IRSE INTERNATIONAL TECHNICAL COMMITTEE

Managing obsolescence of electronic equipment in signalling

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Introduction

The 1980s saw big steps in signalling technology as relay based systems began to be superseded by microprocessor based equipment. These interlockings and control centres are now more than 20 years old and the hardware and software components that they use have been rendered obsolete by rapid advances of computing and communications technology. This in itself is not a problem for the railway, as the systems are generally reliable and continue to deliver their operational and safety requirements, but it becomes an issue when there is a need to replace failed components or make changes to respond to new traffic demands.

The problem is not unique to this particular generation of equipment: it also applies to older systems using analogue electronics and newer software based systems.

The two problems that railways encounter in these situations are:

- Availability of new hardware from the original supplier to replace failed equipment or to extend a system
- Access to the know-how and software tools needed to re-configure the system

How old a system has to become before these problems are encountered will depend on several factors

- Is the hardware bespoke or “commercial off the shelf”?
- Is the system the mainstream product of the supplier or a “one-off”?
- How widely dispersed is the expertise and tools needed to re-configure the system?

Options for the railway

There are a number of options available to a railway operator facing these problems:

1. Complete renewal with a modern replacement

If major changes are required to the railway in the area that the system is controlling, then complete renewal with a modern replacement system is an attractive option. This might be triggered by track layout changes, capacity enhancements or new rolling stock. This will solve the obsolescence problem, allows a choice of suppliers of the replacement system, and allows the new system to be optimised for present-day requirements. However this is be a very expensive solution if all that is required is replacement of failed components or a minor change.

Example – London Underground's Victoria line was constructed in the 1960s with an ATO/ATP system based on analogue electronics, and over the years a number of components have had to be re-engineered to keep the system in service. Full renewal with a modern replacement system supplied by Invensys Rail Systems is now taking place, synchronised with delivery of new rolling stock.

2. Life extension with previously used hardware

At the opposite end of the range of options, it may be possible to extend the life of the existing system using hardware that has been previously used in another location. The concept of "strategic spares" is well established for older signalling components; when an old installation is taken out of service, components that are no longer manufactured are retained for use in similar installations that are being retained in service. However, access to the hardware may not be the complete solution – the know-how required to configure the systems is equally important.

Example – The German train operator DB needed to equip new trains with the ZUB train protection system to operate international services into Switzerland, but the on-board equipment is no longer manufactured. The solution was to remove the equipment from another fleet of trains that were no longer required to operate into Switzerland.

3. Upgrade with compatible modern equivalent

If a supplier can offer an upgrade path from the original equipment to a modern equivalent, this is likely to be more cost effective than complete replacement, because it may be possible to re-use some of the original components and application engineering (e.g. interlocking rules for the area).

Example – The electronic interlocking SSI was developed in the UK in the 1980s by British Rail in collaboration with Westinghouse Signals and GEC General Signal. Invensys Rail Systems and Alstom Transport have both developed modern interlocking products that are compatible with SSI trackside equipment and use the same application engineering language.

4. Bespoke development for life extension

If the original system was a special development for a small number of applications on one railway, then the original supplier will not have invested in further development. The only alternative to complete renewal will be to commission a bespoke development of a replacement system, which will probably only be a viable option in special circumstances.

Example – Another development by British Rail in the 1980s was Radio Electronic Token Block, which allowed operation without conventional signals on low traffic *regional routes. This was based on a very early version of SSI hardware which was superseded a few years later, but the RETB variant remained unchanged. In 2007 Network Rail decided that a life extension was needed to keep these systems in operation until ERTMS level 3 becomes available. A consortium of Signalling Solutions Limited, Park Signalling and DeltaRail was commissioned to modify the system to use the latest version of SSI hardware. If this had been delayed a few more years this solution would not have been possible, as the SSI hardware is about to go out of production, and staff with expertise in the original system are retiring.*

Trends in obsolescence

The hardware in 1980s signalling systems typically contains purpose designed circuit boards, but using commercial of the shelf (COTS) components such as microprocessors and memory devices. As the design and manufacture was under control of the signalling supplier, it has been possible to continue production for as long as the individual components are still available. With some substitution of components a production span of up to 20 years has been achieved for some successful designs.

