Digitalization and the Transport Industry

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Digitalization and the Transport Industry – Are we Ready?

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***Abstract*—Digitalization offers the transport sector great opportunity to revolutionize the way in which it does business, enabling improved interaction with customers, the use of novel business models that span transport modes, and fine-grained control of operations in real-time. Despite the potential advantages of digitalization of fleet and infrastructure, many transport networks have been slow to embrace novel technologies; accepted thinking is that this slow response in many traditional transport settings is due to the long lifecycle of the infrastructure on which many transport networks depend, coupled with the safety-led culture that pervades the sector, but is that true? Based on the outcomes of a workshop session held as part of an industrial Continuing Professional Development (CPD) program, this paper presents an industrial perspective on the challenges posed by the digitalization of the rail network of Great Britain, with a view to stimulating debate around the common digitalization challenges facing rail and other transport modes as we move forward into the 21st century.**

***Index Terms*—digitalization, industrial perspective, legacy challenge, clarity of vision**

I. Introduction

Digitalization offers the transport sector great opportunity to revolutionize the way in which it does business, enabling improved interaction with customers, the use of novel business models that span transport modes, and fine-grained control of operations in real-time. In other sectors, such as healthcare, we have seen relatively swift adoption of digital technologies [1] where they support core business functions e.g. management and transfer of records or managing the interaction with patients, and this trend has been accelerated by the impacts of COVID-19 [2]. In many transport settings however, and particularly in mainline rail, much of the digital transformation activity that has taken place has been by external disruptors, such as Uber, or by third party companies operating across traditional modal silos, e.g. by providing end-to-end ticketing services. So what is delaying the digital transformation of transport, and how, as an industry, can we address those challenges?

II. Literature Review

It has been reported that "70% of all Digital Transformation initiatives do not reach their goals" [3]. While it would be easy to assume that Digital Transformation was all about technology, that there was a "sliver bullet" piece of equipment or service offering which, once procured, would turn an organization into a lean, competitive, innovative entity, fit for the 21st century this is simply not the case; real-world experience has shown that while

technology is a critical aspect of the digitalization of a business, new software and systems alone only provide opportunities for enhanced customer experience, staff productivity, or operational efficiency. In order to leverage those opportunities and achieve the business benefits, it is necessary to think about the technology as part of the wider sociotechnical system of the enterprise, a system in which Industry 4.0 (automation, technology, and data / digital models of assets) complements Work 4.0 (people, business process, and strategy) [4].

The nature of digitalization varies from sector to sector. In production environments, such as steel manufacturing [5], digitalization is about process control and automation of plant or line; in construction, digitalization mainly refers to the adoption of Building Information Modelling (BIM) tools that relate the asset as planned to the asset as built [6] and enable us to understand how they will behave through their lifecycle; in transport, digitalization as a concept is typically associated with many different areas of the business: to the provision of near real-time operational information (either to the customers, or to the operators of the transport network itself), to the development of disruptive tools, such as mobility as a service platforms, or to new ways to control vehicles and infrastructure, be that in the form of self-driving cars, convoying of freight vehicles, or migration to digital signalling / traffic control systems. The chimeric nature of digitalization is linked to the differing strategic priorities of the sectors involved, and means that it can be challenging to transfer best practice around this aspect of digital transformation between sectors.

As well as internal strategic drivers, many digital transformations are responses to external changes in the business environment. The digitalization of the workplace that sprang out of the COVID-19 pandemic for example, has also provided new challenges for transport in the form of "virtual mobility", a concept that is changing perceptions of need for the daily commute [7].

When considering the implications for a business, digital transformation, as with any disruptive change, is likely to result in fundamental changes to established ways of working [8]. In regulated sectors, such as transport, the role of the regulatory authorities in transformation programmes has been recognised for decades (e.g. Mahon and Murray in the early eighties [9]), and means that there are additional political and societal dimensions to digital transformation that must be considered alongside the pure economics. While regulation can be helpful in facilitating sector-wide transformation (particularly where there is an understanding of the need within the constituent businesses), the dilution of the single sense of purpose seen in purely commercial settings makes it more difficult for businesses in regulated sectors to deliver transformational change quickly.

