THE CURRENT TASKS AND DIFFICULTIES OF INTEGRATED PROJECT PLANNING OF BUDAPEST METRO LINE 4 CONSTRUCTION PROJECT

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Summary

The construction Project of Budapest Metro Line 4, the first fully automatic (driverless) metro in Central-East Europe, is made up of several, major sub-project elements. Structural works include the sub-project elements of tunnelling and building the station boxes. Structural works are followed chronologically by the fit-out of the stations, trackwork and then systems and power supply. Parallel, the construction of the depot and the design, manufacture and testing of the trains is also taking place. Within the major project, related surface reinstatements and other minor attached projects are also implemented.

Structure works and tunnelling was the lead activity within the entire M4 Project, which sub-project element was delayed from the outset, and underwent several delays later. This delay had a knock-on effect on the building of the station-box structures, and resulted in an accumulated delay at project level resulting in the postponement of the final completion date of the project. The reprogramming of the procurement of the rolling stock meant a particular problem, which meant that, at the level of the Integrated Project Programme, the deadlines of the interface network regulating the connection between the sub-project elements had to be rethought. This study outlines the project-specific procedures, solutions and programming methods used in the course of working.

Key words:

Budapest Metro Line 4 Project, Integrated project planning, Harmonization of the interface net of the sub-project elements, time-limited (end-limited) scheduling method, block-scheme diagram, CPM scheduling techniques, Cohesion Fund, EU co-financing, Fully automated metro-line, Managing of infrastructural development (huge) project,

1.0 Introduction

The objective of Stage 1 of Metro Line 4, between South Buda and Rákospalota (Kelenföld Railway Station and Keleti Railway Station) is to increase the quality (including primarily reliability) of mass transport between South Buda and the city centre and between Zugló and the city centre, which is currently at a very low level, in order that the level of community transport can be retained (stop the growth of individual transport) and decrease the serious environmental contamination resulting from surface transport. The new metro line will also improve the spatial structure, the social and economic development of the city with line realized, the only major route in the city without a rapid train link – an area, including the agglomeration, is the most dynamically developing area – will now connect to the rapid train network. Its future elongation to Gazdagrét, Rákospalota and Budafok in the agglomeration behind will extend the systemic benefits.

The 7.5 km line has two tunnels built by TBM shields and 10 stations built from the surface by d-walling technology and partly mining methods. In order to realize the complex project with several sub-project elements, several construction contracts were let to contractors, no general contractor was commissioned.

The programming of the Project depends largely on success of coordinating and managing the interfaces between the numerous sub-project elements. The lead activity among construction works was the driving of the two TBM shields. According to the original plans, the shields should have started from Etele tér on 6 April and finish by 5 June 2009. However, the shields stopped before Szent Gellért tér station on 18 August 2008, and tunnelling resumed on 6 January 2009, and shield no. 2 reached receptacle at Keleti Railway Station on 4 July 2010. As a result of the delay in tunnel boring, the delay suffered by other sub-project elements, the Integrated Project Programme had to be rethought, and its interfaces had to be redesigned.

In 2011, a dispute arose between the Employer and the supplier on the procurement of metro trains. Following the settlement of the dispute, a new programme for train delivery was made. Due to train delivery changes, the final completion date had to be changed again and the Integrated Project Programme, as well.

2.0 Integrated Project Planning

The Budapest Metro Line 4 Project is a complex project, divided into 10 major (or 17) Contracts. The Integrated Project Programme was most significantly influenced by the following sub-project elements: Co-02: Tunnel construction (including the Construction of Szent Gellért tér station structure, as well). Station-box construction (Co-03 Kelenföldi pu.; Co-04A/B/C Tétényi u. – Bocskai u. – Móricz Zs. krt.; Co-05A/B Fővám tér – Kálvin tér; Co-06A/B/C Rákóczi tér – Népszínház u. – Keleti pu.); the fit-out of stations (Co-07); trackwork (Co-08); systems and power supply (Co-09); procurement of rolling stock (Co-10), and the building of the Depot (Co-11). Part of the project is the fulfilment of the Engineer's, the technical inspector's duties, which is managed under a separate contract, and also the related surface reinstatement and other minor contracts.

