Electronic Planning Tools for Tower Cranes

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Abstract
The right tower crane operated correctly allows the contractor to build quickly and cheaply. The choice of a tower crane is a complex matter. Many variables have to be discussed at an early stage. The Eindhoven University of Technology is conducting three research projects to develop a set of tools to help the contractor choose and use tower cranes.
In order to choose and hire the right tower crane for a certain building process a selection model has been developed which can be used via the Internet.
To give an idea of how a certain crane works, a computer program has been developed to simulate the crane processes. This tower crane simulator shows the virtual construction site, the building, the building elements and the crane.
To make the most of crane time during a project, measurements and observations are performed on the construction site. The questions comprise: "What are the operating times of the crane?" and "What is the quality of communication between the crane driver and the site manager?". A day schedule with an electronic job-sheet has been developed to optimize communication.
This paper describes the interim results of these three research projects.

1 Introduction

Some time ago, the Eindhoven University of Technology began three research projects designed to develop a set of tools to help the contractor choose and use tower cranes. The tools are necessary for designing the construction process and for achieving an efficient production process. The strategy of these projects was to use information technologies in the development of the tools. This paper presents the interim results of these three projects.

2 Designing a construction process

In the construction of a building, three phases can be distinguished:
- designing the building;
- designing the construction process;
- producing the building. [1]

These three phases are illustrated in Figure 1 using the IDEF0 method.