The alignment of business and IT strategies that is inherent to digital transformation is a difficult and often controversial endeavour [10] within an industry, where the technology-led, roadmap-based delivery vision for corporate IT is frequently at odds with the softer, product and value-led world of business planning. Even within the comparatively uniform world of IT strategy, digital transformation is far from easy to manage. In particular, the interplay between legacy, mission-critical software and hardware, and the new systems necessary to deliver planned future capability create a "Right Tech, Wrong Time" dilemma [11], in which a team can have made all the correct technical strategy decisions in isolation, but then find those efforts cannot integrate with the existing assets on the ground. The issue of legacy hardware is particularly significant in infrastructure heavy transport modes, such as mainline rail, where assets have long service lives; some elements of the operational rail infrastructure in Great Britain date back to the early

20th century [12], and any digital transformation must be done in a way that is cognizant of the fact that those assets will remain in the ground until they are fully life-expired or a major upgrade programme forces their renewal, at huge capital cost.

Digitialization has profound implications for training and knowledge retention within the workforce, both in terms of the upskilling existing staff to successfully operate the novel technologies, and in terms of assisted working, where an employee need only follow the instructions of an IT system [13] (e.g. augmented reality solutions that could direct specific maintenance tasks for a semi-skilled technician / workforce member).

In the rail industry of Great Britain specifically, digital transformation has been on the agenda for the last decade. The rail value for money study chaired by Sir Roy McNulty that was published in 2011 [14] found that at that time the industry's information systems were woefully inadequate to meet the demands of a modern railway, and since that time the theme of digitialization has featured heavily in vision and strategic documents including the Rail Technical Strategy of 2012 [15] and the Digital Railway Strategy of 2018 [16]. The network has also seen some deployment of digital signalling, including the Cambrian line ERTMS trials and the East Coast Digital Programme, yet despite the apparent willingness and drive towards digital transformation widespread change has been comparatively slow to manifest itself within the industry, posing the question "is GB rail ready for digitalization?"

III. Method

In order to understand the industry perspective on the opportunities arising from, and barriers to, the implementation of greater digitalization within the GB rail industry, a half-day workshop was held as part of an industrial Continuing Professional Development (CPD) programme on Digital Railway Leadership. Participants on the programme were senior staff members from the industry, with responsibilities for procuring, delivering, or exploiting future digital technologies within the operational railway. To stimulate discussion between participants and formally capture the outcomes, a professional scribing service was employed to facilitate the session. In order to ensure that participants were sufficient aware of the possible forms of digital transformation the business might experience, the workshop was held towards the end of the delivery of the CPD programme; by this stage all participants had already been involved in visits to supplier sites, to digitalization projects in other rail industry settings across Europe, and in a range of classroom sessions on digital technologies, systems thinking, and change management.

A. Activity Sessions

The half-day workshop was divided into four sessions. Each scribing session lasted for approximately half and hour and had a specific focus designed to draw out the participant's thoughts on a different aspect of the digitalization question; these included capturing the current industrial context in which digitalization would take place, understanding participant views on the challenges the industry presented in the area, articulating the "big questions" that would determine whether the digitalization agenda would be successful, and outlining five "bold steps" that would enable the industry to move forwards in the short to medium term. Once the theme for the scribing session had been introduced to the participants, they were encouraged to engage in free-form discussion around that topic while the scribing team worked to graphically capture the main discussion points on wall charts (in full view of the participants). Once the half-hour discussion period was completed, the participants were invited by the session lead to summarise their

discussion based on the content of the draft wall chart, enabling the scribes to validate their capture of the discussion and add refinements where necessary. The "final" illustrations presented in figures 1 to 4 were drawn up from the wall charts after the sessions, but have been crossed checked against the draft images to ensure they are an accurate reflection of the earlier material, albeit with slight changes of ordering *etc*. to account for repetition or overlap of discussion during the live activity.