The contractors of the sub-project elements were selected in public procurement procedures. Apart from the rolling stock and the technical inspector, Engineer contract, all the sub-project element contracts are based on the contractual system of the FIDIC Yellow Book (FIDIC - International Federation of Consulting Engineers 'Yellow Book' 1999, Conditions of Contract for Plant and Design Build) [1]. The use of FIDIC contracts was a precondition of EU and EIB funding. The management of the contracts and the coordination of the many sub-project elements can be realized at Integrated Project Programme level.

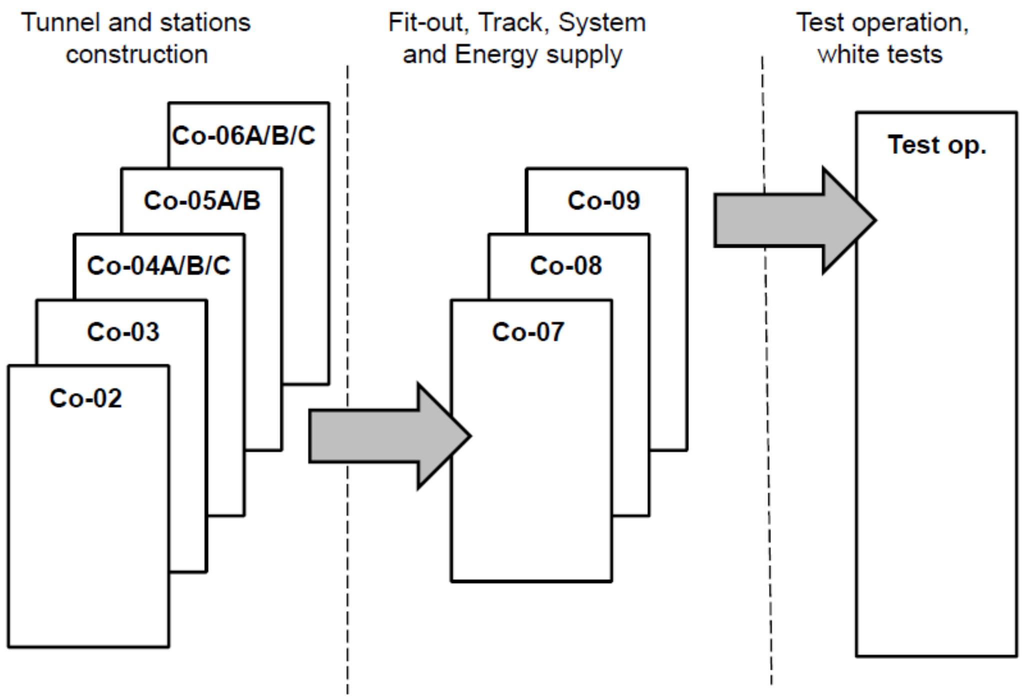


Fig.1. The major sub-project elements of M4 project, simplified relationship scheme.

(Diagram 1: Outline of the system of relations between the sub-project elements of the M4 Project.)

2.1 Human, IT and Software Resources of Project Planning

Within the framework of the project, programming takes place at 3 separate levels. 1) At sub-project element level, by the contractors; 2) at sub-project element by the Engineer and the Employer; and 3) at integrated project programming level by both Employer and the Engineer. There are several examples for this in international practice [2, 3]. The human resources for programming is provided by the Employer and Engineer together under contractual provisions. Generally, it can be stated that, in international practice, much higher numbers are employed as programmers and experts on the sides of contractors, employers and engineers than on the Budapest project. On the Budapest project, the Employer has had a permanent programming group (3 programmers from 2008, 2 from 2010 and 1 from 2012) and the Engineer has 1 expert programmer under the Managing Deputy Director, while the contractors have a permanent staff of max 1 and seasonally 1-3 persons working on programming. The contractors typically (differently as per sub-project element) involve external domestic or international experts or expert groups. It should be noted, that the Employer and Engineer also had the opportunity of involving international experts when demand arose.

The contractors have the software most widely used at home and in Europe, PRIMAVERA [4] or Project Director Enterprise developed by the domestic firm ELM (Project Control Expert as of 2010)., which later came to be called Project Director Enterprise (PDE) [5] and MS Project perhaps the one most widely used in Europe at least [6].

In the first stage, we gave up former practice and required that Contractors employ programmers permanently residing in Hungary and submit data and programmes not only in paper format, but also electronically.

Thus software compatibility had also to be established as soon as possible. The aim was to find cost-efficient solutions ensuring high technical and IT levels, and we also had to take into account that much fewer persons are employed for programming on this project than on similar volume projects elsewhere. DBR is currently able to receive programmes submitted in Project Director Enterprise and MS Project format. As Contractors use not the PDE, but the MS Project system for their daily work, the Employer receives data in this format, and supervises programming using this software.

