IRSE INTERNATIONAL TECHNICAL COMMITTEE

REDUCTION IN COST OF SIGNALLING

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S U M M A R Y

1. Topic

This note aims to present some tracks that may lead to reduce the global cost of signalling equipment and installations both for the manufacturers and for the customers (usually infrastructure managers).

2. Glossary

In this document, the term “signalling system” covers all the equipment required for managing the train movement and for guaranteeing that passengers and freight can be transported with as low a risk as possible.

Therefore, signalling system includes interlockings, CTC, ATO, ATP (on board and fixed equipment), level crossing, wayside equipment…

3. Are signalling systems and installations too expensive?

As far as reducing the cost of signalling systems and installations is being addressed, this may lead to the assertion that they are too expensive.

It seems useful to understand why this opinion is so largely widespread.

First of all, signalling systems and installations must not be considered only as a spending.

Signalling Systems and Installations contribute significantly to the reduction of the maintenance and operating costs.

Are modern signalling systems and installations too expensive in comparison with those from the past?

Are the signalling systems and installations too expensive in comparison with those from other technical fields?

Are they too expensive in comparison with the country affordability?

3.1. Comparison with the past

- The modern signalling systems or installations are without any doubt more expensive than in the past.

  They are more complex. Their validation process is far more complicated and formal. Their lifetime is shorter.

  But their performance in terms of functionalities, RAMS and flexibility is far ahead and has nothing to do with existing ones.
- The modern signalling systems includes an onboard part on the train.

  It is clear that this part may appear as an overcharge since it didn’t exist before.

  In fact, the wayside equipment is reduced and the comparison must now take into account both onboard and wayside equipments.
- Nobody knew and perhaps up to now knows the exact development cost of existing signalling systems and the exact construction cost of existing installations.

The comparison with the past is therefore quite subjective.

- Furthermore, there are unfortunately many examples of projects, which did not respect their initial budget and this is well known and more or less accepted.

  This point has a very negative effect on the perception of signalling field by top management or financial decision-makers.

3.2. Comparison with other technical fields

The Infrastructure Manager's staff mainly comes from the financial sphere of activity and when they are technicians, they come from civil works.

They have no idea of the railway system complexity and of the specificity of signalling:

- The level of safety and reliability,
- The extreme integration of railway system
- The compatibility constraints with existing systems and installations (technical, functional, human factors, procedures, rules and laws).
- The complexity of carrying out maintenance or modification works on running signalling installations.

Signalling systems and installations are not so expensive in comparison with systems and installations, which have equivalent performance, constraints and life cycle time (e.g. nuclear plants).

They are clearly much more expensive than consumer mass-produced systems (e.g. localisation by GPS).

3.3. Affordability

The feeling that signalling systems and installations are too expensive may come from the frustration due to the fact that the country or the IM may not afford the necessary funding for their maintenance or renewal.

4. General considerations on the context

4.1. Compatibility with existing network and Rolling Stock

It is extremely rare to totally replace or design a complete signalling system.

The fundamental requirement is therefore compatibility with the existing installations and Rolling Stock on the technical level as much as for maintenance and operating procedures, thus limiting strongly revolutionary innovations.

4.2. Consequences of non quality

- Signalling installations have a direct impact on safety and quality of service. Any alteration or evolution that is not carefully carried out has immediate consequences on the schedule for the least, as well as on the passengers' integrity for the worst.

- Past experience taught railway engineers from IM and manufacturers to be modest and cautious when innovating.

4.3. Extra costs

The railway is a system. Signalling is a part of the total railway system.

When you change or modify the signalling, you have many obvious or hidden extra costs outside Signalling: telecommunications, maintenance (new spare parts, new procedures, staff training …), operation (new procedures, staff training…), electrical supply …

4.4. Influence of work conditions

It is necessary to make the difference between the construction of new signalling installations and the modification, or remodelling, of existing installations that are usually kept in operation during the altering works.

Work conditions (night or day work, with prohibited traffic or on operated line, with track possession going from several days to several months, etc …) have a tremendous influence on construction costs.

The construction of the new high speed line section of Eastern Europe HSL in France is proportionally far more simple and cheaper than the construction of the section from PARIS station to the beginning of this new section, including the modification of all existing signalling installations while the traffic is still operated.

Solutions may however be found to minimize the cost.