IV. Results and Discussion

A. Industry Context

In the first activity session, the participants were asked to describe the context of the industry and, in particular, of those areas of the industry that would be most heavily impacted by any increased use of digital technologies. The illustration produced during the session is shown in Figure 1.

The central themes of the discussions around industry context were the economic processes and environmental impact of the industry, and in particular how the 5-year funding / planning cycle of GB rail, known as control periods, made it difficult to conceive of the type of far-reaching change that would be required for the introduction of a paradigm shifting technology, such as digital signalling. Governmental targets around net zero carbon were seen as an opportunity in this space, as rail is widely regarded as an affordable, low-emission [17] mode of transport on the proviso that lines are electrified and the generation mix is primarily made up of renewable sources. Any innovative technology that encouraged modal shift towards rail was therefore considered as a net gain for UK plc, and would therefore be considered to be supporting the case for rail in the carbon vs. cost investment argument.

Increased modal competition and falling revenues as a result of the COVID-19 pandemic have been a topic of discussion within the GB rail industry in recent years, and while passenger numbers have largely recovered, the increase in remote working has meant that the lucrative "peak time" passengers have been the slowest to return. In that regard, work from home / virtual mobility was felt by participants to be a significant a "competitor" to rail alongside other transport modes e.g. road. Disruptive digital technologies in competing modes were a cause for concern, particularly where they allowed private transport to become as accessible as rail, e.g. the potential for self-driving vehicles to make door-to-door road commutes productive work time in the same way that rail has always been.

Demographics of both industry staff members and key customer groups were seen as a key point of context during the discussions. In particular, a lack of digital skills amongst the aging core of staff, coupled with diverse skills and appetites for digital services different amongst passenger groups, were seen as a huge challenge. Smart ticketing for example, offers a significant opportunity for improved passenger experience and operational cost savings over the traditional paper-based approaches still in widespread use within the industry, however, while it may be possible to realise the majority of the passenger experience benefits for those willing to adopt the new technology without a complete transition to the new system, it is hard to imagine that anything more than token operational savings can be made until all passengers are both willing, and sufficiently technologically skilled to allow paper tickets to be removed entirely from the network. The drive for improved real-time information was also seen as a key need by the industry, with an aspiration to deliver a more airline-esq experience during disruption, but it was noted that recruiting to expand the digital skills base within the rail workforce had proven