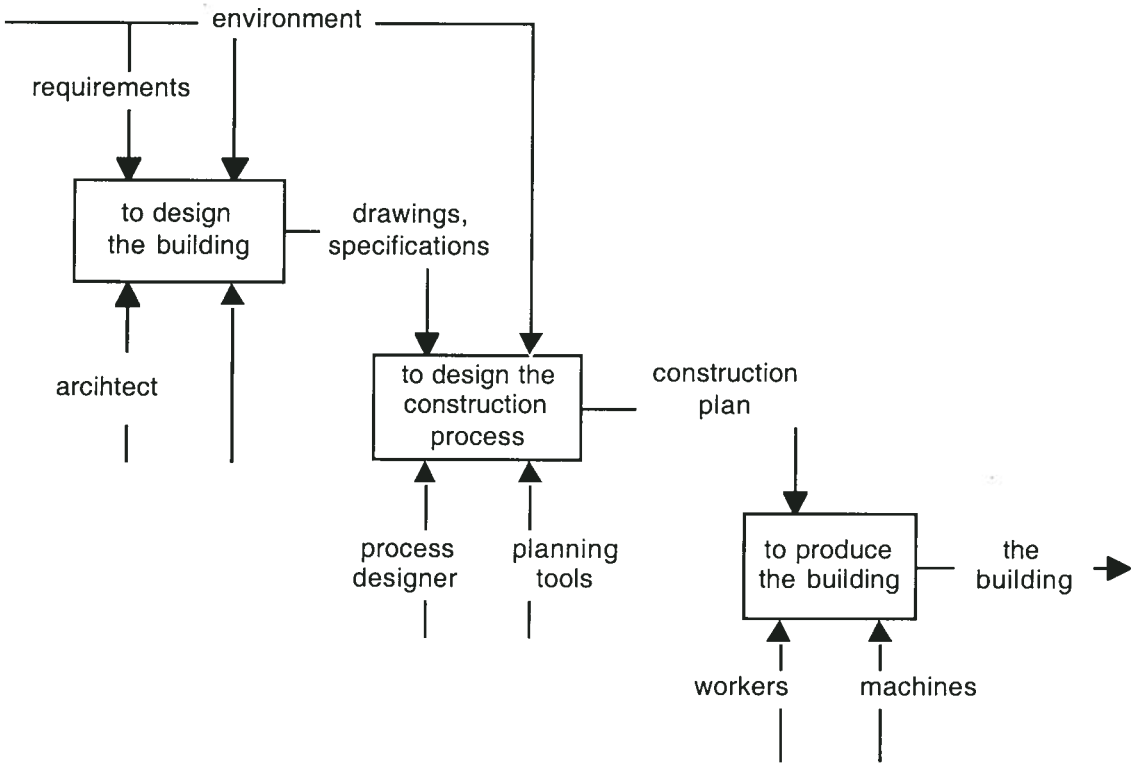

Figure 1 *Three phases in the construction of a building.*

In this paper, we are interested in the result of the second phase: designing the construction process. The process designer draws up a construction plan on basis of: the drawings, the specifications, the situation and the capacity of personnel, machines and materials. The design is a complex and prerequisite process of analysing data, designing and choosing solutions, and reports the results in a construction plan.
A set of tools is required to help the process designer create the best possible construction plan. The tools are developed with the aid of various information technologies. This paper reports on the results of the developing of a set of tools for choosing tower cranes.

3 Crane planning tools

The right tower crane operated correctly allows the contractor to build quickly and cheaply. The choice of a tower crane is a complex issue. Many variables have to be discussed at an early stage. The use of a certain crane has financial consequences in securing an order. When the building process is underway, it is also important to use the available crane time as much as possible to reduce production costs and time.
To help the contractor with this, three planning tools are being developed.
These tools are:

- an Internet choice model;
- a simulator;
- an electronic job-sheet.

In Figure 2 shows the relationships between these three tools.
Ito and Kano [2] are developing a 3-D graphical simulation for crane planning using object-oriented building product models. The three tools in this paper are independent of the building components:
The following paragraphs present the tentative results of these three developments.

