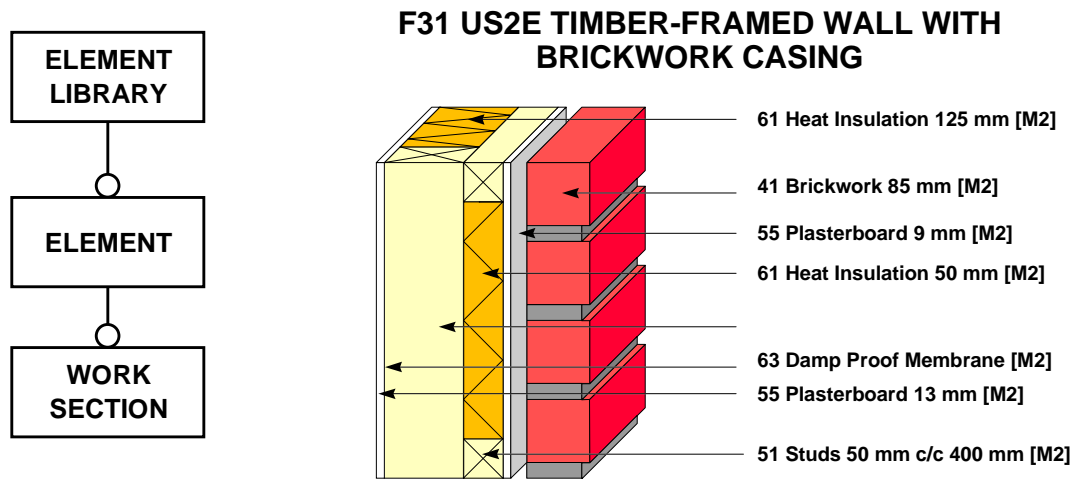


Figure 3. The conceptual model of the element library (left). In the visualization (right) the element (F31 is a Talo 90 element code and it means an exterior wall, US2E is an inhouse code for this technical solution) is composed of work sections.

The element based cost estimating was under research 1985-90. One of the first notices was that the element based cost estimating boosted cost estimating. On the other hand, the cost estimator could produce with element structures bill of quantities consist of mass of work sections and resources very rapidly and the result was very difficult to check; it looked very reliable but could be nonsense.

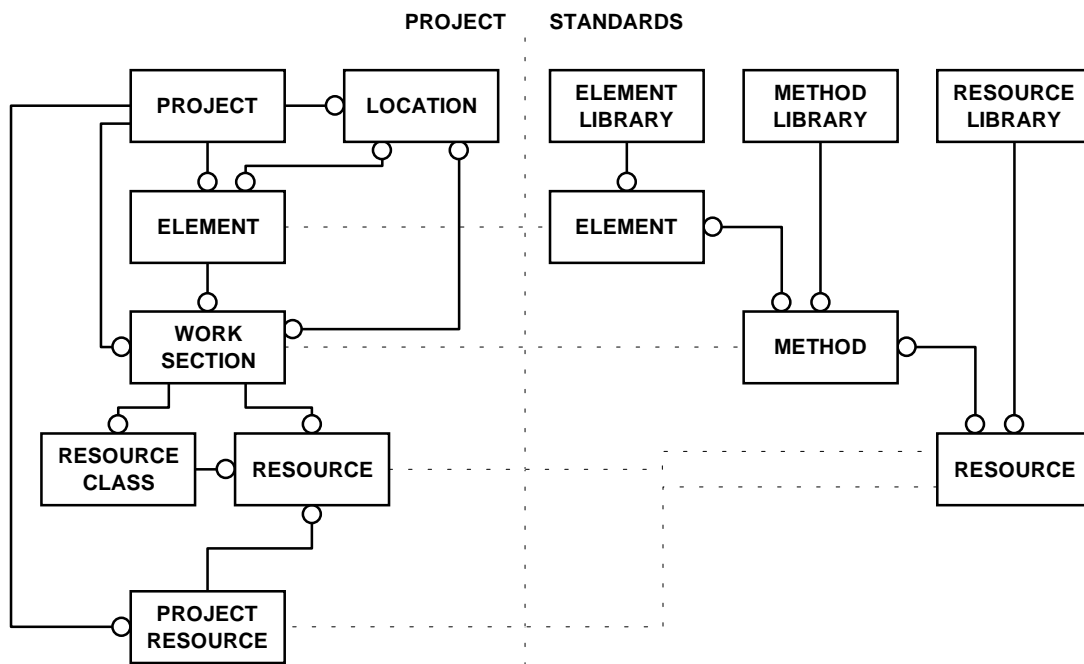


Figure 5. The conceptual model of YIT's cost estimating and tendering tool Tarmo, boosted by element, method and resource databases (Myllymäki et al 1997). Tarmo's conceptual model represents here all existing cost estimating tools as the state-of-the-art.