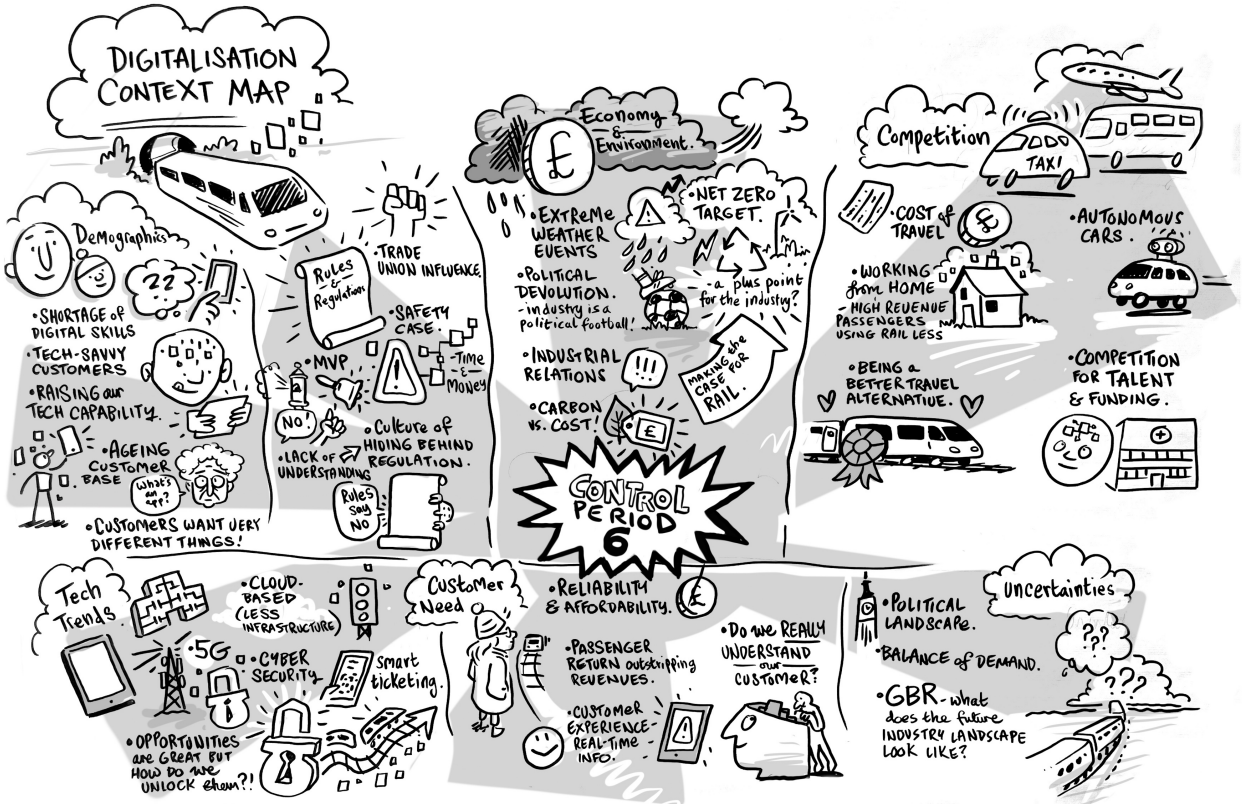

Fig. 1. The "Industry Context" in which digitalization is proposed.

challenging previously, with rail not seen as a prime career target for in-demand IT workers.

Staffing was also considered a significant point of context in terms of the prevalent behaviours and attitudes towards digitalization within the industry. Rail is a safety-critical sector, and therefore highly regulated; participants felt that these regulations, coupled with a lack of understanding of digital technologies within the workforce and an associated unwillingness to sign-off on potentially safety-impacting changes, were often used as an excuse to block changes to the traditional operating processes of the railways. The Trade Unions were felt to be a pivotal influence in this area. An interesting aspect of the safety case discussion was around the need for a new way to deal with safety case development in a digital railway. Traditionally safety cases assume that an asset, once certified, remains largely static (in terms of functionality and behaviour) for its working life; the need for regular patching to, and updates of, digitally-enabled infrastructure mean that the asset could be regarded as changing on a regular basis, and thus require re-certification, a costly and time consuming process. Therefore in a digital railway it will be necessary to come up with new processes for confirming the safe operation of the core functionality of an asset, while accepting that other details of how that functionality is achieved may change. This issue is not unique to rail, and a number of research projects exist in other industrial control contexts that are also grappling with these issues.

Finally, participants commented on the uncertainty in the future of the industry, particularly around governance and structure. It was noted that in countries such as

Norway, where large-scale digitalization activities had started in recent years, these were part of a major commitment by the local authorities to the future of the industry. The wavering levels of commitment by the UK government to initiatives such as Great British Railways, and the constantly changing political vision for what role the GB rail industry should fulfill, was felt to make long-term planning and investment decisions impossible and constituted a serious barrier.

B. The Challenges of Digitalization

In the second session, participants were asked about the challenges large-scale digital systems deployment posed to the industry. Figure 2 summarises the discussion.