The trend in more recent years has been to avoid purpose designed hardware altogether by designing systems around COTS subsystems, i.e. complete circuit boards or computers. This has significant cost advantages, but has had the effect of speeding up the rate of obsolescence. The product refresh cycle for a typical COTS subsystem will be 2-5 years, so it is quite likely that by the time a new signalling system has been developed and achieved safety approval in its first application, some of the components will already be obsolete.

Back in the 1980s, software for signalling systems was written to operate directly on a specific type of microprocessor, often in assembler language. This approach is not possible with the much more complex processors in use today. Modern signalling software is written in high level languages that allow the signalling application to be independent of the details of the hardware. To achieve this, the COTS hardware comes with a suite of COTS software, including an operating system, software libraries and device drivers. This software has a similar product refresh cycle to the COTS hardware, device drivers need to be updated when the hardware changes, and the operating systems and software libraries are also regularly updated. Keeping the software and hardware in step is crucial – if a hardware component becomes unavailable, and there is no suitable device driver software available for the replacement part, then the product can no longer be supported.

Future proofing signalling products of today

So, if railways are already struggling with obsolescence of 20 year old products, and the COTS hardware and software component lifecycle is now down to 5 years or less, what are signalling suppliers doing to ensure their modern designs are going to be easier to manage as they age?

The solution is to adopt a layered approach to system design. The lower layers are the general purpose COTS hardware and software, the middle layers are the generic and specific application software written by the signalling supplier to implement the product, and the upper layers are the signalling rules and geographical information that define the specific application to an area of railway.

By ensuring there is a well defined interface between each layer, the lifecycle for each layer of the system can be decoupled from the others. In many cases one layer can be changed without any impact on the others. When there is an impact, it can usually be contained to a change in the adjacent layer- for example a hardware change may require an update to a device driver in the operating system layer, but will have no impact on the application software or the signalling rules.

For safety related software, the layered approach has to be reflected in the safety case, with causes of hazards and safety requirements to mitigate them clearly assigned to each layer of the system. This approach avoids having to revisit the entire safety case when a change is made to one part of the system. It also reflects the need for different types of safety argument and validation methods that are needed in the different layers. This is in line with the CENELEC concept of Generic Product, Generic Application and Specific Application safety cases.

Layer	**Lifetime**	**Validation Methods**
Geographic data Signalling rules	50 years	Checking tools Principles testing
Application software Generic software	20 years	Formal methods Diversity Testing
Virtual machine Operating system Device drivers	5 years	Standards compliance Proven in service
Hardware	2 years	Standards compliance Conformance testing

Recommendations

Based on this analysis of the problem, the International Technical Committee of the IRSE has the following recommendations for railways and suppliers:

For railways –

1. Ensure that you understand where the products that you use are in their product lifecycle, and consider what options will be available when you run out of spare parts or need to make a change.
2. When you are making a decision on how to extend the life of an obsolete system, consider all the options and how they can be used in combination to minimise costs, e.g. where an old system is replaced by a modern one, this can release hardware to repair or extend similar installations elsewhere.
3. When purchasing new systems, try if at all possible to buy from the supplier's mainstream product line that will be supported and upgraded, and avoid one-off bespoke systems.

For suppliers –

1. Adopt a layered approach to systems development so that your R&D investment in software and safety cases does not become worthless when the original hardware platform becomes unavailable.
2. Provide customers with an upgrade path for your previous products so you do not lose them to another supplier.
3. Look for opportunities to replace an obsolete product that is no longer supported by the original supplier with a modern replacement by implementing compatible interfaces and functionality.