2. PRESENT CHALLENGES

Need to manage the information flow through the building process from the briefing to the maintenance has laid down challenges for the people who are developing the building processes and tools for them. If the cost estimating process has carried out as before and it supports only budgeting and tendering, a quite large deal of the work needed in the production planning has to be done afterwards. Therefore not only the cost estimating process but also the cost estimating tools need rethinking. The cost estimating process is a part of greater building process and it must benefit not only the budgeting and the tendering but also the design management, the production planning, the production management, the procurement, the purchasing and even the delivering.

Generally, there can be seen three major different views which have impact on the structure of the cost estimating and the production planning (Oinas et al. 1998).

2.1 Design view

Since the design phase produces the model of the building and the model consists of components, the design view should be based on components. Component can be spatial, structural or HVAC element. The mass of components must be grouped by several factors (e.g. component type, location, Talo 90 element code etc.) and the information concerning component locations and relationship should be utilized.

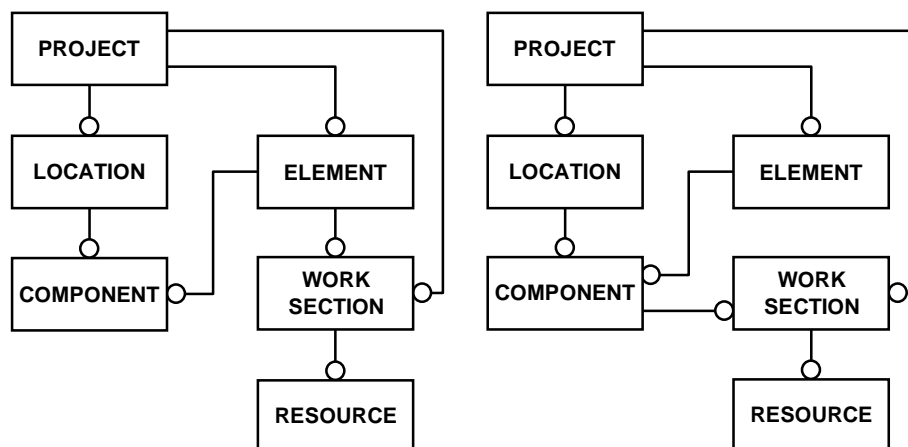


Figure 6. Two simple conceptual models where the product model (location & components) and the element based cost estimating (the element are used as the component class) are combined.

2.2 Construction view

Every component (or element) has a production structure which consists of the work sections. Every work section is based on one method, picked from the method library (pre-made) or planned uniquely. So, there is the bill of work sections and the work sections belong to separate components.

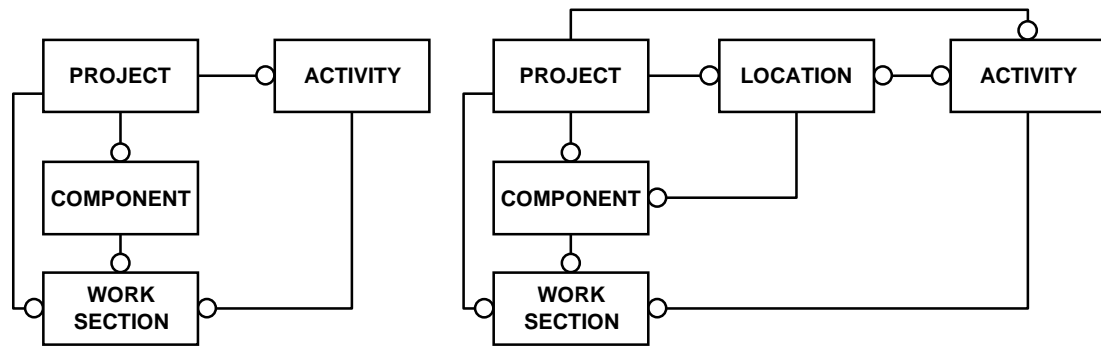


Figure 7. The bill of work sections can be grouped by activities (left) but the wider scope of the production planning (right) shows the needs for the cost estimating tool.