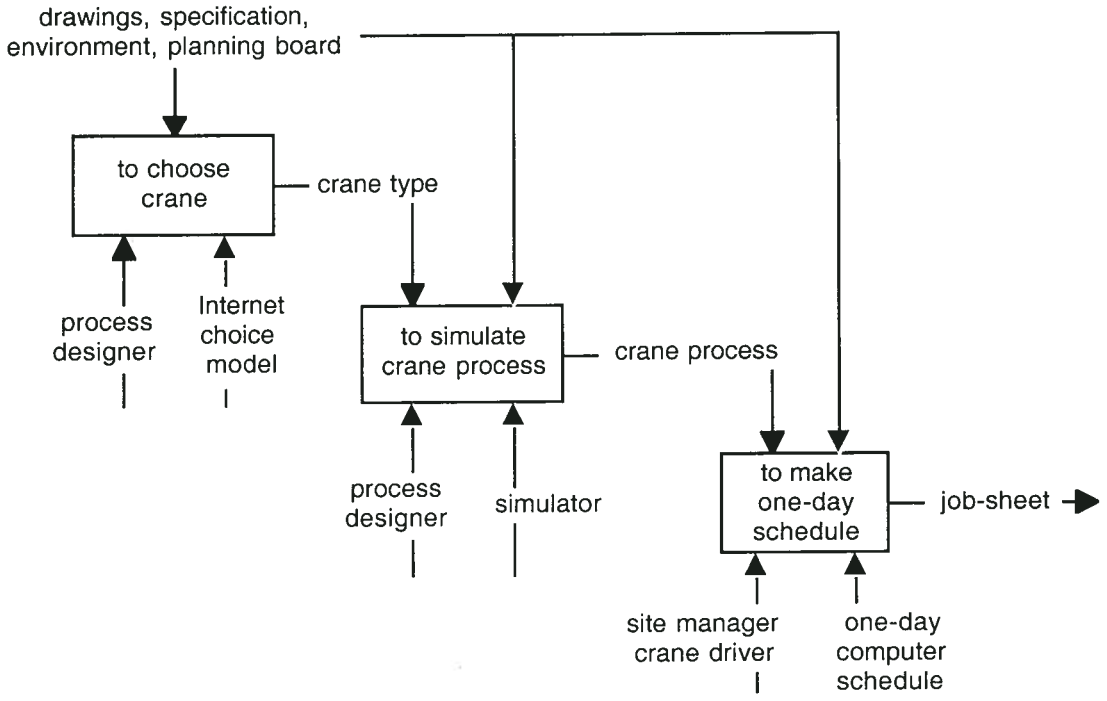

Figure 2 *Relationships between the three planning tools.*

4 Internet choice model

The objective of this project was to design a structure on the Internet with which the process designers and the crane rental firms can communicate. See Figure 3.
Van Dijk [3] first developed an expert system to come up with a crane profile. This expert system can be integrated on the Internet. The expert system is used to generate a flow chart. See Figure 4.

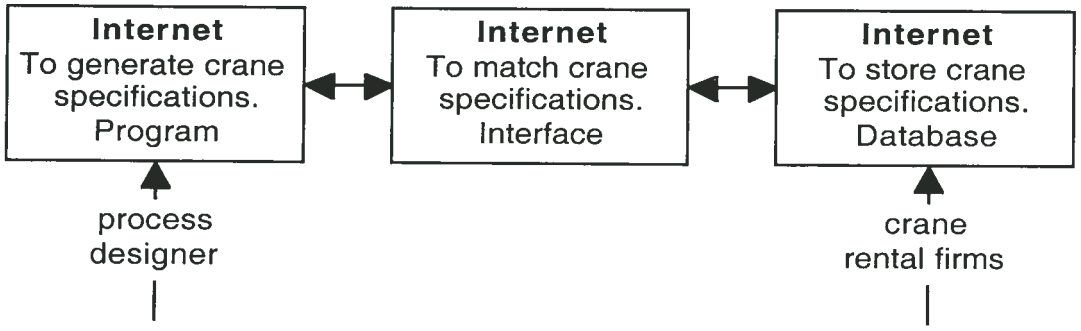

Figure 3 *The Internet and crane choice.*

Once the crane profile is known, the Internet tries to match tower cranes with crane rental firms. These firms describe their tower cranes using a special format on The Internet. The result is a list of tower cranes from which the process designer can make his choice. Van Dijk has put a dummy version on the Internet.
The following step in this research project is to write the computer program. The data and crane specifications has to be structured in a database.

5 Simulation of crane processes

Jessurun [4] has built a test simulator to simulate the crane processes and their environment. With the help of the simulator, the process designer can:
- evaluate alternative crane processes;
- see where the problems are;
- provide the principal with building information;
- see what problems the crane driver will encounter;
- draw up a detailed schedule.

The crane processes are described in an adapted IDEF0 language. The dVISE system is used to implement the simulator. dVISE is an interactive Virtual Reality (VR) designing system. A script language is used to read the information for the simulator. The syntax of the TS script is based on the dVise VDI files.

One problem that occurred was that the simulation times take some weeks, which is too long for the process designer. A concept was developed to go straight to the point where the process designer evaluates the crane process.

The following developments are required:
- To put the information into the simulator, three programs are necessary: construction site program, a building design program and a building process program.
- A user-friendly representation of the result of the simulation and not in figures.
- A simulation with more than one tower crane.
- A better way to describe the processes of the tower crane.