2.2 Introducing the unified WBS (Work Breakdown Structure) of Project Planning

After discussions with the sub-project-element Contractors, we established the detailed time data of the new Integrated Project Programme for the entire Project, which was the result of a several-stage reiterative process. In the course of this process, we contrasted the programme versions made at sub-project element level, and proposed further detailing or development to the Contractors.

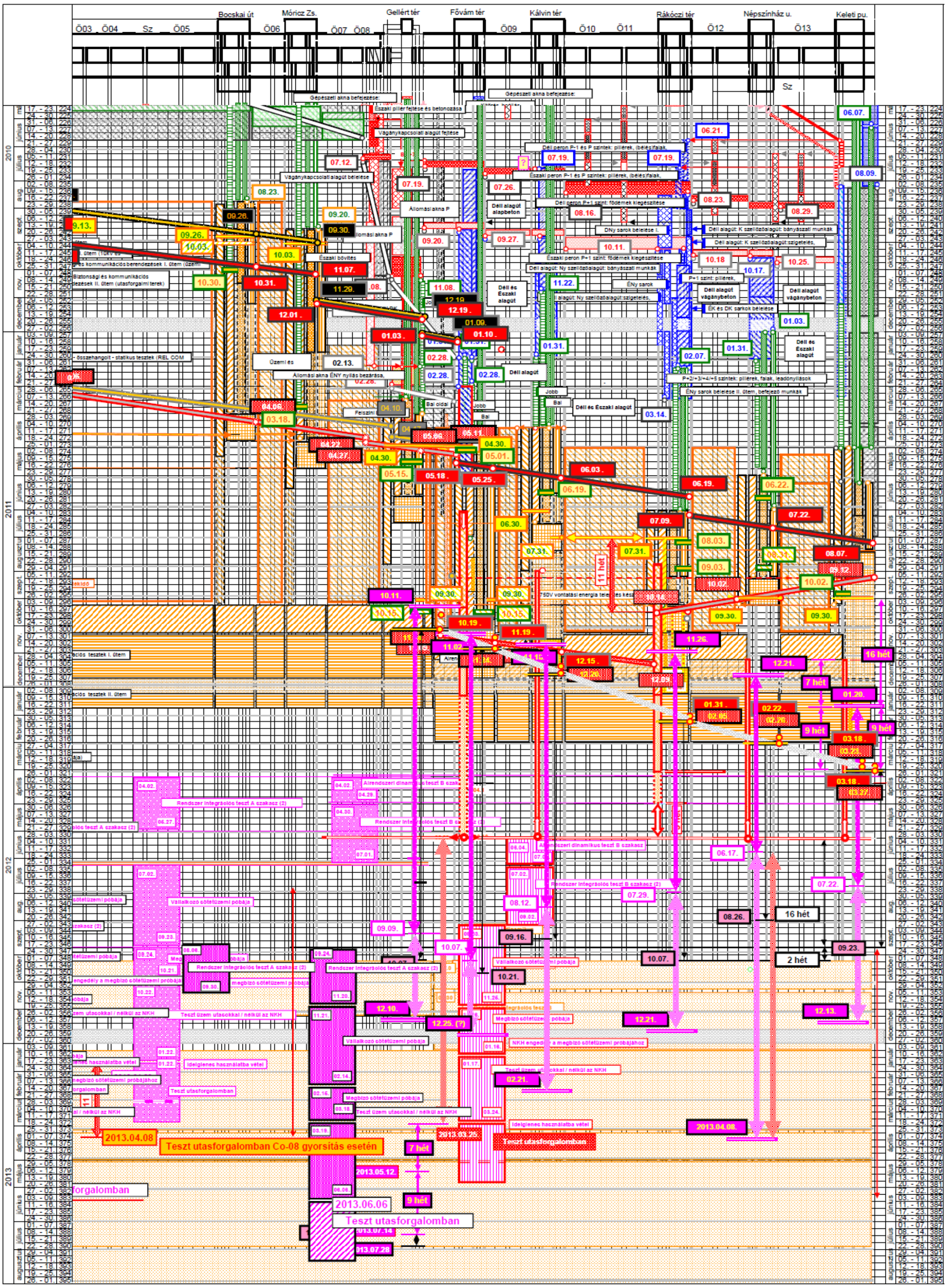
Thus not only did programming have to be rethought at sub-project element level taking contractual, technical and business aspects taken into account, but interface points, the work processes between sub-project elements, had also to be coordinated, paralleling activities – bringing some processes forward, delaying others – following the examination of their effects on the whole process.

