Strategic drivers of change in the signalling industry

Prepared on behalf of the IRSE International Technical Committee by Alan Rumsey

The purpose of the IRSE's International Technical Committee (ITC) is to provide thought leadership and disseminate learning on technical topics relevant to train control and communication systems. This provides value not only to IRSE members but also to the wider rail industry. The committee's particular strength lies in its international membership, enabling engineering principles and practices from a diverse range of countries to be brought to bear upon the subjects that are debated.

In this report Alan Rumsey describes the committee's view on the strategic drivers that are leading to significant changes within our industry.

This report has been prepared to summarise the strategic drivers of change in the signalling industry, as viewed by the IRSE International Technical Committee (ITC).

This report does not attempt to capture every factor influencing change in our industry, or focus on specific technical details, but rather to capture the primary trends, from an international perspective.

The report is divided into two sections. The first section discusses drivers of change from the perspective of the user/specifier of signalling system. The second section addresses drivers of change from a supplier/provider perspective.

The ITC considers the primary technology drivers to be:

- Continued emphasis on system safety (re-definition of 'safe-state', re-evaluation/application of ALARP principles, cyber security, etc.).
- Increased focus on operations (capacity, automation, system reliability/availability/maintainability, 'big data', etc.).
- Lower cost signalling solutions to support business case for signalling upgrades (commercial considerations, obsolescence considerations, etc.).
- Maintaining a competitive edge (engineering processes, hardware costs, software costs, implementation costs, etc.).
- Global solutions/products (and technology convergence).
- Communications technology considerations

The reasoning behind the above list is summarised in the following sections of this report.

Many of the topics in this report have been the subject of prior ITC articles, or are the subject of articles currently under development by the ITC. Relevant references are provided as footnotes to this report. Note that the ITC has also recognised the challenges of introducing changes within the railway industry[1].

SECTION 1: DRIVERS OF CHANGE FROM THE PERSPECTIVE OF USERS/SPECIFIERS

Continued emphasis on system safety

Maintaining and improving the safety of rail transportation systems, through the application of 'fail-safe' principles, will continue to be a primary technology driver within the signalling industry, with the goal of mitigating hazards arising through human errors in design, installation, operation and maintenance[2].

Re-definition of 'safe-state'

It is increasingly being recognised that while bringing a train or trains to a stop may mitigate any immediate hazard of a train collision or derailment, this state may not be free from other hazards, nor does a stopped train fulfil its fundamental mission to transport people and/or goods[3]. As such users are driving the signalling industry to take a more holistic view of rail transportation operations with designs that recognise the importance of both system safety and system availability, and that not only provide 'fail-safe' characteristics but that also exhibit graceful degradation characteristics following equipment failures.

Application of ALARP principles

It is recognised that safety is not absolute, but involves an assessment of risk and a judgement as to whether or not a risk has been mitigated as far as is 'reasonably practicable' such that the level of risk can be considered acceptable or at least tolerable. The phrase 'reasonably practicable' itself implies that a risk mitigation measure must not only be possible, but implementable at a cost commensurate with the safety benefits to be gained.

Whether or not a particular hazard has indeed been reduced to as low as is reasonably practicable (ALARP) will therefore need to be periodically re-assessed in light of operational changes (e.g. increases in line capacity which may increase the likelihood of a hazard occurring), and with consideration of the newer technologies that become available (which may reduce the costs of mitigating a hazard) as well as experiences from other Users and decisions made on other projects.

Cyber security

Historically, the definition of safety within the signalling industry has not been extended to address security, which deals with harm through malicious intent. However, current security concerns and, in particular, cyber security threats, will drive signalling technologies, approaches and architectures that integrate these two disciplines in the design and operation of rail transportation systems; the safety management system will become the safety and security management system[4].

Increased focus on operations

Delivering higher levels of service, and removing operational constraints imposed by the signalling system, will continue to be important technology drivers in the future[5]. The signalling level will no longer be the primary focus; instead the focus will move toward the operational level.

Capacity

Maximising the operational utilisation of rail transportation infrastructure through 'moving block' signalling principles and control centre consolidation[6], for example, with increased emphasis on operational decision support systems, will continue to be significant drivers of signalling technology evolution, and may include consideration of alternative safe braking models that are not based on an instantaneous 'brick wall' stop of a preceding train[7].

Automation

Although the rail industry is not pursuing automation at the same pace as the automobile sector, there are nevertheless increasing trends towards higher levels of automation of rail transportation operations, up to and including driverless/unattended train operations[8]. This trend is expected to be a continuing technology driver in the future, not only for urban transit systems (metros/light rail), but also for main line rail systems[9].

System reliability/availability/maintainability

The next generations of signalling technologies will also be expected to inherently offer improved reliability/availability/maintainability characteristics, moving away from reactive corrective maintenance to risk-based, condition-based preventative maintenance, and better service recovery[10,11,12]. This will include the increased use of low-cost sensors and communication systems to deliver continuous/regular condition monitoring, supporting predictive preventative maintenance.