Continuing the theme from the earlier session, funding mechanisms and a lack of consistent vision were first and foremost in the minds of the participants early in the session. It was noted that the predefined funding periods of only five years, in an industry where even the vehicles could realistically be expected to last for three decades or more, encouraged short-term thinking and a misalignment between the long-term aspirations of the industry and the ability to procure the necessary digital systems. The poor alignment between vision and funding was also felt to contribute to a lack of clarity within the industry on whether the priority was to renew the infrastructure or to enhance it (e.g. to improve capacity), with different funding streams accessed for the two models and a fragmented approach taken across different routes within the network. The clarity of thought around keeping the railways running during the early stages of the COVID-19 pandemic were seen as proof that the industry could rise to the challenges in this area, with the single sense of purpose around the continued delivery of freight and key worker services felt to exemplify the thinking needed for large-scale digital change.

The widespread provision of data itself was, unsurprisingly, considered to be a key element of the move towards a Digital Railway, and it was noted that there was a "chicken and egg" problem within the industry around the need for investment in digital systems to generate sufficient data on network performance, to then make the business case for investment in those same digital systems. The prevalence of legacy infrastructure within the industry, be it part of the existing Information Technology (IT) infrastructure, the vehicles, or the physical assets such as track and signalling equipment, was considered a huge barrier to digitalization initiatives, with no opportunity to adequately instrument many older assets in a cost-effective way, and existing condition monitoring / operational telemetry provision (where such provision was in place) being siloed and therefore limiting the ability of the industry to take decisions across system boundaries. A lack of incentives around digitalization in some areas of the heavily privatised rail industry was also seen as a contributing factor, with little reason provided for the owners of older rolling stock, for example, to invest in digital equipment fitments to their assets when that equipment would not provided a return on the investment in the asset's remaining useful life.

It was felt that there was a lack of clarity around the industry's thinking on the need for digital, with one discussion comparing some existing digitalization activities within the industry to the folktale of the "emperor's new clothes" in that the idea of digitalization had been used to sell initiatives with no real value in the digital space, leading to a failure to deliver real benefits. The lack of delivery on the initial promise of digital was believed to have contributed to a widespread feeling of distrust in the idea of a Digital Railway within the industry (in much the same way that a consumer brand can become tarnished), and overcoming that reluctance to try again after successive failures was considered a major barrier

