Interface management on rail infrastructure projects: the special case of signalling

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This article discusses the consequences of splitting multidisciplinary rail infrastructure projects into multiple design and/or construction contracts. Signalling is one part of a project that is often contracted separately, as work on this aspect takes place over much of the project life-cycle and only a small number of specialized firms are able to design and build signalling systems. When a project is split up, there is the risk that the various parts will not match up as they should at the end of the project. The risks inherent to splitting off the signalling aspects of the project emanate in particular from the large number of interfaces between signalling and other areas of the same project.

This article will discuss the most significant of the risks inherent to splitting up project segments – especially signalling – and how these risks can be controlled by means of interface management. We shall also examine the various roles of an interface manager. A new tool will be presented that can predict the risks involved in splitting a project, before those splits are carried out. We shall conclude with a number of real-life examples and an overview of the added value of an interface manager.

Multidisciplinary rail infrastructure projects are almost always split up into multiple design and construction contracts, each of which is put out to tender separately. This creates the risk that the various parts will not match up as they should at the end of the project. The signalling element is particularly complex, as work on signalling occurs over much of a project’s life-cycle and signalling has many links to other parts of the project. Using interface management can reduce and control the risk of interface problems and hence the risk of time and budget overruns and of impaired project performance.

Splitting large projects into several design and construction contracts can be risky. Nevertheless, there are many reasons for doing so [figure 1]:

- It may be necessary or desirable to start utilizing part of the project output before the project as a whole is complete.
- The project may be too large for one supplier to handle. Dividing up the project will allow a larger number of suppliers to take on sub-projects, which may reduce costs.
- Requirements concerning later aspects of the project, such as finishing, may not yet be available or may depend heavily on choices made in earlier phases.
- Allowing more freedom for development in one of the sub-projects may stimulate innovation.

Signalling as a sub-project

In the vast majority of projects, signalling forms a separate sub-project. One reason for this is that work on the signalling aspect runs through a large percentage of a project’s life-cycle. Right at an early stage, it needs to be clear what time-tables will be possible on the line concerned, so that timetable planners can start work. Work then continues on signalling right through to final system testing, including proof of safety and approval by the competent authorities. Furthermore, only a small number of specialist firms can design and build signalling systems.

In some cases – especially interfaces with neighbouring rail projects, which may or may not involve a different customer – it is very important to think about the contracting of the signalling sub-system at a very early stage of the project. This was very much the case for the Flanders – Maastricht tram project, as it involves linking the Dutch and Belgian tram signalling systems, and both systems will need to be maintained. This kind of interface between two countries’ signalling systems is probably one of the most difficult rail infrastructure interfaces [Box 1].

The large number of signalling-related interfaces

The signalling sub-project is exceptional in that it has interfaces with many other sub-systems, including point...
mechanisms and the insulated rail joints that allow sections of a rail to be separated from each other electrically [figure 3]. These insulated rail joints have to be installed by the contractor who installs the rails. However, changes in the signalling design may still occur at a late stage of the project because of such factors as the journey times required or the maximum distances over which signals and points can be controlled. At certain locations, this will entail changing the lengths of block sections and hence the positions of the insulated joints.

There will also be interfaces with structures, because of the need for cable troughs on bridges and viaducts, and cut-outs and other modifications to the shape of fixed concrete slabs under the track. These structures are built at an early stage of the project. However, it is quite likely that modifications to structures will be required at a later stage of the project, once the signalling design becomes more detailed. It is therefore a requirement that the civil engineering aspects of design impose no constraints on the design of signalling systems.

There will also be an interface with the overhead line sub-system. On one project, the signalling design assumed that the overhead line would continue to a particular point on the track. However, the overhead line as built stopped short of that point. Because this change was not communicated to the signalling designer, the first electric train to use the track ran past the end of the overhead line, as the sign indicating the end of the electrified section had been installed where the overhead line was originally supposed to end [figure 4].

**Risks inherent in sub-dividing sub-projects**

Each new split in a project creates an interface between two sub-projects that originally formed a single project, plus interfaces with the sub-projects that already existed. Every new sub-project will also create a number of external interfaces between the project and its environment. Splitting large projects can create the following risks:

- The split may turn out to be in an inappropriate place, leading to complex sub-projects with interfaces to other sub-projects that are difficult to create and to test.
- The interfaces between the various parts of the project and other sub-projects may not be planned properly.

**Signalling sub-system on the Flanders – Maastricht Tram Line**

The Flanders – Maastricht Tram Line (TVM – Tram Vlaanderen – Maastricht) is a new tram link between the towns of Hasselt in Belgium and Maastricht in the Netherlands. Most of the rail infrastructure for this line is new build. Construction is in the hands of Belgian customer De Lijn on the Belgian side, while the TVM project organization is responsible for the Dutch part of the line. Trams will run over existing ProRail track between the outskirts of Maastricht and the Belgian border. This track will be converted to local track, but will continue to be used by freight traffic on an occasional basis. Signalling on the entire line, both in the Netherlands and in Belgium, will use ERTMS Level 1.