For example, in Germany new constructions are build in parallel to the existing system and put into operation in a very short time. Hanover main station was put into operation in two nights; during the day between these nights normal traffic was operated. Hanover main station has a volume of some 850 points, signals, blocks, locking keys.

4.5. Risk management

The allocation of risk between the IM and the manufacturer must be balanced.

If the manufacturer is obliged to support extraordinary risks as sabotage or bomb attacks, the manufacturer will make a very big provision.

Recommendation: a risk analysis must be done before the project begins. The risks must be identified and reasonably allocated to the IM and the manufacturer.

4.6. The real driving criterion for cost is the LCC

The LCC is a quite new approach, even if many people use to say that it is commonly used.

The LCC includes :

- Development costs
- Procurement and construction costs
- Operating and maintenance costs
- Disruption costs

The construction cost of a signalling installation is the main part of the LCC. This is not the case for the track for instance

5. Many actors influence the cost

The cost of Signalling, systems and installations, depend on many actors (IM, manufacturers, No BO, Safety authorities, operators, Standardisation Bodies …) whose objectives are not necessarily coherent.

Every actor must know that its decision may have huge consequences on the others and must not forget the optimisation of the overall railway system.

6. Setting up costs for signalling equipment and installations

6.1. Different cost items

The main cost items are the following:

1 - Development of generic equipment

1.1 - Development

1.2 - Safety demonstration

2 – Procurement and construction of a specific installation

2.1 - Identifying needs for the installations (operation and maintenance needs)

2.2 - The construction of the installation

2.3 - Testing and commissioning

2.4 – Training of operators, drivers and maintainers

3 – Operating and maintenance costs

3.1 – Operating costs

3.2 – Maintenance costs

6.2. Solutions to reduce cost of a generic equipment

6.2.1. Development costs

- Identify very well the needs before starting developments.

  This can seem obvious but how many development projects exceed expectations in terms of cost and duration because high and low level needs haven't been correctly stated at the very start, also because the real users haven't been sufficiently involved and that the human element or social acceptability has been underestimated ?

  Recommendation 1: the IM should define its requirements for the network or defined parts of the network (high-speed lines, line with low density of traffic…) as precisely as possible.

  Recommendation 2: As far as it is possible, the manufacturer should propose a generic system. Then, if you have a global system solution, which fulfills all the system requirements of an infrastructure company, you will only need developments in very few cases.

- The development of any new signalling system lasts at least three or four years.

  The actors may change. The context may change.

The risk of change request must be managed and reduced.

Everyone must be aware that the cost of these changes is quite important and that they have negative influence on delays and on quality (including safety) and finally they generate extra costs.

Recommendation: Do not change needs and specifications during the development. Define functional stages

- The development cost of software is the main part of the total cost.

Recommendation: design the software as independently as possible from the hardware and implement the means to control obsolescence problems.

It is very important that the IM does not change the requirements / specifications too often. Ideally, the specification should not be changed over a long time. And in the mean time the project have to respect the restrictions given by the requirements / Specifications.

- Define technological stages.

i.e.: Stick to a technology during 10 or 15 years and do not follow blindly the market.

Recommendation: Enter into partnership or make long lasting deals with industrial manufacturers.

- Try to increase the volume of series, standardise what can easily be.

i.e.: Design electronic interlocking modules able to process several signalling principles from different countries.

Recommendation 1: Do not try to standardise what is too national specific and involves heavy alterations of regulation leading to important training costs.

Recommendation 2: Promote type approval for a long series of installations to avoid adaptations of the approved type in nearly every project. It must be clear for the IM's, that every change of the approve type will drive the cost and that the IM's have to pay for it.

- Have resort to standard industrial off the shelf solutions and not only railway specific.

Recommendation: Use industrial PC or programmable controller but define at the same time as the development a clear and efficient spare parts politics

6.2.2. Safety demonstration costs

- The cross acceptance should be strongly encouraged. See (1) (2) (3).
- Use proven solutions already existing where applicable and limit specific development. If this is not possible:
  - Define very carefully at the very start of the development the hazardous situations, what is the tolerated level of risk and what safety level is aimed at.
  - Define very clearly at the very start of the development, how identified hazards will be controlled and reach a consensus between designer and safety authority about the safety principles used and the proposed methods to demonstrate that they do allow to achieve the expected level of safety.

Recommendation 1: Safety of a system must be considered as a whole. It lies on explicit and implicit rules (which depend on the culture and the industrial history of the country)

Ex. 1: The culture of “safety” and therefore the associated behaviour of Latin operators (France, Italy, Spain) is very different from the one in Nordic countries.

