Cost and Schedule Controlling in Relation to Liquidity Management during Construction Projects

Martin Kopyto, University of Applied Sciences Giessen-Friedberg (martin.kopyto@bau.fh-giessen.de)

Armin Möller, HochTief Construction AG, Frankfurt (armin.moeller@hochtief.de)

Michael Petersen, CIP Engineering Consulting, Darmstadt (petersen@cip.de)

Joaquín Díaz, University of Applied Sciences Giessen-Friedberg (joaquin.diaz@bau.fh-giessen.de)

Summary

The present paper describes a software application which can be used for relating the scheduled events of a construction project with the respective financial parameters, leading to an overall improvement in general controlling and liquidity management. For this purpose, existing construction schedules are taken and details of the assignment are recorded. Thus it becomes possible to assess a future payment status should changes in the designated schedule occur.

1 Introduction

This paper was compiled as part of a technology transfer project involving the University of Applied Sciences Giessen-Friedberg, HOCHTIEF Construction plc and CIP Engineering Ltd. The main aim of the study was to develop a software application for controlling both costs and schedules. With the help of such an application, it becomes possible to survey cash flow in relation to deadlines and to assess the respective state of affairs regarding payment at any given point in time during the construction process. In this connection, the time schedule itself becomes an important tool in terms of controlling; it facilitates a consistent target/actual comparison and gives an indication of future developments regarding the construction process.

The cost and schedule controlling application provides cash flow reports which afford a continuous overview of incoming payments made by the principal, outgoing payments make to subcontractors, the respective balances and a prognosis regarding future liquidity. Critical shifts in the cash flow are made transparent; this information can then be used in making strategic decisions.

2 Starting position

2.1 Importance of the application

The cost and schedule controlling application can be used for large-scale construction projects involving general contractors. In such projects, a major company or a consortium consisting of several general contractors agrees with the principal to complete a property on a turnkey basis for a fixed price. A contract is drawn up stipulating the scope of the services to be rendered and the respective quality standards. Usually, this is accompanied by a written description of the envisaged performance, including detailed plans. For their part, the general contractors mostly commission and supervise subcontractors (in terms of quality and schedules), who carry out special tasks within the overall project.

The project director, project controller and schedule controller are responsible for carrying out the designated procedures.

2.2 Typical terms of payment

As a rule, the principal agrees to settle monthly after checking the performance to date. For this purpose, special charts are compiled giving an overview of the work which has been carried out in different parts of the building or on different storeys and a progress report is presented for each section of the project. The overall level of completion is brought into line with the respective price(s) stipulated in the contract and a total amount is calculated, which is payable on a certain date. Generally, 90% of this amount is then paid, the remaining 10% are withheld by the principal as security until the property has been completed and finally accepted. Settlement is made in compliance with a bill of quantities. Advance payments are only made in special circumstances. In such cases, the principal once again withholds 10% of the amount as security.

2.3 Target/actual comparison

The schedule-related target/actual comparison is an extremely important factor in ongoing construction projects for a number of reasons:

- it provides information about the status of the construction work,
- it facilitates strategic decisions which are necessary for avoiding contractual penalites and/or additional costs (e.g. delays caused by the site manager, problems with site facilities, overtime carried out by subcontractors),
- it explains the reasons for and consequences of delays in the schedule, which might be of great importance in the case of disputes between the contractual parties,
- it helps to forecast the possible date for final acceptance, which is naturally of great importance for the principal.