In the course of several rounds of discussion, we tried as far as possible to unify the programmes the Contractors submitted for each sub-project element. We provided every Contractor with WBS proposals. Our guiding principle was to develop programmes for each Contract, site and station level. With the help of international experts with experience in metro construction projects, we developed a code system whereby work processes were simpler and clearer to identify, and easier to compare with sites and sub-project element works. [7].

The programmes of the sub-project elements include a significant number of activities (~1500 – 3000). In view of the fact that, in respect of the fit-out sub-project element, each of the stations have their own programmes, it is clear that an Integrated Project Programme required significant numbers of programming data to be handled and updated. Thus in order to enable searches, filtering, arranging, etc., a code system had to be developed for the entire project. With codes to be applied, the identification of the type of programme lines, work process and site had to be solved and broken down according to colour and place. In order to measure progress, all this had also to be linked with contractual Price Centres and payment milestones, enabling the latter to be integrated with the code system.

Due to the significant amount of programme data and interface points, bar charts or network programmes (Gantt diagrams) would not enable quick and clear overview of the project. For quick overview and integrated programming data management, a new graphic visualization was developed, the so-called block-scheme programme. Attributing a colour code to each contract breakdown, the easy and quick discernment of parallel work activities, their progress and the great numbers of interface points is guaranteed.

Fig.2. Block scheme time schedule of the M4 project.



(Diagram 2: the Block-scheme programme of the M4 Project.)

2.3 Application of Time-limited (end-limited) Scheduling Method

As a result of the accumulated delay in tunnelling and station-box construction, we were forced to establish and publish a new completion date for the Project in the autumn 2009. (By completion date we mean the earliest possible commencement of the Test in Traffic Operation.) To estimate and determine the new completion date and the new interface points and dates of the Project, we used the so-called "final deadline limit method" (Time-limited (end-limited)), generally used in the programming of complex projects.

In practice, we first made an engineering estimate of the final completion dates of tunnelling and station-box construction. The completion of these work processes could be foreseen with an acceptable margin. After this, we estimated the time requirements of the sub-project elements following tunnelling and box-structure construction, i.e. trackwork, fit-out of stations, systems and power supply, depot, etc., and thus established the new completion date of the Project.

From the completion date so established, we determined the time requirements of the activities influencing the work processes of each sub-project element by taking the contractual durations into account through back engineering, as well as their interface points with other sub-project elements.

In the contracts of the sub-project elements, the interface points with other sub-project elements were defined as Key Dates. As the deadlines of the activities of the chronologically preceding sub-project elements are also the commencement dates of the follow-on sub-project elements. These also mean handover procedures between Contractors. Contractually these are single days, but actually the handover of a worksite may take weeks and even months (see diagram 3: The turning of an interface point between sub-project elements into a process.) At the level of Integrated Project Programme, these processes may result in significant, cumulating delays.