Ex. 2: Regulations and therefore hazards that are mitigated by applying procedures by operators, especially in degraded situations, are very different from one network to the other.

Recommendation 2: A generic risk analysis should be carried out for a network or a defined part of a network but should not be carried out for every project with different results and consequences for the technical solution.

To neglect these parameters can lead to deep and late questioning concerning the specification of new systems and therefore to huge overcharge.

6.2.3. Procurement costs

- A major part of procurement costs results directly of choices made during the specification and development stages.

  The functionalities of the generic system must be restricted to the real needs.

  For instance, on small lines, the following ideas must be used:

  - Create portative on board equipment that are brought by the driver, instead of fitting all the rolling stack units with fixed equipment.
  - Accept the existence of small series of rolling stock units, adapted to specific lines / instead of having a homogeneous fleet.
  - Use satellite based systems (as GPS)

- Appeal to new technologies

  They may be used in an efficient way in signalling field.

  For instance, the GSM-R gives the opportunity of removing many cables or fixed telephones along the track. GSM-R may transit information for automatic warning systems ensuring staff protection.

- Appeal to innovating materials commonly used in other fields (for instance composite materials).

6.3. Solution to reduce construction costs of a specific installation

6.3.1. Costs of identifying needs for a specific installation

- A good analysis and valuable expression of needs:

  A signalling installation is intended to answer operation needs: how many trains per hour? How many will stop? How many pass at speed? What speed? Which operator will come? Which speed control system will they use? Which operations do we want to be able to perform simultaneously? What traffic density on this portion of line?
  These needs have to be correctly registered and formalised.
  These needs have to be stated in terms of performance and not in terms of technical solutions.

The interests of the various railway activities (long distance passengers, regional passengers, Freight, Infrastructure maintenance) are usually antinomic.

A formal process must lead quickly to an unquestionable compromise.

There are very few complete and rigorous tools to analyse needs for operating.

These analyses are often carried out by experts who are easily contested by operator managers, maintenance managers and investors.

- The need analysis for a specific installation must take place in a global and long-term planification of the network's evolution.

  If it has been decided to build only big control centres, any change in any concerned station has to comply with the long-term strategy.

  Nevertheless, the installation must comply with the known needs (for the next five years for instance) and must not be over-specified.

  This long-term strategy must take into account affordability. The IM may not have at once all the necessary funding for the complete and most efficient solution.

- The standardization of operating rules and signalling principles

  Recommendation 1: Existence of standard operating rules (at national and, if applicable at european level, known and respected by bodies responsible for defining the needs for installations and by the Infrastructure Manager.

  Recommendation 2: The maximum elimination of specific geographical configurations leading to site-specific operating rules or signalling principles.

  For instance, in France, the non motorization of points located on main lines and leading to private tracks or the automatization of level crossings close to stations create usually new site specific operating rules.

- The signalling people must clearly explain to the operators what the future installation will be.

  The signalling people do not always explain clearly enough to the operating people what the future installation possibilities will be.

  The description may be given in a too technical way and it is difficult for the operators to project themselves to the future, forgetting their present difficulties.

  Recommendation 1: Use operator oriented simulators

  Recommendation 2: The training documentation must be written by operator people.

To question expressed needs is subject to important overcharge for signalling installation, and the later this questioning occurs the higher the overcharge.

6.3.2. Costs of the procurement and the construction of the installations :

Different examples are described in appendices:

- Appendix 1: Refurbishing an existing line (without change of lay out)
- Appendix 2: Building a new High Speed Line
- Appendix 3 : Building a new interlocking

Tracks for organisation

- Nominate skilled project managers in signalling area personally responsible for the project planning and cost monitoring.
- Get through a deep preliminary thought on the conditions of execution of the working site :

  Ex. : How many phases do you need for the track works ? for the overhead line works ? for the signalling works ? Does the interlocking have to be set with the final configuration?
- Negotiate long traffic interruptions with the railway undertakings.

  In some countries, the separation between infrastructure manager and the railway undertakings has allowed getting unbelievably longer track interruption than in previous organisations.
- Have resort to innovating techniques for the installation of equipment.

  Ex. 1: Install panels by using helicopters.