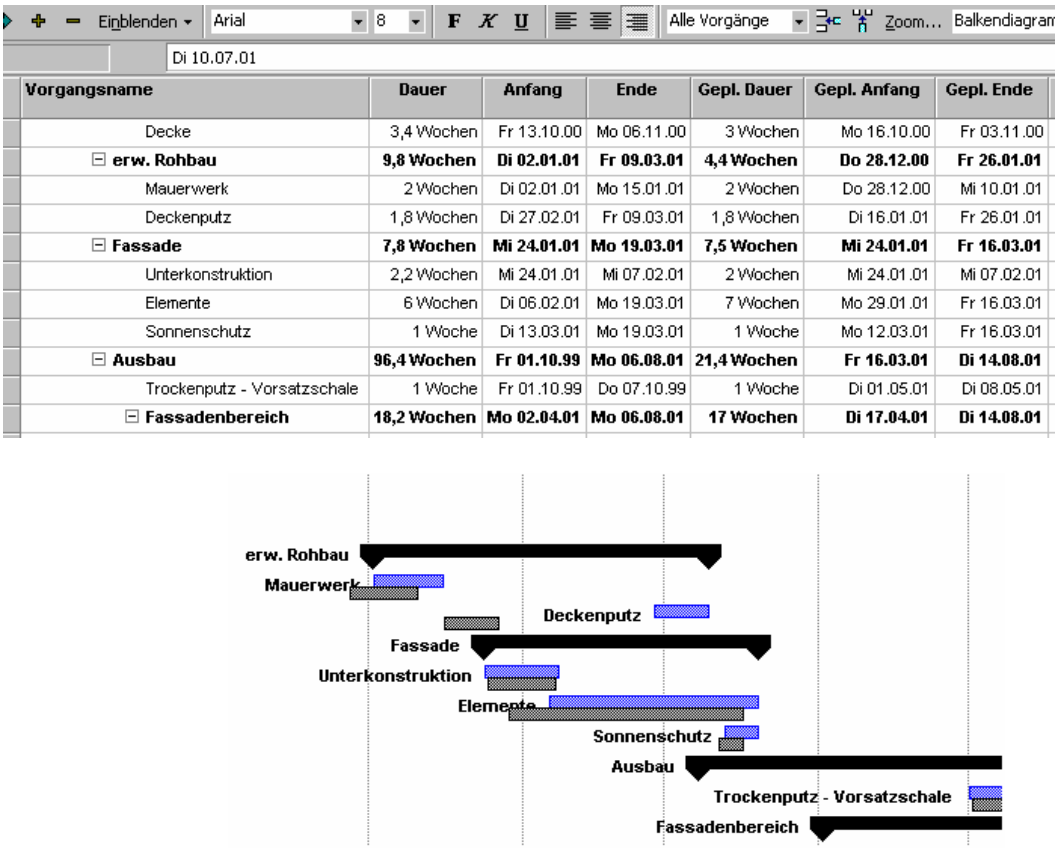
The target/actual comparison is currently carried out by HOCHTIEF with the help of the MS Project programme using basic plans. In this connection, a target schedule is compiled which represents the ideal sequence of events and contains the key points as laid down in the contract (e.g. completion of the building shell).

The target schedule then serves as a basic plan for all subsequent activities and is generally valid for the whole duration of the project. The deadlines stipulated in the basic plan (commencement, completion, duration) are entered in special columns entitled “planned”. The processes contained in the basis plan are shown as grey bars (see Figure 1).

The actual statement defines what has actually been achieved in terms of commencement, completion and duration. This information is usually shown in the schedule as blue or red bars. By using different colours in the chart, it is possible to compare the respective values and to follow the development of the respective bars more easily.

Because the various steps are interdependent, any delays will mean that all subsequent processes will be affected to a greater or lesser extent. The completion date itself will change and some processes may have to be redefined.

Because the target/actual comparison is an essential factor in the execution of any given project, it makes sense to use this instrument to demonstrate cash flow and to guarantee future liquidity management.