This cross-border project involves two customers, with each of them putting their own part of the infrastructure out to tender. In principle, therefore, at least two parties will perform design, construction and maintenance. As for the contracting aspects, it is necessary to address the tendering process for the Dutch signalling sub-system at the present early stage. Reason for this is that contracting has already started on the Belgian side, and it may well be sensible to include the Dutch part of the signalling system in that process. On the Belgian side, the decision has been taken to award a Design-Build-Finance-Maintain (DBFM) contract, which includes the Belgian signalling system.

The complex interfaces between the Belgian and Dutch signalling sub-systems require a profound technical assessment: the project will involve exchanging data between these Dutch and Belgian signalling systems at the border. ERTMS balises will be installed on the Dutch side to announce the approach of trams and trains at two Belgian level crossings located close to the border. Balises will also be installed on both sides of the border to provide trams with the 'National Values' that they require. Once the line enters service, maintenance will have to be carried out on the signalling system, on both the Dutch and the Belgian sides of the border.

If different suppliers are chosen in the two countries, further complications will arise, as the standardized ERTMS specifications do not yet cover all interface items. This will therefore be a highly complex interface, which means that careful analysis will be required beforehand. The project team in the Netherlands has looked at how best to create the signalling system on the Dutch side of the border. Three options have been considered:

- De Lijn adds the Dutch signalling system to its DBFM contract.
- TVM puts the Dutch signalling system out to tender.
- TVM enters into a contract with the Belgian signalling supplier.

Each option has advantages and disadvantages as regards interfaces, technical aspects, finance, tendering law, other legal factors and organizational matters. A general survey of these topics has been carried out and they will be examined in more detail before a final decision is taken.
Contract Management

– or at all – before the work is put out to contract. This often leads to extra work during integration testing, and in some cases even to a partial re-design.

A change in one contract may cause changes in others. If this is not recognised in time, it may only be possible to modify other contracts at a late stage.

Sub-contracts may not state clearly that contractors are supposed to work together on the substance of the interfaces, and to test them together. In such cases, the need to do so often becomes apparent only towards the end of the project.

In the case of design and construct contracts, in particular, contractors assume that they have a free hand regarding many aspects of the work. However, this is not true of interface requirements. These requirements must be binding, as otherwise the connection to the interface partner or partners will not function correctly.

Overall, therefore, interfaces can be seen as “prime suppliers” of project risks.

Managing risk by managing interfaces

Interface problems constitute a serious threat to the management and quality of the entire project. In particular, the requirement that project performance across interfaces not be impaired by the boundaries between contracts is difficult to fulfil, and generates a number of project risks. It is therefore essential to make the risks manageable, by managing the interfaces. As well as providing a precise description of the content of each contract, one must specify clearly the interface requirements that each contractor is required to fulfil. If the project is to produce the results it should, the customer or the manager of the project consortium must manage the contracting parties in such a way that they align their work at the interfaces between their parts of the project. This means that the customer and his engineering consultants must set up interface management very carefully.

The customer must make someone from his side responsible for the processes related to the interfaces – the interface manager. The interface manager draws up an interface plan, contributes to the contracting plan and has tools with which to manage the interfaces for the entire duration of the project. He will also be involved when changes are proposed, as a change in one contract may result in changes in others. Each contractor responsible for a sub-project must also designate an interface manager who will be responsible for interfaces as far as that contractor is concerned.

A useful ‘splitter’

A tool developed by Eurvel Winters of engineering consultants Movares during the final year of his studies at Delft University of Technology is of value when splitting a project into several contracts. His work on ‘The Alignment of interface risks of multidisciplinary projects in the Netherlands’ has produced a tool that can help a customer select the best points at which to split a project during the initial phase. This tool gives customers a clearer idea of the risks attached to the various ways of splitting a project into sub-contracts [Box 2].

Binding interface requirements

Once decisions have been taken as to how a project is to be split, interface requirements can be formulated. The interface requirements for each sub-system can then be entered into a database of requirements, such as Relatics. Many of these requirements will be related to the content of the sub-system. In the case of train detection, for instance, there will be requirements regarding the section blocks, while for a bridge there will be minimum service life requirements. Contractors often have a degree of freedom as to how they go about meeting these requirements (in the case of a design and construct contract). But for each sub-system, there will also be requirements concerning the interfaces with other sub-projects. Here, no freedom is possible, as the parties on either side of

Figure 3: Test set-up for a prestressed insulated rail joint (foreground) and a conventional insulated rail joint (background). These insulated joints provide electrical separation between rails in adjacent block sections.

Figure 4: Sign to indicate end of overhead line
the interface have to produce an interface that works. In other words, the interface requirements for each sub-project must be binding, and must form part of the requirements stored in the database of requirements.

**Interface matrix**

One of the difficult aspects of drawing up interface requirements is ensuring that they are complete. To achieve this, an object tree is created for each contract. The Relatics database of requirements is based on the object tree for the whole project and the way in which the objects are assigned to contracts. This results in a partial object tree for each contract. The assignment of objects to contracts can be modified quickly and easily in the Relatics database, directly updating the associated interfaces.

