Why is Innovation so Difficult in Railways?

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Railways, and signalling in particular, are not generally well-regarded for being innovative. Talented job applicants with a high-tech back-ground, such as software engineering, are predictably surprised when told that mechanical computers (i.e. interlockings) are still widespread in the railway system, even if not a mainstream technology, and that relay-based interlockings are still regarded by some as "modern", and in certain respects are considered to be superior to ones based on electronics.

To an outside observer who is familiar with the fascinating potential of modern technology, the pace of innovation in railways might well be perceived to lag behind other industries just a bit too much. This observation applies not only to signalling but also to the speed of change in railway telecommunications, when compared with commercial and consumer telecommunications

When railways were first introduced, they represented an industry where cutting edge innovation occurred. For instance, when the first mechanical interlocking was installed in 1843 at Bricklayers' Arms Junction, England [1], it was in fact a state-of-the art logic computer, occurring at a time when Charles Babbage was working on his mechanical computing machines [2]. The mechanical technology for conquering arithmetic problems is long gone, yet mechanical interlockings are still here.

So it is reasonable to ask the seemingly simple question – why is that? Why are mechanical interlockings still being renovated? If in fact there is a business case for such an activity (compared with using lean IT technology with its associated potential for efficiency improvement in operating the overall system) – then should we not ask if something has gone wrong with the innovation process in railways, and if so what and why?

To avoid confusion about what is meant precisely by "innovation" for the purpose of this article, we should distinguish between "innovation", "invention", and "technological development/improvement". For the remainder of this article, the following definition and distinction is adopted:

"Innovation is the development of ... different or more effective products, processes, services, technologies, or ideas that are readily available to markets, governments, and society. Innovation differs from invention in that innovation refers to the use of a novel idea or method, whereas invention refers more directly to the creation of the idea or method itself. Innovation differs from improvement in that innovation refers to the notion of doing something different (Lat. innovare: "to change") rather than doing the same thing better." [3]

No one would claim that there is a general absence of innovation (or inventions or technological improvement for that matter) in railways. The European Train Control System (ETCS), Positive Train Control and Speed Advisory Systems for instance, can clearly be considered as being innovations, based on various inventions and making use of general technological development.

To illustrate the differing ways in which innovation is perceived, some people consider that relay-based and electronic interlockings are just "doing the same thing better" than mechanical ones. Others point out that the range of safety functions implemented in modern software-based interlockings, e.g. relating to overlap and flank protection, is much more advanced; not to mention the potential for improved efficiency by remote control and automation that they offer. They would therefore claim that these advances are "innovative" according to the definition given above.

There is one factor above all others that governs the speed of introduction of innovation on rail systems, namely the "scale" on which the innovation has to be applied in order to be worthwhile. Thus, for instance, Disneyland had moving block in the 1970s; and some metro systems have driverless trains. But these are localised applications.

These advances have occurred not because the engineers in those areas are any better or more innovative than signal engineers working on large railway networks. On the contrary, one could argue that maintaining a large quantity of heterogeneous technology across a large and distributed infrastructure network with such a high level of safety and reliability is an art mastered by no other engineering discipline to the same extent. The longevity of mechanical interlockings could be claimed as proof of the signal engineer's far-sighted design, rather than being a criticism.

It is however apparent that the scale (size) of a railway network, and the large number of people/bodies that need to be aligned in order to introduce any change, seem to pose more challenges to the innovation process than in other contexts where localised innovation is possible. A further difficulty with innovation may be that railways are a mature industry, so that innovations do not easily offer returns on the investment made.