Activities are basis for production planning. The content (work, material and sub-contracting resources) of every activity should be planned and activities must be scheduled. Modern scheduling is based on activities and their locations (=blocks). This kind of production planning produces well basic data for purchasing tasks and makes the total cost forecasting and cost monitoring easier. So, the activities are the most important factors on the construction view.

2.3 Procurement view

The aim of the procurement is to purchase the material as low priced as possible and supply them to the construction site with the right quality and quantity at the right time. If the material needs are known beforehand, it is possible to negotiate short or long period contracts with good terms. So, the procurement needs rather rough information on the briefing, the design or the cost estimating phase; the purchasing tasks need quite exact and detailed information on the sufficient early phase. If the detailing level in the cost estimation (resources) is approximately same than in the procurement (products on suppliers' catalogs), the management of the information flow from the cost estimating through the production planning to the procurement is easier.

Logistics on the project level belongs without doubt to production planning activities but logistics on the enterprise level belongs to procurement activities. Therefore both the project and the enterprise level logistics have been included in procurement's view. In the project level logistics the material needs are grouped and shared so that material lots can be delivered in the right position at the right time. On the other hand, the material need arrives in purchasing activities so early that both contractor) and the supplier has enough time for their tasks (call for tenders, tender comparing, contract negotiations, ordering, order handling, production and delivering). If the material lots are small, there are several methods for boosting material transportation to construction site and receiving on the site (Tanskanen et al 1993, Wegelius et al 1996).

In the enterprise level logistics the material needs should be able to be grouped and summarized over projects. If that is possible, the procurement can centralize the deliveries to one or some supplier(s). The procurement can make annual, seasonal or regional contracts as a result of this operation and the total costs of these contracts are lower than distributed contracts. These large contracts can then be saved in the procurement databases as price lists and they can be used in the purchasing.

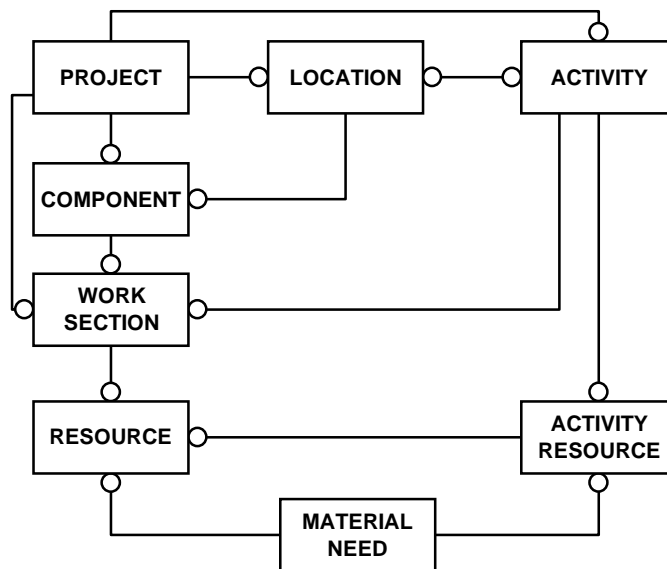


Figure 8. The material need can be drawn with the help of either cost estimation's or production plan's resources. In the latter case the delivery time is known too.

2.4 Other viewpoints

Some other viewpoints which affect the cost estimating are for example the client's viewpoint, the enterprise management's viewpoint and the green viewpoint.

The client's viewpoint is not clear since there are different kind of clients and customers in different kind of projects. Client can be representative of either itself, owner, user or group of users (e.g. housing association or realstate corporation). Some client's aspects are concerning the design (e.g. alternative solutions) but some are concerning the cost estimating. That kind of things are a tender which meets the client's positions and the alternative tenders.

The enterprise management's viewpoint focus on the management accounting and the enterprise resource planning. Both of them summarizes information from the projects and their information source is project's cost monitoring which is based on activity planning. So, the enterprise management's viewpoint has indirect impact on cost estimating (through activity planning).

