Reimagining the Railway

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Dateline May 2035 anywhere in England...

The light, strong aluminium and carbon-fibre Inter-City High Speed train eases silently from the platform propelled by electric motors powered by fuels cells and boosted by energy harvested by the KERS system; the transmission based control system adjusts the pace so the train inserts itself in the centre of its moving block. As the train accelerates the gas turbine spools back up from idle, generating the electricity required for high speed operation and seamlessly takes over propulsion – near silent running is preferred in urban locations.

Meanwhile, settling in their allocated seats, older passengers are impressed at the way the ticketless 'turn up and go' system allows them to optimise their journey, in real time, against both price and timing AND always guarantees them a seat. Younger passengers laugh out loud at the references to 'tickets' and 'standing room only' – it was never really like that surely? All continue to be delighted at the easy access – no gates or ticket offices on the station concourse, reservations made on their smartphone in seconds, the 'clock face' timetable eradicates concerns about missed trains and reliability of vehicles, the network is such that delays are unknown.

Smartphones connect to the on-board wifi network and passengers presence is confirmed by proximity sensors at each seat, the intelligent train verifies that reserved seats have been occupied, fares have been collected, registers which seats are vacant and which will be vacant at the next stop, updating the seating allocations system. The system notes that one seat is occupied but has not registered so it alerts the Train Manager to assist the passenger and, if necessary, collect the fare. Even in 2035 not everybody has a Smartphone.

While the train gathers speed, its trainionics and external sensors monitor the condition of the infrastructure it passes over and send details to central control where relevant data are re-transmitted to following trains. Rail-head condition is measured to eliminate wheel slip, embankment telemetry is linked in to the active suspension systems to improve the ride over 200 year old civil engineering, and weather radar, together with satellite imagery and local radar, identifies potential environmental impacts such as lightning storms and detects track obstructions.

The 30 year 'lean asset management protocol' and 'lean infrastructure transition engineering' programme first implemented in 2015 draws on BIM to deliver progressive adaptation and increased resilience, making this a highly reliable, self-monitoring and in some cases self-healing infrastructure.

The food stock control system sends an order to the next stopping point to replenish the bacon sandwiches – everybody has an appetite.

1: Introduction – Current Reality

The scenario outlined relies on technology already available in 2014. All of the individual parts are in commercial use somewhere – nobody has yet integrated them in a railway system.

If Darwin were reflecting on GB Railway he would observe a system in which it appears the capability for evolution:

- is inhibited by a risk-averse, bureaucratic culture
- is fragmented by the separation of infrastructure from operations
- subordinates the interests of the rail user to those of the industry itself.

The net effect of this pathologically self-perpetuating behaviour – a process known as autopoiesis (Maturana and Varela, 1987) - is to increase costs and decrease performance over time to such an extent that significant impairment if not collapse of the system appears inevitable. Current operations rely on sunset technologies and energy delivery systems which are potentially damaging to the environment and which themselves perpetuate vulnerability to climate change through extreme weather events (wind and precipitation), increases in average temperature (power line sag, track buckle) or simple loss of supply or shortage of carbon based fuels. The results are iatrogenic (caused by the 'physicians' to the system) and answer to Hutber's Law– "improvement means deterioration".

The system requires increasing levels of funding to maintain itself employing business and operating models which become ever more disconnected from the interests of both the users and the host nation. Meanwhile, franchise operators, admittedly working with low margins, continue to draw profits from the system. Profits are not a bad thing, generating a surplus of income over expenditure is the essence of economic growth. However, profits made in a heavily subsidised industry are, perhaps simply a corporate taxation on industry subsidies while the 'not for profit' infrastructure operator receives direct grants which act to distort true industry costs.

While the profits are illusory, the challenges of the railway are real. The infrastructure is unable to deal adequately with current weather events, lacks the capacity and flexibility to accommodate either normal operational perturbations to service or the impacts of extreme weather events and is not being maintained or upgraded at a rate that will ensure continued operation (NR Earthworks' Remediation Plans – Strategic Business Plan). 'Tipping Points' (Gladwell) and 'Black Swan' (Taleb) events are notoriously difficult to anticipate, the absence of meaningful telemetry and lead indicators makes this harder, but it would appear there is substantial systemic risk. GB railway is failing.

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2: A Brief History

GB Railways led the world – from the earliest recorded use of static steam engines by Thomas Newcomen in 1712 to pump water out of mines and enable access to hitherto unreachable coal seams - to the development of the Stephensonian boiler in the 1820s that brought the compact and portable power necessary to build the world's first railway system.