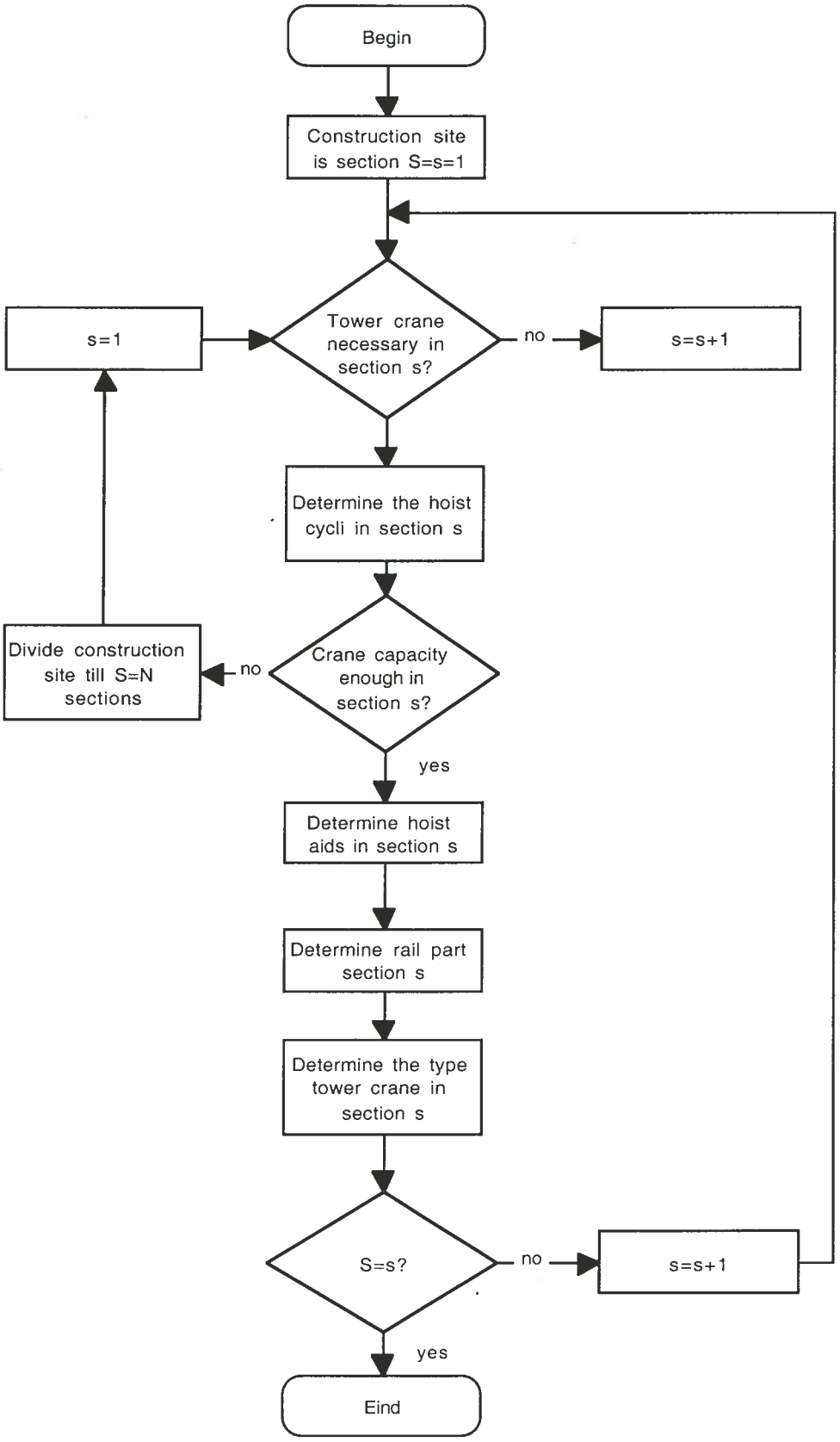

Figure 4 *Crane choice flow chart.*

6 Electronic job-sheet

The objective of this research project was to increase the efficiency of the tower crane by increasing the quality of the information transfer between the crane driver and the site manager.
Overveld and Van der Sanden [5] measured the productivity of two tower cranes on a construction site. See Table 1 for the results of these measurements. The inefficient productivity rate of 9,9% should decrease by achieving better communication between site manager and the tower crane driver.

Table 1 Measurements results.

Productivity	[%]
efficient productivity	43,6
inefficient productivity[1]	9,9
non-productivity	46,5

[1] Inefficient productive means that the hoists were not useful or were not necessary.