Vorgangsname	Dauer	Anfang	Ende	Gepl. Dauer	Gepl. Anfang	Gepl. Ende
Decke	3,4 Wochen	Fr 13.10.00	Mo 06.11.00	3 Wochen	Mo 16.10.00	Fr 03.11.00
erw. Rohbau	**9,8 Wochen**	**Di 02.01.01**	**Fr 09.03.01**	**4,4 Wochen**	**Do 28.12.00**	**Fr 26.01.01**
Mauerwerk	2 Wochen	Di 02.01.01	Mo 15.01.01	2 Wochen	Do 28.12.00	Mi 10.01.01
Deckenputz	1,8 Wochen	Di 27.02.01	Fr 09.03.01	1,8 Wochen	Di 16.01.01	Fr 26.01.01
Fassade	**7,8 Wochen**	**Mi 24.01.01**	**Mo 19.03.01**	**7,5 Wochen**	**Mi 24.01.01**	**Fr 16.03.01**
Unterkonstruktion	2,2 Wochen	Mi 24.01.01	Mi 07.02.01	2 Wochen	Mi 24.01.01	Mi 07.02.01
Elemente	6 Wochen	Di 06.02.01	Mo 19.03.01	7 Wochen	Mo 29.01.01	Fr 16.03.01
Sonnenschutz	1 Woche	Di 13.03.01	Mo 19.03.01	1 Woche	Mo 12.03.01	Fr 16.03.01
Ausbau	**96,4 Wochen**	**Fr 01.10.99**	**Mo 06.08.01**	**21,4 Wochen**	**Fr 16.03.01**	**Di 14.08.01**
Trockenputz - Vorsatzschale	1 Woche	Fr 01.10.99	Do 07.10.99	1 Woche	Di 01.05.01	Di 08.05.01
Fassadenbereich	**18,2 Wochen**	**Mo 02.04.01**	**Mo 06.08.01**	**17 Wochen**	**Di 17.04.01**	**Di 14.08.01**

Figure 1

Schedule-based target/actual comparison in the MS Project

2.4 Liquidity management

In the context of performance-related payment agreements, it can happen that certain payments are not effected due to the fact that there has been no corresponding performance. The ongoing costs, however, continue (e.g. site facilities, hoisting gear, site management, labour costs), and this can lead to liquidity problems.

If performance-related payments have been agreed on with the principal, but the respective performance has not taken place on the construction site, the general contractors may be required to make considerable prepayments. Insofar as these are not covered from other sources, this can lead to substantial losses regarding interest payments or alternatively to additional interest charges. In any case, unnecessary and avoidable financial disadvantages may arise, which in turn can negatively tip the balance with regard to profit in view of the slender margins which exist at the moment in the construction sector. A liquidity assessment is at all times necessary to reveal the current financial situation. This helps on the one hand to avert negative developments in a financial sense and on the other hand to explain the actual situation to persons to a superior level.

The already existing software models do not sufficiently cover the liquidity issues which are related to delays in the execution of the construction work. Although there is a possibility of following the schedule and of intervening in a corrective manner if necessary in order to avoid contractual penalties or extra costs (due to long delays caused by the site manager, non-availability of hoisting gear, etc.), it is not generally possible to make a sufficiently exact

statement as to how a change in the schedule affects the inflow and outflow of capital in the future course of the project.

However, it is absolutely essential to carry out a prognosis concerning possible changes in cash flow with regard to future liquidity management.

If an attempt is made on the basis of just one change in schedule to review the new dates of commencement and completion as well as changes in duration, the chart depicted in Figure 1 could show which performance has already taken place in which part of the building or on which storey and how the respective value of this work relates to the inflow and outflow of capital.

Due to the complex interdependency which governs most construction work, almost every change in schedule has direct consequences for all subsequent processes. Generally speaking, there is not just one single change in schedule in the course of a large-scale project; thus it would seem that a cash flow analysis is by definition impossible – or is only possible if a tremendous effort is made.

The two parameters - duration and cash flow - must be reviewed in relation to one another and their interdependence must be made evident. This is extremely important for the project director, since this is the only way of making strategic decisions accurately.

3 Demands made on the application and methods of resolution

3.1 Demands

The software application is required to meet the following demands:

- It should be possible to carry out a rapid and straightforward cash flow review in relation to the scheduled events.
- It should be possible to recognise failure in the cash flow at an early stage, i.e. any deviations from the planned status must be presented separately.
- It should be possible to predict the payment status at any given time; this facilitates tactical intervention in case there are changes in the overall financial circumstances.
- It should be possible to issue cash flow reports showing budget-related inflows or outflows with reference to target/actual developments and respective deviations.
- It should be possible to export reports in the form of a spreadsheet for the purpose of further processing.
- It should be possible to integrate existing software environments.