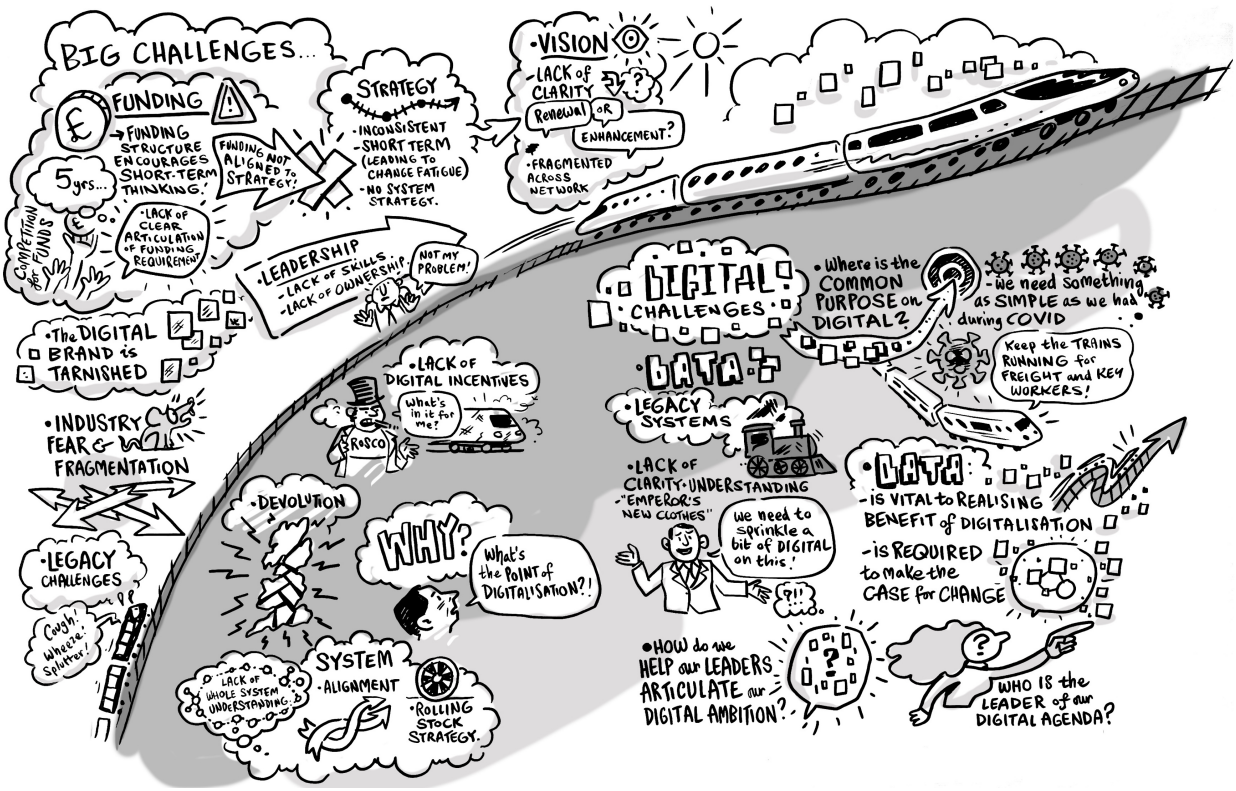

Fig. 2. The "Challenges" of digitalization.

to future success in the digital space.

C. Big Questions Facing the Industry

The third session of the day, captured in Figure 3, saw participants presented with a set of six "Big Questions" designed to help crystallize their earlier thinking on the digitalization of the industry; what was being changed by digitalization initiatives elsewhere, how could the industry deliver those changes internally, what was the vision for digital moving forwards, what was the case for change, what were the major challenges, and what would the consequences of failure be?

The key change resulting from other sectors going digital was considered to be in customer perception of the rail industry, re-enforcing the long-held view that the rail industry was a relic that failed to move with the current technological trends. Competing sectors, such as automotive, were felt by participants to be seen to be innovating quickly, and while the shorter lifespan of their assets made that transformation more straightforward than delivering widespread technology change in rail, it didn't alter the fact that customers were used to experiencing the benefits of digital (e.g. continuous connectivity and improved real-time information allowing them to make informed decisions on their journey) elsewhere in their lives, and therefore expected those same services of rail.

Delivering digital would depend not only on leadership and vision from those in charge of the industry, but also a willingness on the part of all stakeholders to work in partnership for the good of the industry; novel business models (for example by using large framework contracts to encourage big suppliers to work together on delivery across a single, national rail network) that