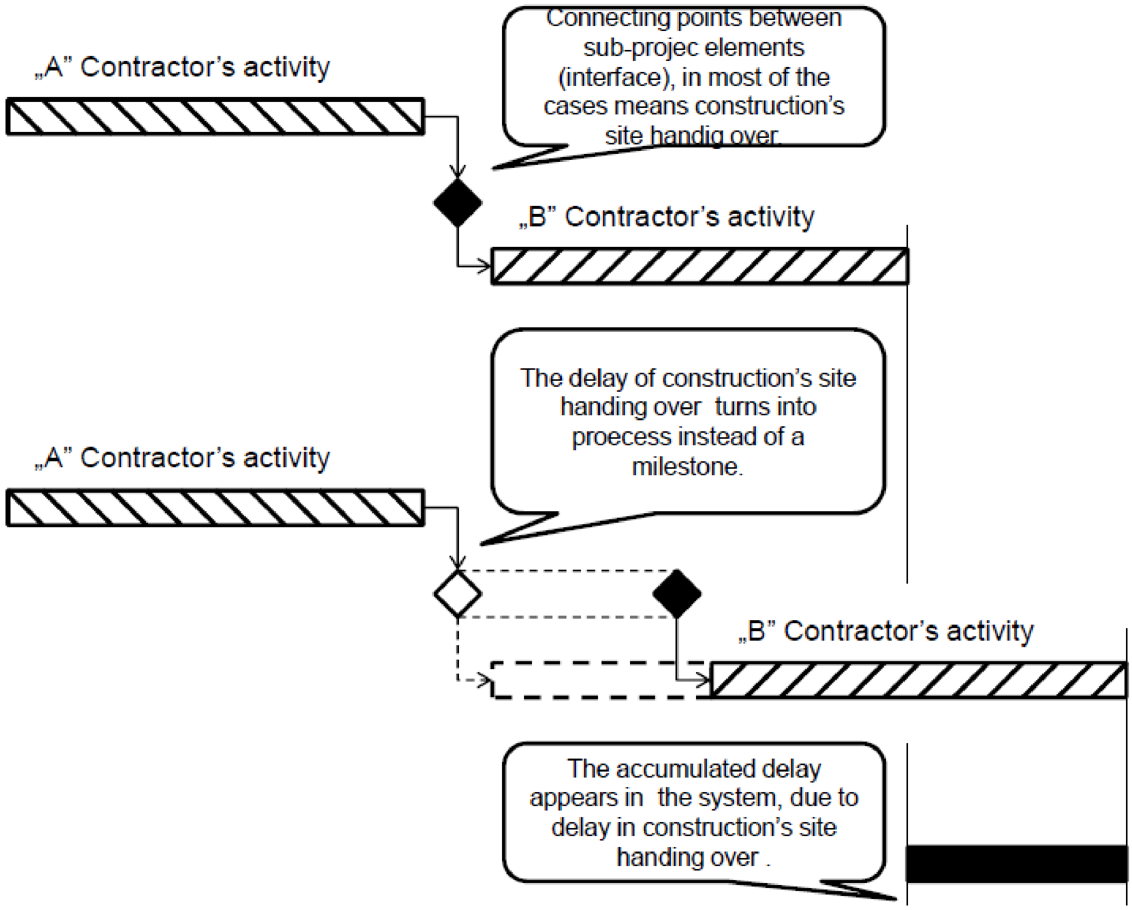
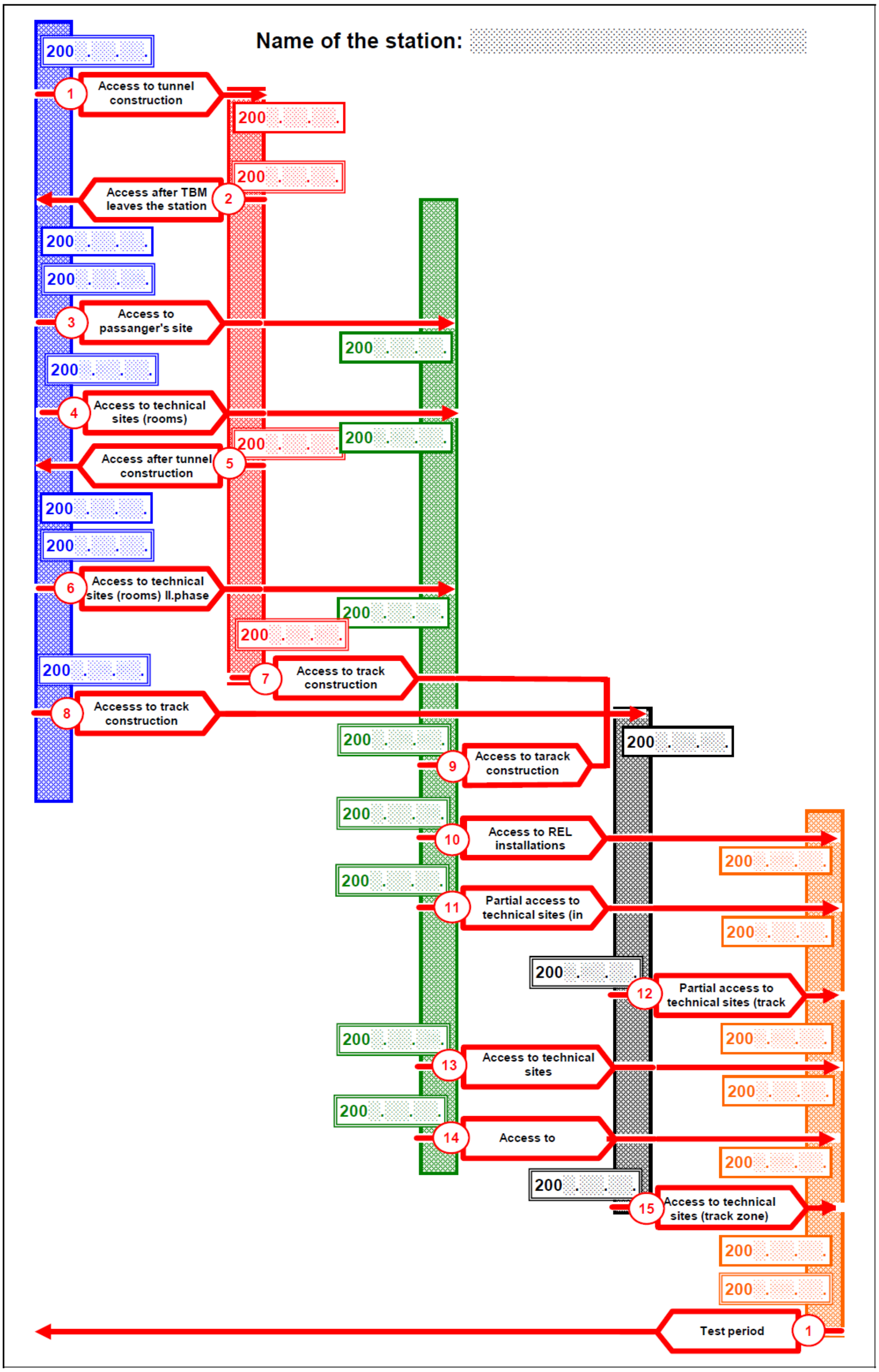