In addition, there appears to be a number of more subtle reasons for the failure of innovative ideas in our engineering domain, including:

1. The new idea does not fit with the existing (often aged) infrastructure;
2. The new idea does not fit with the culture of the corresponding railway/country;
3. The new idea does not fit with existing regulations and operational proce-dures;
4. The idea does not meet a real need, in the opinion of railway experts;
5. The originators of the idea are not trustworthy and/or do not have the right background, in the opinion of railway experts;
6. The originators of the idea (or the organisation they work for) are not considered to be likely to be around for long enough to support the innovation through its whole life cycle, right through to obsolescence (50 years or more);
7. In the opinion of railway managers, there might be no business case for the idea;
8. There might be a business case on the global level, but local application within a fragmented industry prevents the potential benefits from being realised;
9. The market potential is seen too small for investment by railway suppliers, because the application circumstances differ too much from country to country;
10. The idea is innovative at a component level, but there are no standardised non-proprietary interfaces to enable replacement of the old version with the new one, without renovating the systems of several other suppliers at the same time;
11. Safety approvals appear too difficult to obtain, or there are other liability issues that cannot be overcome;
12. No sensible roadmap can be constructed upgrading the entire network.

Having established this list of plausible reasons for the failure of new ideas to reach the implementation phase, the fact that innovation appears to lag behind in the railway industry seems less surprising.

However at the strategic level, it should be clear to all stakeholders that any system that consistently lags behind in its application of technology will lose its competitiveness sooner or later and hence be removed from the surface of the Earth, or be banished to the museums at best! Given the current cost base of our industry, one main goal of innovation must be to lower the whole life cycle cost of systems and thereby make change more attractive.

As stated earlier, this article does not suggest that engineers in other comparable industry sectors are better than those in our own. On the contrary, other systems that comprise a large collection of existing infrastructure, such as air traffic control, seem to have similar struggles. For instance, the introduction of new generations of transponders into aircraft fleets takes some 40 years. In comparison, the 20 or so years that it took for ETCS to move from concept to its first reasonably efficient introduction in a project (the Lötschberg Base Tunnel in Switzerland) seems surprisingly fast.

Cleary, no one can imagine a quick technological, "i-phone-like" revolution in railways. On the other hand, at the very least evolutionary innovation should and must be possible. True innovation needs a clear vision as to how we want to operate our railways and rail transit systems in the future, and needs pioneers/champions committed to take on the challenge of delivering that vision fast enough, such that the investments pay off.

Looking again at the "12 reasons" stated above it should be obvious that we need to distinguish between "valid reasons" that hinder innovation – intrinsic and unavoidable in the system "railway", and "other reasons", which would cease to obstruct innovation if the right structural changes were made at the strategic level. For example, considerable progress with the standardisation of interfaces in road traffic control systems (see reason 10 above) – another strong competitor of the railway – seems to have been made already. If, as a consequence of such advances, this reason were no longer apply to apply in the rail sector, it might also remove other obstacles (e. g., nos. 1, 6, 8, 11).

Based on this example it seems worthwhile establishing a more comprehensive list of reasons for relative scarcity of innovation in our industry, and to perform a cause-consequence analysis in order to understand the underlying mechanisms better. However, that would be part of the next step, i.e. answering the question "How do we make railways more innovative?", which lies beyond the scope of this article.

Some people might argue that this article delivers no real news and that there are other underlying obstacles to innovation. For instance, during the development of ETCS the standardisation of interfaces on the vehicle had been proposed, but was declined by industry, suggesting that the difficulties with innovation may also be attributed in part to conflicts of interests. This may be true, but nevertheless a fundamental review of the mechanisms of innovation in our industry still seems to be a crucial step for long-term success.

Clearly, no single stakeholder in the rail industry would be able to remove a sufficient number of hindrances to innovation. Therefore it would seem necessary for governmental agencies, railway companies, suppliers, research bodies – and indeed the IRSE – to collaborate and to establish roadmaps for removing obstacles for innovation in the railways, while taking into account the particular interests of each group.

Given the IRSE Centenary theme of "Facing the Future", if the vision for the future and the pioneers/champions committed to implementing this vision do not reside within a body such as the IRSE, then where do they reside?

[1] ***http://en.wikipedia.org/wiki/Interlocking***
[2] ***http://de.wikipedia.org/wiki/Charles_Babbage***
[3] ***http://en.wikipedia.org/wiki/Innovation***