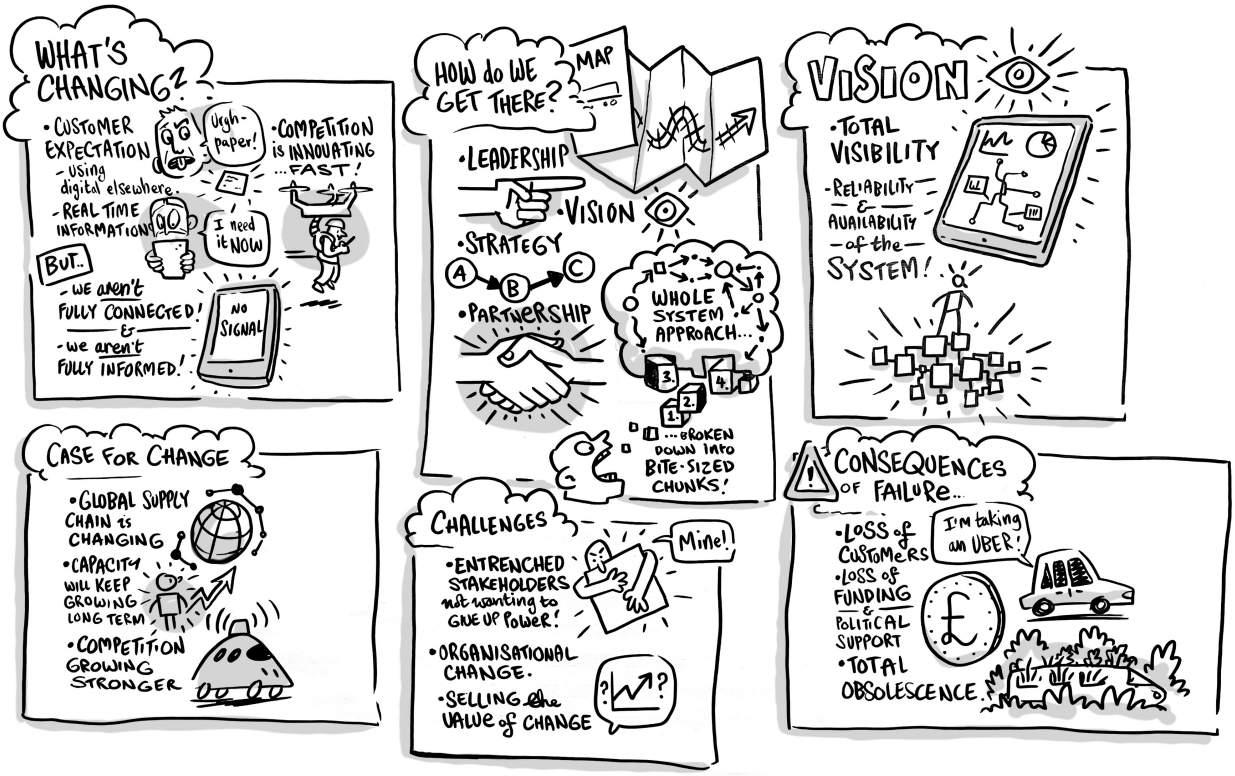

Fig. 3. Six "Big Questions" posed by digitalization.

supported this type of collaborative thinking had been seen by the participants to work in other railways around the world, and ensuring that GB rail could import and learn from those ideas was seen as crucial to success. It was also noted that any plan for digitalization would need to consider the rail system as a whole, helping to avoid siloed thinking, but that solutions would need to be delivered in carefully defined, bite-sized chunks, to allow practical management of the programme.

Participants believed that the vision for digital across GB rail should be nothing short of total visibility of the national network in near real-time. It was felt that having data at scale would allow effective decision making, improving the overall reliability and availability of the limited infrastructure, and a better overall service for customers.

The case for change was felt to by driven by the combination of changes in the global supply chain (e.g. around delivery of services and freight), the need for continuing growth in capacity without associated expansion of the infrastructure, and the increased competition from other modes, including automotive, who were making use of digital technologies to erode the unique selling points of rail (e.g. the ability to work while travelling). Without embracing digitialization, it was felt that the industry would fall behind the competition; this idea would be revisited when discussing the consequences of failure.

The major challenge facing the delivery of the digital railway was seen to include unwillingness on the part of established industry players to step back from their existing positions of power over key systems and functions, blocking innovation and the introduction of new ways of working that could deliver an overall benefit to

the industry. This was closely coupled to the need for organisational and business change within the industry, however it was felt these issues could be overcome if the value of change was presented and sold correctly within the industry.

Finally, the consequences of failure to deliver the digital railway were expected to be a gradual loss of customers, first on passenger services and ultimately freight, leading to a loss of political support and funding, ultimately resulting in the obsolescence of the railways themselves.

D. What Next for Digitalization?

In the final session of the workshop, the participants were asked which five steps should be taken in the short term to take the industry forwards on its digitalization journey (see Figure 4).