3.2 Methods of resolution

In order to relate factors such as time and money, convention controlling methods can be used, since the data are already in the schedule (Chatfield and Johnson 2000). If schedule-specific data are related to budget-specific data, payment procedures can be calculated and expressed in cash flow reports. The basic aim is to spread the budgets associated with the principal and the subcontractors in a linear fashion over the whole duration of the respective contract and then to calculate partial budgets (i.e. the value of a single work unit).

The budget value depends on the duration of the work, i.e. it is variable. If, for example, the overall duration is extended while the budget remains the same, the turnover per working day

will become smaller. Based on the daily budget, the value of each process can be determined in relation to its duration.

The process-specific budget is in turn spread over different months. The following figure shows an example of cost distribution for a certain process in the target/actual comparison. The integral factor remains the same.

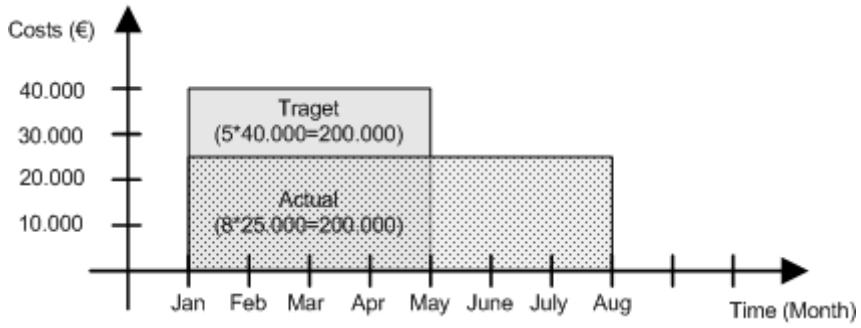


Figure 2

Linear methods or resolution

If there are extreme deviations in the linear cash flow, as in the case of specific tasks, another procedure is shown. If we take heat technology as an example, we can see that the time-consuming installation of the pipes accounts for just a small part of the whole budget. The assembly of the main devices on the other hand can be carried out in just a few days, but this section constitutes the greater part of the total amount. If one used a linear cash flow as a basis for calculation with regard to these processes, there would be great variations from the actual situation.

In order to counteract such distortions, separate “orders” are made for non-linear tasks. In the example given, this would mean that an order covering the installation of the pipes would be spread across the whole construction period, whereas the assembly of the central devices would be shown to last only a few days.

4 Implementation

4.1 General

The application is implemented in Visual Basic, so that it is possible to use existing interfaces to other products efficiently. Moreover, there is a means of accessing components for effecting communication between the applications involved. It is possible that this can be done through OLE automation using the Component Object Models (COM).

4.2 Cost and schedule controlling

The basic product comprises schedules in Microsoft Project; the respective files are selected from the schedule by accessing Microsoft Project Object Library and are subsequently inserted in a relational data bank using Joint Engine Technology (JET) (Doberenz and Kowalski 1999).

In accordance with results obtained from an analysis of the demands, the data bank model was formally described (see Figure 3) and implemented using the relational model.