The green viewpoint consists of several aspects. Some of them (e.g. material recycling, materials' energy content) can be taken into consideration via cost estimating on the resource level but some (e.g. life cycle economy) should be rather taken into consideration in design management.

3. CONCEPTUAL MODEL OF THE FUTURE COST ESTIMATING TOOL

3.1 Background

The bases of this paper are current PROPLAN which is a project in Finnish VERA technology programme, the former Eureka project COCON and YIT's inhouse Tarmo project. YIT has developed design and planning tools and methodologies in these projects (Laitinen 1995, Siipola 1995, Oinas 1997). However, the product models and the integration between design

and construction has been a quite interesting research area during last years in several countries (Jägbeck 1996, Kim et al 1996).

The focus of construction area's information technology research and development work has been on the information flow and management from the design management to purchasing. With COVE (Cost and Value Engineering) system it is possible to build up a product model, analyse and prepare it and transfer the information via cost estimating and production planning to procurement and purchasing activities.

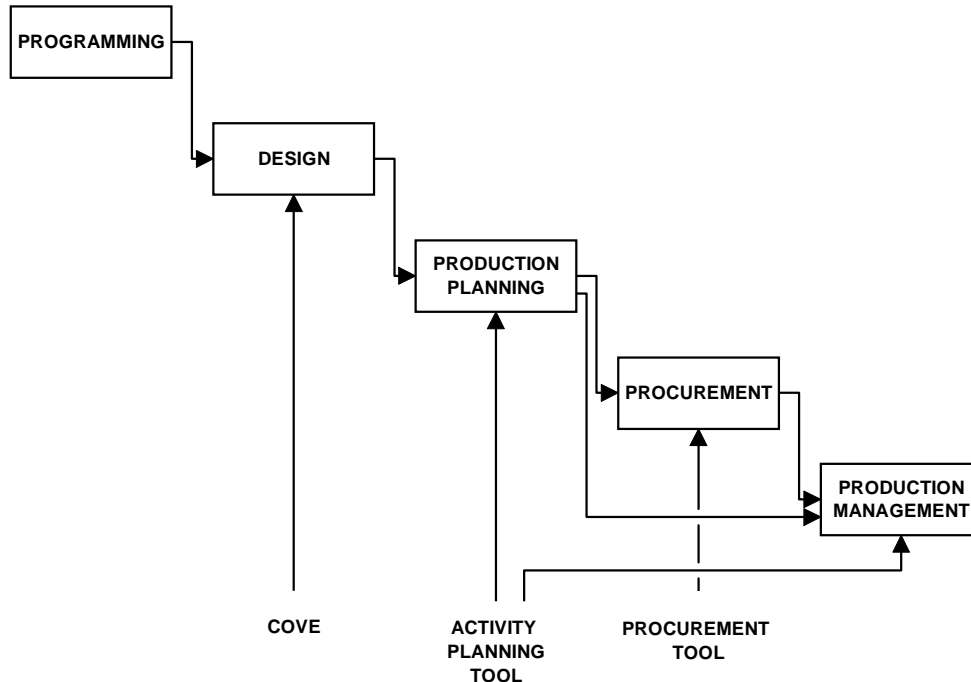


Figure 9. YIT's major development efforts focus on design, production planning & management and procurement and their tools.

3.2 Component - work section - resource solution

Probably the most straightforward way to meet most of the needs presented in chapter 2 is using component - work section - resource tree (figure 10). The design management system like COVE writes component, work section and location information directly to the project database and the model is completed by copying the recipes from the method database and resources from the resource database. Every component has a location and work sections and resources can inherit their component's location. When work sections are linked to activities, it is quite easy to allocate activities' resources to locations in order to set the material needs to the delivery lots.

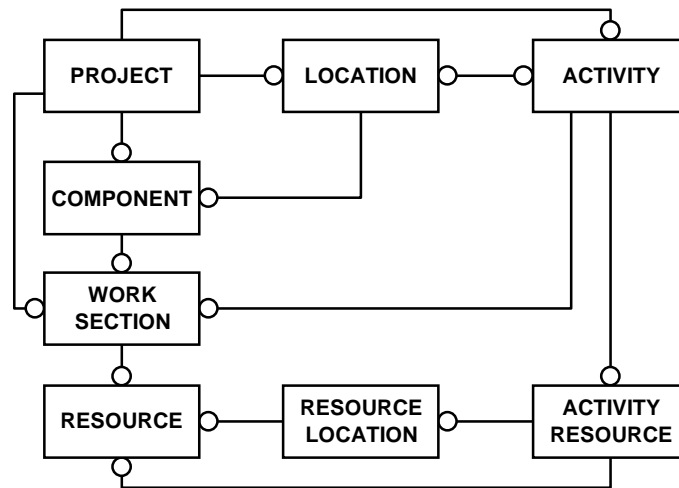


Figure 10. The straight component - work section - resource tree is too operose.