The key to successful delivery was felt to be in defining a vision for the digital railway that all stakeholders could understand, articulate, and buy into. This should be followed by properly defining the boundaries of the railway system, enabling the scope of digitalization activities to be clearly understood. Participants felt that the industry has historically performed poorly in terms of both finishing transformation projects and recognising those successes, so it was suggested that there should be some mechanism to ensure that at least 20% of the outstanding project load should be prioritised for completion in each planning cycle and that those achievements should be publicised and celebrated. Data, which was earlier identified as a critical component of any digital railway, should be opened up to innovators, and a continuous improvement plan should be put in place to drive forward change.

V. Conclusions

The workshop sessions highlighted a range of challenges and opportunities facing GB rail as it moves forwards with its digital transformation journey. Many of these were expected, with issues like the industry's relatively short funding cycles having been widely commented on in the past, but others were more of a surprise, with comments around replicating the common sense of purpose across the industry that resulted from the response to COVID-19 suggesting real willingness to find novel routes to make progress. A key point that stands out from the responses, is that the issues around digital transformation of the industry are now well understood and accepted by those who will have to deliver that transformation; this is (somewhat surprisingly) in contrast to the unwavering optimism that characterised previous attempts to drive forward the digital railway in Great Britain, and suggests that a more measured programme may result.

In conclusion, while it is difficult to say whether the GB rail industry, or the transport sector in general, is yet ready for the digital transformation that must inevitably come if any of the constituent industries are to survive over the medium term, the awareness from industry stakeholders of the challenges and opportunities provided to the industry by digital technologies does suggest that future digital transformation initiatives will be based on a pragmatic realism that may make the difference and lead to a bright future for the digital railway.

Acknowledgment

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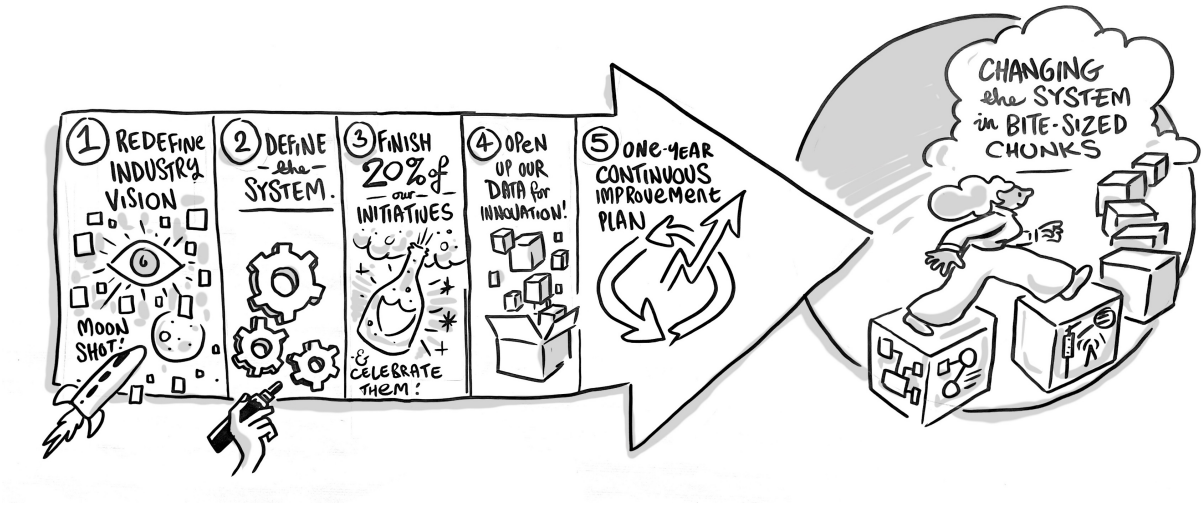

Fig. 4. Five "Bold Steps" to take the industry forwards.

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