Most of what is now the UK railway network was laid down by the 1850s, routes built up on freight and passenger demand, laid out to feed industry; coal and iron ore from the mines to the furnaces, coal to dwellings, for cooking and heating in the expanding cities as the populace migrated to service the demands of the manufacturing centre of an Empire, and to the Royal Navy and Mercantile Marine, finished goods transported to markets at home and abroad; raw materials exported. At its peak, the entire GB network comprised a network of some 20,000 miles and 5000 stations, most of which were served by goods trains and necessarily had goods-handling and distribution facilities. In all this Britain led the world. Britain defined the state of the art.

After World War 1 with the mass influx of surplus road vehicles into the home transport market and the General Strike of 1926, railways began to decline, with closures ramping up until the 'Beeching cuts' of the 1960s. Decline continued until the 2000s when rising costs, congestion on the roads network and increased awareness of the carbon impact of travel are attributed by some to the generation of an increase in passenger usage on the GB network, of some 10,000 route miles and 2,500 stations.

The transformative Beeching work might be considered a reductionist response to industry challenges driven by demand for a more 'efficient' railway. However, from a systemic perspective what Beeching seemed to create was a 'machine for eating the railways' (Beer, 1966). The closure of 'loss-making lines' was, apparently, undertaken in the absence of understanding of the impact of consequent revenue losses on the 'profit-making' lines. The 'profits' of the main lines needed to be moderated by the 'losses' incurred in getting passengers to them. In nature the water flow in a major river is a function of the combined flows of all of its tributaries and the main stream – drying up the tributaries will reduce overall flow. Simply, the branch lines were tributaries providing passenger flow to the main lines, (the major rivers,) the withdrawal of services did not see a migration of those passengers to the main lines but to private cars. The railway ceased to be convenient and much of the revenue was lost to the system altogether.

The Beeching work seems to have accepted the notion of 'efficiency' as an absolute general good but not to have challenged the thinking from the perspective of effectiveness. To be systemic it is necessary to determine the purpose of the railway before any meaningful conversation can be held about its effectiveness and its efficiency will be defined by the cost-effectiveness with which it fulfils the purpose of the whole NOT by simple accounting measures of branch line revenue and cost.

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3: GB Railway: Innovation and Technology

The railway in Britain is technically very similar to that of the 1950s. After the transition from steam engines to both diesel and electricity – the latter delivered by third rail or overhead wire - technology innovation at the core of GB Railway appears to have stopped. Modern trains in the UK are refined evolutions of 1950s trains. While France pioneered very high speed passenger services with their TGV trains on the LGV network, globally there are 13,000 miles of high speed lines (those capable of speeds greater than 126mph). Britain has 70 miles of HS1 primarily dedicated to services to the Continent. Meanwhile HS2 linking the south with Birmingham, Leeds and Manchester seems a dream with commissioning anticipated for the initial phase in 2026 – but only then if a compelling business case, at a 2013 estimated cost of £42bn, can be made and the massive project can be delivered on time.

While the introduction of information technology across the network has provided improved customer information, advances such as new, more reliable rolling stock and improved infrastructure availability combined with moving block signalling (if it is implemented over the next 15-20 years) can be expected to provide a step change of at least 15% and a likely 30% in system capacity by decreasing the space between trains. Other than that emerging in signalling, there do not seem to have been any step changes in technology, or driven by it, since the 1950s albeit new generations of trains are lighter overall than their immediate predecessors.

Meanwhile, the railway 'sub-systems' are organised in siloes, treated independently of each other. Perhaps the ramifications for overall railway performance of maintenance of drainage on earthworks' stability, track quality and registration of overhead wire conductors is understood but it is not then managed as an integral part of a whole 'system'. Many delays arise from failure to manage the interactions between the elements of the system and any improvement is limited in impact when it is acknowledged that network performance, for any network, can only ever be as good or as resilient as the weakest link and if that is 50 years old and failing then the whole system will perform as 50 years old and failing, for example the engineers do a good job sustaining signalling systems on the Great Western route that were installed in the 1960's. The system fails at its weakest point.

The railway is known for its inertia and traditionalism, but is the industry itself to blame? It appears to lack visionaries capable of seeing past current technologies or able to promote the transfer of technologies from other industries. Perhaps though, innovation (and even thinking about innovation) is stifled by a risk-averse, fearful culture in which 'no-one can say what they really think', inhibited by government transport policy five-year control period economic regulatory thinking and by high-cost and short term franchises for most passenger operators. Franchise period are inadequate for a system which, by its very nature, has long-life assets – whether mobile or static. A rail vehicle may reasonably be expected to have a 30 to 40 year life while for structures and drainage systems life might be 100 years or more. Innovation in telecommunications assets (which

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typically have a much shorter asset and technology life cycle) is inhibited by the need to 'retrofit' technologies to line-side, vehicles and other assets which cannot support them. Could railway engineers and operators become frustrated by these time-driven artificial constructs; rolling stock life, franchises and control periods? These very people very often pursue a career in rail and so will experience constant change in culture, fiscal rules, policy, strategy and managers through reorganisations (for those organisations that last longer than 5 years say), and multiple employers for the rest.