If changes to the project occur during design, the database of requirements quickly shows which other contracts may be affected. It is then a simple matter to implement the changes.

Using the interface requirements in the database, an ‘interface matrix’ or ‘N2 matrix’ can be generated, showing the sub-projects with which a given sub-project has interfaces [figure 5]. The horizontal and vertical axes show the object trees of two contracts that affect each other. This kind of matrix is used to identify, define, summarize, design and analyse both functional and physical interfaces in a systematic manner.

Each cell in the matrix indicates whether there is an interface between two objects and assigns a number to that interface if it exists. The more interfaces a sub-project has, and the more complex they are, the greater the risks associated with the sub-project. The customer and his interface manager should pay special attention to these risks.

**Advising a customer before he splits a project into sub-projects**

Splitting a project into sub-projects is common practice, despite the inherent interface risks. This approach can save time, as certain sub-projects can be handled over earlier, or carried out concurrently. It may also have financial advantages, partly by creating more competition.

When a customer decides to split a project, potential interface risks are often forgotten, or not examined with sufficient care, generally because the risks are not sufficiently clear at that stage of the project.

In conjunction with engineering consultancy Movares, Eurel Winters developed a tool in his final year at university that eliminates many interface risks at an early stage and gives greater control over those that remain. The tool makes customers aware of the motives that may influence the splitting of projects and gives them an understanding of the potential interfaces and associated risks early on. Identifying the motivation behind the dividing up of a project makes it possible to identify the consequences and additional interface risks at an early stage. Customers can also reduce the number of interfaces by splitting the project at well-chosen points. This can limit any additional costs and other negative consequences when projects are split.

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greater attention to these sub-projects, with a view to minimizing those risks.

**Drawing up and decoupling interface requirements**

An interface matrix is filled in on the basis of the knowledge and experience of specialists. The interface matrices make it possible to specify for each interface requirement what must happen at the interface. An example: the positions of the foundations of noise barriers on the line between Gouda and Alphen have to take account of the cables that form part of the signalling contract. This results in certain obligations for each of the parties at the interface. For instance, the contractor responsible for the noise barriers must ensure that there are at least Y metres between the barrier foundations and the track. The signalling contractor must ensure that his cables are laid not more than Y metres from the track.

The next step is to draw up the requirements that will be included in the contracts for each party, working in accordance with SMART principles. The contract for the noise barriers will specify that their foundations be located not less than Y metres and not more than Z metres from the centre line of the nearest track. The signalling contract will specify that cables running parallel to the track be located not less than X metres and not more than Y metres from the centre line of the nearest track.

This ‘decouples’ the interface requirements, enabling each contractor to produce their part of the project and between them generate an interface that works. Decoupling also occurs in the requirements regarding the interfaces along the track. For instance, one contractor may be required to build a new overhead line as far as kilometre point X and install a temporary termination at that point. The second contractor is then required to build an overhead line starting at kilometre point X, which will involve connecting to the overhead line built by the first contractor and removing the temporary termination. This ensures, for instance, that small differences in the height of the two sections of overhead line do not cause a “step” in the overhead line at kilometre point X.

**Complex interfaces**

In the case of more complex interfaces, such as when linking two signalling systems, each of which consists of train detection, interlocking and ERTMS, such an approach will not be possible [Box 1]. In such cases, the designers and/or builders of the systems will have to work together to create the interface. They will have to agree which of them creates which part of the interface, how each part is to be tested and how the two parts are to be tested together. They will also have to agree how to prove that the interface does not impair the performance of the project as a whole. If one of the two parties has not yet been selected, their role will be taken on temporarily by a representative of the customer. The interface manager will have a particularly important role to play here. He will lead the process of developing complex interfaces on behalf of the customer. The interface manager can monitor the performance of the interface and take decisions regarding implementation if necessary. When complex interfaces are being implemented, work proceeds in stages. After each stage, both parties confirm in writing that a particular design or construction stage has been completed successfully. This process continues right up to and including final testing. The parties agree beforehand what information and documents are to be made available at which stage.

**The importance of interface management**

An interface manager who advises the customer regarding the optimum points at which to split the project, ensures that the database of requirements contains a correct and complete set of interface requirements and follows and
manages discussions regarding interfaces throughout the entire duration of the project will enable interfaces to be managed in a structured manner. Even in the complex field of signalling. This results in:

- an optimum contracting plan;
- complete, thorough contract documents;
- well-designed, well-built and safe interfaces;
- demonstrable project integrity;
- time savings during construction;
- control over timing differences between contracts;
- successful integration testing;
- reduced workload for the customer.

Interface management makes it possible to control both interfaces within the project and external interfaces, especially in projects where signalling is a separate and important contract item. This substantially reduces both the number of interface risks and their impact.

**ZUSAMMENFASSUNG**

Schnittstellenmanagement für Schieneninfrastrukturprojekte: der Sonderfall der Signalisierung


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