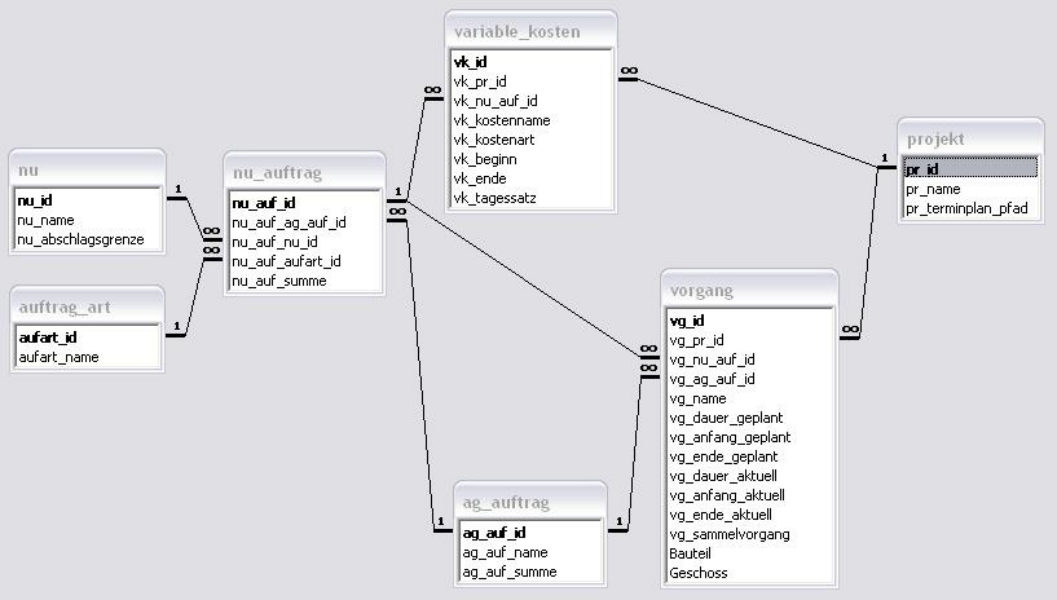


Figure 3

Relational model

Here all the relevant schedule-related information was stored per project. In this connection the following points are important:

- the contractual conditions, including the relationship between the principal and the subcontractors,
- the single order-specific budgets with the corresponding inflows and outflows,
- the schedule-relate status of the individual processes.

The ADO interface (ActiveX Data Object) was used for data access. (Kofler 2000)

In the cost and schedule controlling application, the budget data are entered and further processed; cash flow reports are issued via the COM interface in line with Microsoft Excel.

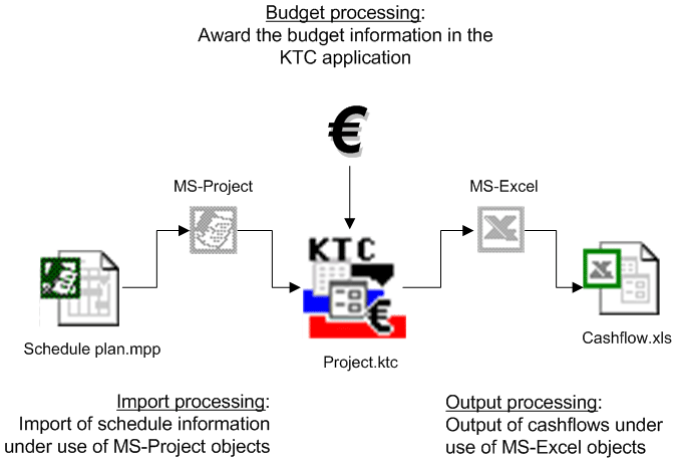


Figure 4

Procedure for the cost and schedule controlling application

The budget data is spread according to various algorithms, which allot the cash inflows and outflows in a linear fashion to the months when payment is due. In order to calculate outflows to the subcontractors, all agreed minimum advance payments are considered and are carried forward as partial budgets to the following months. At the time of the final payment, however, the whole remaining budget is also due, irrespective of its extent. Furthermore, there is a possibility of entering and processing time-dependent cost elements e.g. long delays or rental payments. The performance and payment procedure related to the entered budget data is visualised directly in cash flow charts, which provide an immediate overview of the situation. The varying status of the schedule (planned course, actual course and deviations) are presented in different colours for better recognition.