On the other hand, all changes in work sections' resource structures are possible but difficult to do since the knowledgebase's methods are used several times. If the Cove's product model contains 5000...10000 components, each of them approximately 5 work sections and each of them approximately 5 resources, the project database contains 25..50000 work sections and 125..250000 resources. The access times will grow too long and the database is too operose to handle.

3.3 Component - work section & method - resource solution

The harmonization of design management system's component libraries and cost estimating system's method database made creating links between components' work sections and methods possible. Therefore methods and their recipes can be copied to the project database. Work sections are still linked to methods but these methods lies in the project database; work sections are not completed by forming a resource structure for everyone of them (figure 11).

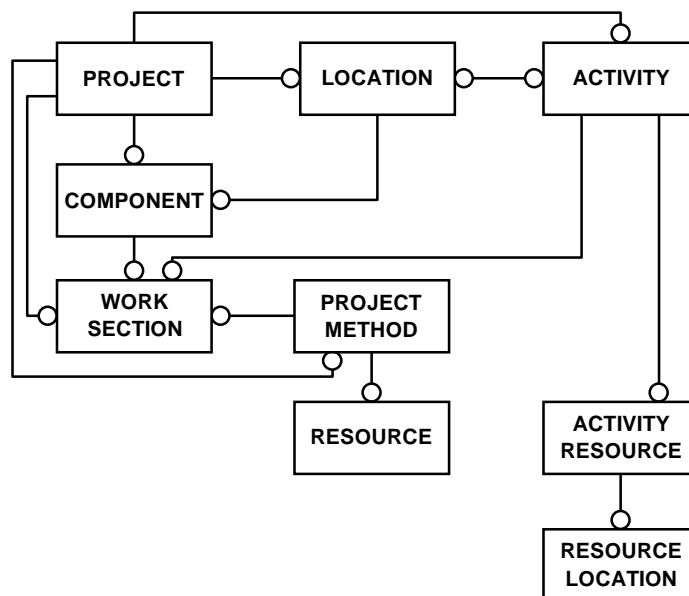


Figure 11. Component - work section & method - resource combination is too difficult to calculate.

Method changes are easy to do since work sections are linked to project methods. Activity resources' and their locations' quantities calculation is possible but operose to do since all the calculations must be done through work sections. This makes this solution almost impossible.

3.4 Final solution

The direct link between activity resource and work section resource is justified in order to make production planning throught activities easy. On the other hand, changes of work sections' recipe are easy if used methods are copied from method database to project and linked to equivalent work sections. Both views can be taken into consideration (figure 12).

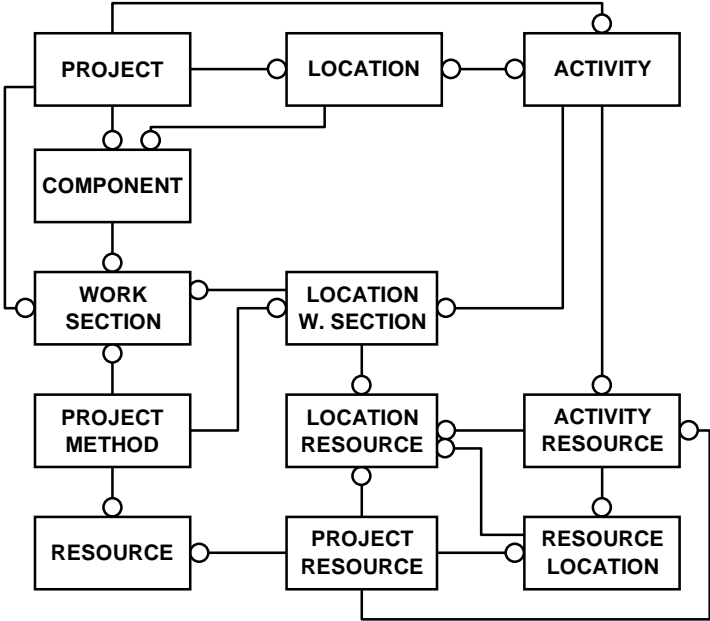


Figure 12. Both the direct link between the activity resource and the work section's resource and easy changes with the project method have been carried out in the final solution by forming the work section and the resource sums for every location.