  Ex. 2: Organise the work site in order to install equipment to the maximum by road means instead of rail with work trains.
- Carry out cabling and testing on test benches or in factory as much as you can instead of having them made on site.
- Control the supply process to avoid shortage that would disorganize the work site.
- Have the works subcontractors to enforce a quality assurance process in their companies.

Tracks for procurement cost

- Have resort to mass produced non-railway specific industrial solutions.

  Ex: The resort to low voltage industrial UPS reduced the costs of supplies by 30%.
  In such cases, define clear and efficient spare parts and obsolescence politics.
- Deal with industrials on contracts lasting from 5 to 8 years.
- Try to have two sources for each equipment or system.

Other related tracks

Signalling installations are connected to other kind of non-signalling equipment for which the costs are not often well known by signalling engineers who greatly underestimate them.

It is particularly the case for buildings and civil engineering related to signalling (cable trays, underground railway crossing, access gallery, outdoor cubicles, field centres).

Standardise these equipment, have resort to solutions likely to limit the work on site (ex.: shelters) and undertake optimisation studies of service will lead to important savings.

For example, using shelter for way side buildings including the whole inside equipment which can be delivered from the manufacturer directly to the installation site

So the shelter including the interlocking can be manufactured and tested in the factory. There are fewer costs for assembly of the inside equipment in the installation.

6.3.3. Costs for testing and commisionning

- Analyse in detail the global process of execution for an installation and in order to avoid double work define carefully the tasks assigned to the manufacturer and to the external body in charge of technical audit (usually carried out by the network on behalf of the safety authority or by the safety authority itself).
- Define well the verification and testing methodology to avoid letting too much latitude to appreciate the depth of the verification and testing.
- To be discussed: (Comment KHS: Check the possibility to carry out assessments by in-house ISA’s (see our first publication on cross acceptance) and the successful way in Germany regarding “Prüfleitstellen”.)

7. Solutions to reduce operating and maintenance costs

7.1. Operating costs

- Remote control and big control centres
- Standardize the work of each operator
- Flexibility on the number of operators depending on the traffic density

7.2. Maintenance costs

They may be divided in three types:

- Preventive maintenance costs
- Corrective maintenance costs
- Evolutive maintenance costs..

The classical ways of reducing preventive and corrective maintenance costs are the following:

- The system must have an efficient and ergonomic auto-diagnostic tool
- The system may allow for a simple first maintenance level by simple spare part exchanges

- The use of predictive remote-maintenance system, especially for field equipment (eg points) or for power supplies.

The classical ways of reducing evolutive maintenance costs are the following:

- Even if it’s obvious, try to limit the number of evolutions
- The IM must be conscious that We should make clear that the cost of for adaptations of approved types are not only driven by the development but also (and perhaps more) by the administration of all of these similar but different types over a long time on the side of the supplier and the IM.)
- If it’s impossible, gather different evolutions in only one major modification
- The principle must be: whoever asks for a modification must pay for it.

For instance, the evolution of ETCS from V0.0.0 to V3.0.0: who will pay for this evolution and for the following versions?

Appendix 1

Refurbishing an existing line

(Without change of lay out)

	Source			
Part	Network Rail (GB)	SNCF (France)		
Signalling cost / overall project cost	30%	30%		
Signalling Equipment procurement cost (1)	5%	15%		
Building (1)	20%	12,5%		
Power Supply (1)	15%	6,5%		
Telecom (1)	10%	10%		
Pway (1) (2)	5%	2,5%		
Civil Works (1)	20%	20%		
Project Management (1)	15%	15%		

(1) In comparison with the total signalling cost

(2) In comparison with the superstructure overall cost

Appendix 2

Building a new HSL

	Source			
Part	Network Rail (GB)	SNCF (France)		
Signalling cost / overall project cost	30%	20%		
Signalling Equipment procurement cost (1)	5%	15%		
Building (1)	20%	10%		
Power Supply (1)	15%	6,5%		
Telecom (1)	10%	10%		
Pway (1) (2)	5%	2,5%		
Civil Works (1)	20%	20%		
Project Management (1)	15%	15%		

(1) In comparison with the total signalling cost

(2) In comparison with the superstructure overall cost

Appendix 3

Building a new interlocking

	Source			
Part	SNCF (France)			
Building (1)	10%			
Power Supply (1)	8%			
Outside cables (1)	10% (2)			
Field components (1)	32%			
Electronic Interlocking (1)	20%			

(1) In comparison with the total signalling cost

(2) Including civil works

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