It may be that government transport policy constrains good railway managers, operators and engineers to only think in terms of short term target-based outputs, some of which create perverse and unintended outcomes such as the 'man marking' prevalent before Network Rail brought maintenance activity back in house in ?2004.. It might be that everybody is faithfully and blindly following a set of rules which guarantee the failure of the very thing they are intended to preserve. Railway rules ensure safety but safety measures can bring about poor performance as traditional ways of maintaining safety include holding trains at signals while problems are fixed. Perhaps current thinking is perpetuated through the focussed, specialised training and professional development that was prevalent during the 1990s and 2000s, with a generation of engineers educated in only a 'silo' based understanding of the parts, one that enables the bigger system to be neither seen nor understood.

Work towards adopting sustainable development principles has emerged recently but there is lack of understanding and agreement about what 'sustainability' means and how the principles can be applied in practice. For example there is drive to gain 'excellent' or 'good' BREEAM scores for projects, but do these scores encourage project delivery through 'lowest first cost' thinking rather than whole life, whole system value delivery? The project delivery value engineering mentality may hamper the economic delivery of long life asset management being a 'Wicked Problem' (Churchman, 1967)

Government policy notwithstanding, GB Railway does appear to welcome thinking about new technology when funded elsewhere. The excellent initiatives to introduce innovation involving influential players such as the Technology Strategy Board, the Railway Industry Association, Rail Safety and Standards Board and the Transport Systems Catapult appear very positive. However, it seems these initiatives have likely come about because it is recognised that the industry itself behaves in an insular and technology averse manner.

The concern about these initiatives is that rather than focusing on the whole system they address matters at the operational, asset management and supply chain levels. At such organisational levels much emphasis is upon process within the sub-system for the short term (less than five years) and not on innovative thinking that could find creative solutions at total system level for the long term (10 – 50 years). In an industry where system components such as bridges and earthworks have lasted over 180 years

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and fast moving ICT has to undergo so many tests it is obsolete almost before its introduced (e.g. GSM-R) there is a reluctance to adopt the new. An engineer will not want a new paint system on 'his' metal bridge unless it can be proven to last more than 20 years, for example.

The Rail Technical Strategy risks stifling innovation as it appears to have been developed by railway people without external input, viz:

> "RTS 2012 has been developed by TSLG with significant contributions from the industry's System Interface Committees (SICs) and representatives from government and suppliers."
> (Source: see web refs)

Whilst it refers to ideas such as adopting a whole system approach, it then goes on to say,

> "A whole-system approach features coordinated planning and operations, consistent and aligned asset management and the adoption of an industry- wide framework to help the industry to implement change and improve reliability, availability, maintainability and safety (RAMS)"
> (Source: see web refs)

There have been major setbacks in the past on the technology front. The West Coast Main Line upgrade costs were predicated in the mid-1990s on new transmission-based signalling technology. That was expected to eradicate line-side signalling and the concomitant installation and maintenance costs. The technology to make this happen was, perhaps, not ready at the time, but it is now.

The Advanced Passenger Train (tilting train) saw the introduction of gas-turbine power, tilting bodies and a hydrokinetic (water-turbine based) brake system in the 1970s. The failure of the brake system allegedly in freezing weather harmed the credibility of the concept, while the project was abandoned after high profile failures of the three electric prototype trains in the early 1980s. The designs of the APT 'powered tilt' carriages were sold to Fiat Ferroviaria, which exploited the technology in the second generation of tilting train. The functionally similar "Pendolino" trains travel now on the WCML. Is the corporate railway memory of such major failures reinforcing the technology-averse nature of the industry? By contrast with the UK there is a MagLev train operating between Shanghai Airport and Long Yang Road – 30km in 71/2 minutes and Elon Musk, founder of PayPal is developing thinking around Hyperloop Alpha – San Francisco to Los Angeles in 35 minutes in a partial vacuum tube at over 700 mph.

As already suggested it may also be that short-termism is brought about by the regulatory control periods of the regulated industry. The infrastructure manager Network Rail works to targets agreed every five years by the Office of Rail Regulation, so is less likely to innovate and experiment on live railway tracks where failure can lead to penalties through the performance regime. Franchised train operating companies

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acquire 7 – 10 year franchises which again set out targets reinforced with penalty payments for poor performance. The time to payback on substantial investments is often 3 to 5 years and the corporate focus tends to be on profitability over the life of the franchise so where is the incentive to innovate? A strategy of 'more of the same' is most likely to deliver benefit to the franchisee.