This solution is used in two phases: after the design management system has written components, work sections and locations in the project database, the methods with their recipes are copied from method database, used resources to project resources from resource database and then methods' recipe's resources are linked to project resources. On this phase all changes and modifications can be made on the project methods. On the phase two when the list of activities and locations are prepared, the work sections are simplified and summed to location work section and resources to location resources. After that, location work sections will be linked to activities. The activity resources are computed from location resources through activities and their location work sections.

This solution enables

- flexible method modifications (recipe changing, resource adding/deleting, changing the resource consumption) until location work sections are established; after that the modifications are still possible but more difficult
- independently living of the product model, the cost estimate and the activity plan on the design and production planning phases since there are no direct links between components (and their work sections) and activities, the product model. However, the relationships between them are quite easy to maintain
- easy resource cost changing and transferring to the project since all resources are linked to project resources
- both product model-based and traditional cost estimating in same database with different tools.

The final solution is more complex than the previous solutions (chapter 3.2-3.3) but its degree of complexity departs not from the other production planning tools available on the market. The complexity offer possibilities to apply the final solution to different kind of needs.

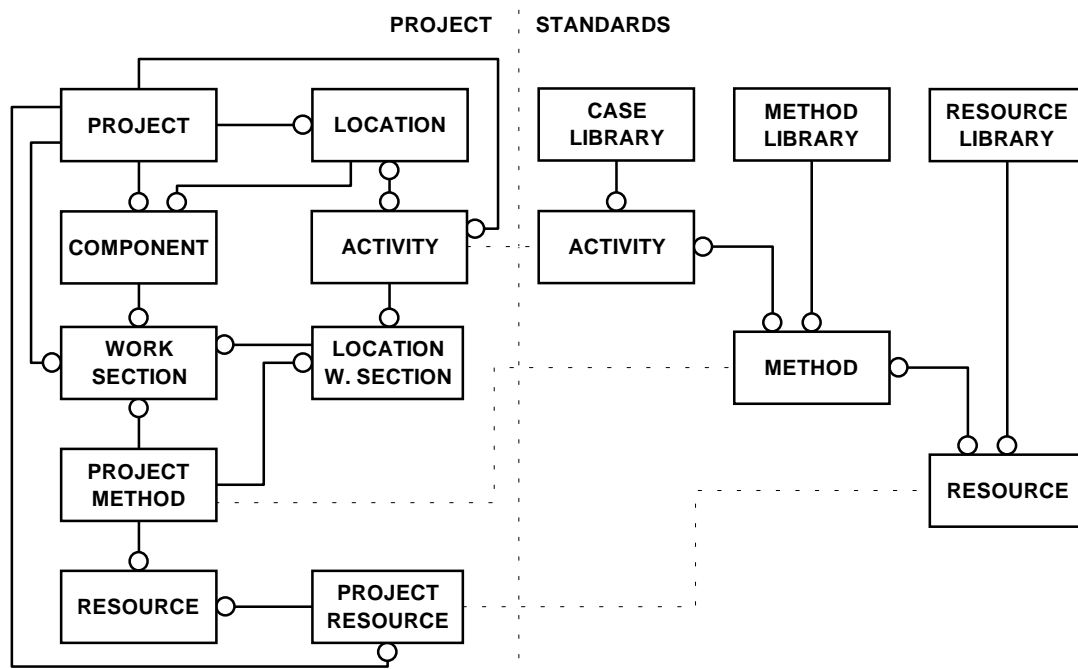


Figure 13. The conceptual model of the future cost estimating tool. The knowledgebases are taken into consideration.

CONCLUSION

The cost estimating plays an important role between design and production. Therefore both design and production viewpoints must be taken into consideration during the development of cost estimating tools. This paper shows that it is possible to include them in the conceptual model of the cost estimating tool. A condition of the successful tool is a serviceable conceptual model.

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