Inefficient productivity	[%]
Transporting materials	5,8
Waiting	3,6
Wrong materials	0,5

Non-productivity	[%]
No job	31
Climbing the crane	2
Break	9,5
Waiting till picking	3
Miscellaneous	1

Overveld and Van der Sanden measured also the information transfer between the crane driver and the site manager. Results were:
- 14% of the information transfers by walkie-talkie was poor.
- 20% of the information transfers were incomplete.

A one-day computer schedule is developed to increase the productivity of the tower crane by increasing the quality of the communication between the crane driver and the site manager. The output of this schedule is displayed on a screen in the crane cabin: the electronic job-sheet. The crane driver is able to adjust his schedule for the current day.
The relationship between this one-day schedule and the long-term schedule is shown in diagram form in Figure 5.
The next stage in the research is to write the software program. The program of requirements, screens and flow charts are ready.

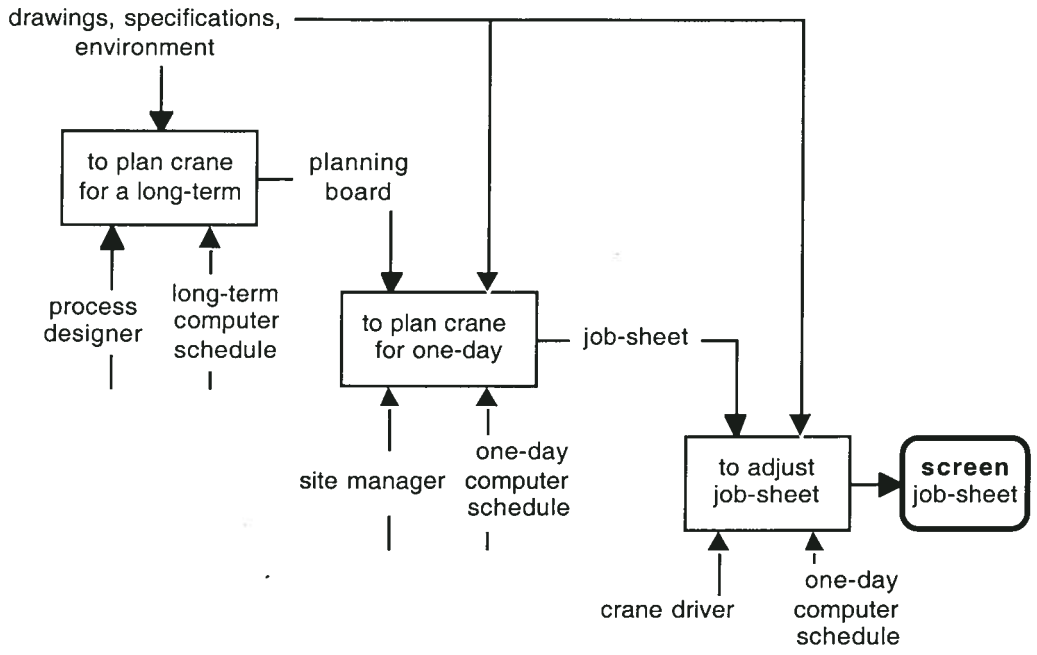

Figure 5 *Relationship between one-day and long-term schedule.*

7 Discussion

The three tools are developed independently of one other. The next stage in research is to find how to integrate them. The software must suitable for the contractor, process designer and site manager.
In the case of the Internet choice model, tower crane rental firms must find it worthwhile to put their tower cranes into the database.
The crane driver can be given a more important position, such as that of logistics manager for part of the building process.
This research is focused on tower cranes. It should be possible to use the structures of this research for other equipment as well.

8 References

[1] E. Leijten, E. Vastert en G. Maas, Construction planning re-design. In Sherif Mohammed (ed.): *Construction Process Re-engineering*, Griffith University, Queensland, Australia, 1997.
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[4] A.J. Jessurun, *Tower crane simulator*, Eindhoven University of Technology, 1997.
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