'Big data'

Modern signalling and communications technologies are able to capture and store increasing volumes of valuable operations-related and maintenance-related data. The magnitude of this data can however be overwhelming to system users. This is driving an increasing interest in, and application of, 'big data' tools, fully integrated within signalling/train control system designs, to provide more efficient and more effective system alarm management and system analytics, specifically to meet the user needs described above.

Lower cost signalling solutions to support business case for upgrades

While the safety and operational benefits of the latest generations of signalling technology are well recognised, the cost of implementing such systems can often be prohibitive when developing a business case justification[13]. Developing lower costs signalling solutions will therefore be an important technology driver in the future. The users (infrastructure managers) have expressed many time that they need to do more with less money available.

Commercial considerations

Commercial considerations will continue to drive the need for interoperability and interchangeability standards to avoid, for example, the need to equip rolling stock with multiple signalling systems, and to provide for multiple sources of supply with competitive procurement of both train-borne and wayside signalling equipment.

Obsolescence considerations

The drive to deploy new signalling technologies to meet the business needs in a timely fashion also needs to drive fundamental changes to the current system and safety assurance processes which are often onerous, costly, and time consuming[14]. In addition, the business case for new signalling systems and signalling system replacements will increasingly focus on life-cycle costs in addition to initial capital costs, with specific consideration of provisions to mitigate equipment obsolescence[15].

Focus on lifecycle cost leading to standardisation

Infrastructure managers are forced, due to dwindling budgets made available by national authorities, to do more with less. As the operational costs over the lifecycle of a signalling system are now usually larger that the upfront capital outlay the focus is shifting to how to reduces lifecycle costs. One chosen way forward is the standardisation of the interfaces in the signalling system.

SECTION 2: DRIVERS OF CHANGE FROM THE PERSPECTIVE OF SUPPLIERS/PROVIDERS

Maintaining a competitive edge

The primary driver of change from the perspective of suppliers/providers of signalling solutions is, of course, to obtain a competitive edge in the industry in order to maintain/grow market share.

Engineering processes

With the increasing general shortage of qualified technical resources in the industry, this also drives a need to do more with less, and in a shorter period of time, which is turn drives the need for more efficient and more cost-effective engineering techniques to specifically include, for example, formalisation of requirements management processes and pragmatic, value-added systems engineering and safety assurance processes.

Hardware costs

Custom designed and built hardware for signalling safety system will become increasingly unsupportable and the need to reduce hardware costs will drive increased use of commercial-off-the-shelf (COTS) products within SIL4 signalling systems. This in turn will offer possibilities for new entrants into the signalling markets.

The need for increased flexibility and ease of reconfiguration may, for example, also drive the development of small sensors/controllers, with standardised interfaces, all linked together through an IP network[16], to continuously monitor asset condition, particularly of those trackside assets such as switches and crossings.

The trend to 'moving block' type systems, with reduced track-based equipment, may also drive the development of low cost sensor technology to, for example:

- Precisely and reliable determine train location in a fail-safe manner.
- Determine train length and train integrity[17,18].
- Confirm route integrity[19].

Software development costs

With the increasing use of computer-based signalling systems, software is becoming the key value-added investment which will drive the industry to keep abreast of the latest developments in software development tools and processes, for the cost-efficient production of both vital and non-vital high-quality, bug-free software. The goal should be to allow software to be ported to updated hardware with the minimum of new safety assessment work.

Implementation costs

One of the significant cost drivers in implementing new signalling systems, particularly on 'brownfield' projects, is the time required to fully test and commission the system in the field. The need to reduce implementation costs will drive an increased focus on minimising field test activities through enhanced factory testing with more sophisticated simulation tools, including the use of 'formal methods' where appropriate.

Flexible update and upgrade scenarios

The above are helping to create flexible update and upgrade scenarios where only life expired subsystems are replaced instead of complete systems. The user requirements for lifecycle cost reductions are a big driver here and as a consequence the current market behaviour of the supply industry needs to change.

Global solutions/products

The drive to reduce signalling system costs will continue to drive a move away from agency-specific and country-specific signalling solutions/products to global signalling solutions/products.

Technology convergence

The signalling industry is currently divided into two distinct and separate markets: the main line rail market (intercity passenger and freight), and the urban transit market (light rail, metros, commuter rail). Given the commonality of business requirements, and the need to drive cost efficiencies, there will inevitably be a further drive towards convergence in technologies and products to serve both markets.

Communications technology considerations

It is clear that the next generations of signalling technologies will be increasingly 'communications'-based, with increased relance on fibre optic and radio networks, and IP-based protocols, etc. The evolution of communications technologies (LTE, LTE-R, 4G, 5G and so on) will therefore be major drivers in advances in signalling technology to achieve the user needs identified in Section 1, with associated implications on radio spectrum allocation/regulation and interface standardisation, as well as safety and security acceptance/management processes. The access to cost-effective and efficient radio technologies will continue to be a critical issue for signalling system design.

This trend to communications-based signalling solutions is also shifting many signalling functions from the infrastructure to the train, driving the need for closer integration, and interface standardisation, between the train-borne signalling equipment and the other train subsystems.

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