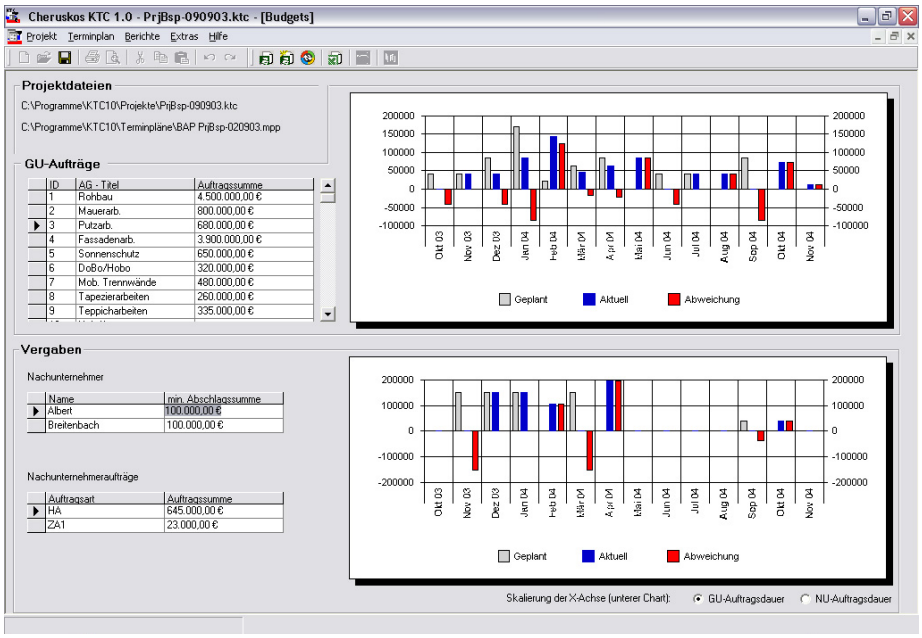


Figure 5

Main mask of the cost and schedule controlling application

4.3 Mobile controlling

Consistent schedule controlling is extremely important for the ongoing execution of a project (Trupp 2001). This is usually done with the help of site inspections during which entries are made by hand in work copies of the schedule. These entries are subsequently transferred to the MS Project schedule – a process which can be extremely time-consuming. Many site managers, however, are equipped with handheld PCs (palms) (Lui, Stumpf and Kim 1994). Thus it was decided that schedule controlling could be simplified by means of mobile devices, which avoids making entries by hand and thus reduces the number of mistakes.

Thus it was considered necessary to present a simple and easy-to-understand overview of the scheduled dates on the handheld PC, with the possibility of updates. The user should have the chance of administering and choosing different projects on the handheld PC. The updated status on the handheld PC must be easily synchronised with the status of the main application and the MS Project schedule.

Furthermore, because of the different approaches used in on-site controlling, it is desirable that controllers should have the chance of compiling their own special procedure plans. If, for example, different tasks are to be completed one after another or if only one special task is of

importance at a given time, it should be possible for the PC user to devise his/her own procedure.

The use of handheld PCs with the Pocket PC 2002 operating system is useful for the following reasons:

- high compatibility with other existing applications,
- free development environment - eMbeddeb Visual Basic 3.0,
- access to components of the respective applications via object libraries,
- access to the database for cost and schedule controlling by means of ADOCE (ActiveX Data Objects for Windows CE),
- simple data synchronisation and conversion via the ActiveSync standard software,
- widespread use of handheld PCs with the Pocket PC 2002 operating system.

Development and testing was carried out on the handheld PC Compaq IPAQ 5450. After synchronisation, the user has the possibility of accessing the relevant cost and schedule controlling projects. After selecting a specific structure, the user can view schedules and subsequently make alterations concerning individual processes. After renewed synchronisation, the cost and schedule controlling projects as well as the schedules themselves are updated on the host system.