Fig.3. The interface point between sub-project elements turns into process.

Before determining the new dates, it became inevitable that we rethink the interface network describing the connection between sub-project elements. Within a single station, 17 major interfaces had to be managed. (See diagram 4: The interface connections of a station.) Even if we prepare the simplest interface network including all the deadlines and the dates of partial and full access, we will model it in a network programme with some ~850 items.

Fig. 4. Interface connections within a station



After several rounds of interface coordination with Contractors, the Employer-Engineer team developed the Simplified Integrated Project Programme (hereinafter: SIPP) (issued: 30.07.2010) and later its enhanced version, the Integrated Project Programme (hereinafter: IPP) (issued on 15.11.2010). The way interface connections were managed was that the SIPP and then the IPP defined so-called access windows.

The interface windows established the time frame for managing interfaces between sub-project elements at each site. Contractors could manage their interfacing, site handover duties within the time frames of interface windows. The SIPP and later IPP provided sufficiently detailed programming information (input data) to the still active sub-project element Contractors (trackwork, fit-out, systems and power supply) for elaborating their detailed programmes. This provided the Contractors with a framework taking fully into account their contractual durations and with a realistic time frame for performing the tasks still to be done.

As a result of the resolution of the dispute with Alstom in July 2011, a new train delivery programme was developed in August 2011. Under the new conditions, part of the endurance test will have to be conducted on Metro Line 4, its Section A being partially commissioned for the purpose. Another task in the near future is the coordination of integrated tests, taking into account and applying all possible parallelization to secure meeting the final deadline. In defining interfaces and applying programme overlaps, the Time-limited (end-limited) method was used.

3.0 Conclusions

The major project divided into several sub-project elements required the simultaneous management of significant quantities of programme data. The high-level realization of this is only possible with adequate human and IT resources.

The proper management of the interface points between the sub-project elements of the highly complex M4 Project (the establishment and continuous updating of the interface network) and the handover processes between sub-project element has a key role in upholding the duration of the M4 Project.

The management of the accumulated delay in the course of implementing the sub-project elements, the successful prevention or timely mitigation and undoing of possible interface delays are a key task.

In the course of implementing the project, the obligation to provide sufficiently detailed and precise programming data was breached, and was not fulfilled. The reason for this was that as a result of the legal disputes between the parties, they developed contrary interests. Totally mistakenly, participants deemed the programme not as a means, but as a cause. A change in attitudes would be necessary to successfully complete the project or settle disputes as soon as possible.

In the course of developing the Integrated Project Programme, the creation of the code system and the new programme structure (breakdown by contract, site and level) and the wholly new block-scheme visualization method developed for major complex projects provided good and usable tools to the experts managing the project.

Acknowledgements

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