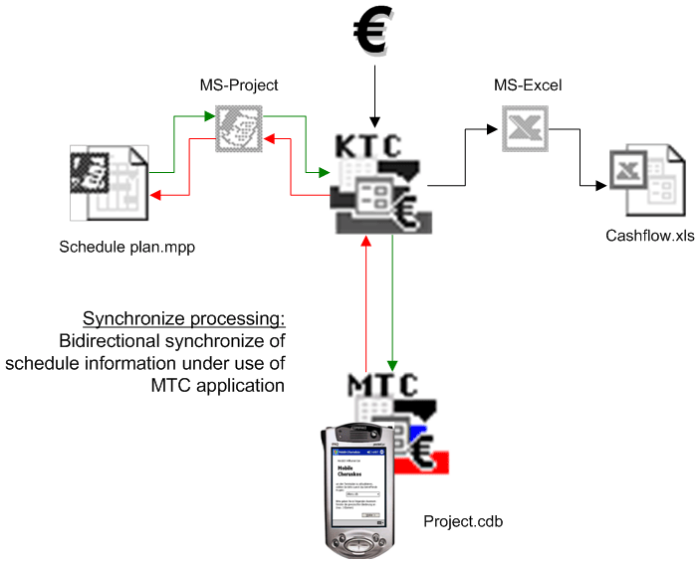


Figure 6

Procedure for cost and schedule controlling and mobile controlling applications

5 Summary

The present study describes a restructuring of cost controlling at the construction site using modern IT methods. Initially the actual situation associated with cost controlling was analysed and subsequently the demands on the newly developed software tools were defined. Finally, a separate software system, the so-called cost and schedule controlling application, was implemented.

The target group for the new application mainly comprises project directors working for large construction companies, who need support in decision-making processes throughout the respective project with special reference to liquidity assessment. It must be possible for such persons to carry out a rapid and uncomplicated liquidity prognosis in connection with schedule controlling. In this way, the possibility arises of reaching strategic decisions without unnecessary delay and avoiding damage to assets.

In this paper, special importance has been attached to depicting the relationship between the participating companies. In addition, it was considered necessary to provide a basis for determining the liquidity-specific effects of schedule-based delays.

All relevant schedule-related and contract-related issues have been presented in the relational database model. This contains all the relevant information concerning processes and orders which are entered by the user after the process information from the MS Project has been imported. The user can now relate the data in question to the respective budget values. By calculating the values of the single processes and applying them to the respective performance periods, the user can obtain reports about inflows and outflows during the whole project and export them to spreadsheets.

The cost and schedule controlling application is implemented in line with the Visual Basic development environment, using the component technology COM. This guarantees efficient communication with the above mentioned Microsoft products, irrespective of which version is used.

The experience made during the development of the cost and schedule controlling application has shown that the updating of planned schedules is of immense importance. In order to do justice to the requirements of holistic cost and schedule controlling, a solution for mobile data collection was developed, involving the use of mobile terminals.

6 Future prospects

Based on the experience gained during the implementation phase, certain approaches for further optimisation and future development have appeared.

- In many cases payments from the principal and to the subcontractors are only effected at a rate of 90%, whereby the remaining 10% form a security buffer. This phenomenon will be considered in the next version of the software together with the possibility of granting cash discounts.
- Based on the server-side database, it might be possible to create multi-user operations – for this purpose, it might be useful to compile user displays with different reading and writing functions together with a user administration system with password access.
- At the moment it is still necessary to synchronise the updated schedules formatted in PDA. This problem may disappear completely if the mobile components can be imported as a client-server application. In that case, it might be possible to transfer the schedule-related data which is collected on site directly to the database (for example via a wireless LAN connection) – this will then be correspondingly updated.
- A further important point is to analyse the possibilities of further processing the results obtained from the cost and schedule controlling application of the commercial departments in the different locations (e.g. SAP).

7 References

Chatfield, C., Johnson, T. (2000). Microsoft Project 2000 – Schritt für Schritt. Microsoft Press Verlag.

Kofler, M. (2000). Visual Basic 6 – Programmiertechniken, Datenbanken, Internet. Addison-Wensley Verlag.

Lui, L., Stumpf, A., and Kim, S. (1994) Applying Multimedia Technology to Projekt Control, Proceedings of the First Congress on Computing in Civil Engineering, American Society of Civil Engineers.

Trupp, T. (2001). Mobile Computing in Construction Management. University of Illinois at Urbana-Champaign.

Doberenz, W., Kowalski, T. (1999). Datenbankprogrammierung mit Visual Basic 6. Microsoft Press Verlag.