Perhaps what is needed is a new vision for GB Railway, a vision rooted in a systemic understanding of the railway and its purpose – the reasons for its existence and its contribution to the social and economic well-being of the nation. That vision and purpose is unlikely to be expressed meaningfully in terms of only profit and loss.

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4: GB Railway: A Systems Perspective

In order to consider GB Railway as a whole system we must, for the purpose of this paper, undertake our work as if the numerous legal boundaries between entities did not exist. We know that GB Railway is legally constituted from multiple entities (ROSCO's, Network Rail, Franchisees, ORR, DFT and so on) but we also know that these legal boundaries inhibit meaningful examination of the railway, by or for its constituent members, as a whole system. The UK interpretation of European Directives, an interpretation that led to the current organisational situation, was that vertical separation of the railway was required to stimulate competition. However, evidence that a systemic, integrated approach can and should be taken is provided by the experiment in vertical integration being undertaken by Network Rail and South West Trains in 2013 through their 'alliance' and SNCF & Deutsche Bahn have successfully challenged the directive previously interpreted as requiring vertical separation. The demand for competition has been interpreted as necessary between rail service providers whereas a systemic perspective might offer road, marine and air as the transport system substitutes with which rail is competing.

To consider GB Railway as a purposeful system and thereby render it susceptible to consideration as a whole the entire organisation must be embraced, i.e. regulation, infrastructure, vehicles, operators, passengers, freight and the supply chains

Purposeful is a key word here. It is argued (Beer, 1985) that:

"the purpose of a system is to be itself".

In order to be itself the system must exist in a context, an eco-system or environment that supports it; no system exists in isolation. For the context to support the system there must be some kind of exchange of benefit between the system and the host. Each must derive some gain from its interaction with the other (Dudley, 1998). For clarity, this exchange of benefit does not have to be measured in monetary terms in fact MUST not be measured purely in monetary terms. Every eco-system experiences an interconnected set of exchanges of benefit, it is only in human social systems that benefit is measured monetarily because, collectively, we treat money exchange as a shared proxy for benefit exchange – a convenient, but sometimes misleading common language.

In fulfilling its purpose, the system exports something of utility to its host and imports something of utility to itself. This is perhaps a form of symbiosis, an exchange rooted in mutual benefit. Fulfilment of the purpose of the system, as negotiated with the host, is fundamental to continued existence and the key to its viability; the ability of the system to survive in a changing environment

What does GB Railway do that has utility to the society that hosts it? There are a variety of possible answers to this, all dependent upon the perceptions of the observer. In isolation, none of the legal entities that constitute GB

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Railway can provide a robust answer, each has a partial perspective on the whole, none can observe the whole system, their position is intra-systemic, they and their perspectives are within the system. A robust response needs an extra-systemic perspective, a view from outside. That, perhaps, can only be provided by Government as the representative of society (the ultimate stakeholder in the railway) as a whole. In a system which is ultimately owned by the nation, Government makes that determination on behalf of the electorate, ideally in consultation with all stakeholders – and careful stakeholder engagement and management will be a key element in delivering a different future for the railway.

Government is the controlling mind and the individual representative of that controlling mind is the Secretary of State for Transport who is, or should be, in a position of extra-systemic omniscience, i.e. able to observe the whole of the system from the outside. This privileged position of observation is, or again should be, supported by a body of expertise within the Department for Transport. One of the challenges for transport in general and railways in particular is that from 1951 to the time of writing there have been rather more Secretaries of State for Transport than there have been Governments. (Source: web – see refs). 38 Secretaries of State across only 18 Governments suggests that none has been in post long enough to either develop an informed view of the whole system or do anything about that which is observed.

Absence of clarity of purpose suggests that policy making may well be inadequate and has collapsed into operations. It can be informed by only the partial, intra-systemic views of DfT civil servants and industry representatives,

In the absence of informed guidance from the Minister, we shall take ours from Beer. If we accept Beer's (op. cit.) definition of purpose as a working principle then the purpose of a railway system, as we observe it, is:

> to move people and goods to and from locations on the system.

So, GB Railway, is a system for moving people and things. Note that this definition excludes any value or benefit words, it does not talk of speed, cost, profit or loss, efficiency, performance, delay minutes or NPS. Those things are performance attributes of the system not expressions of its purpose. That is not to say that performance attributes are unimportant but that it is open to us as observers to first determine the purpose of the system and then to identify the performance characteristics which are most useful in helping to understand how effectively that purpose is fulfilled. It is open to the electorate to communicate to the Minister the performance attributes they believe are important and to the Minister to respond to that. Ministers in particular and governments in general are subject to being voted out of office when they fail to meet the demands of the electorate.

Dudley's Trialogue (2000) proposes that sustaining the fulfilment of purpose is the first fundamental obligation of the human actors who purport to govern a system.

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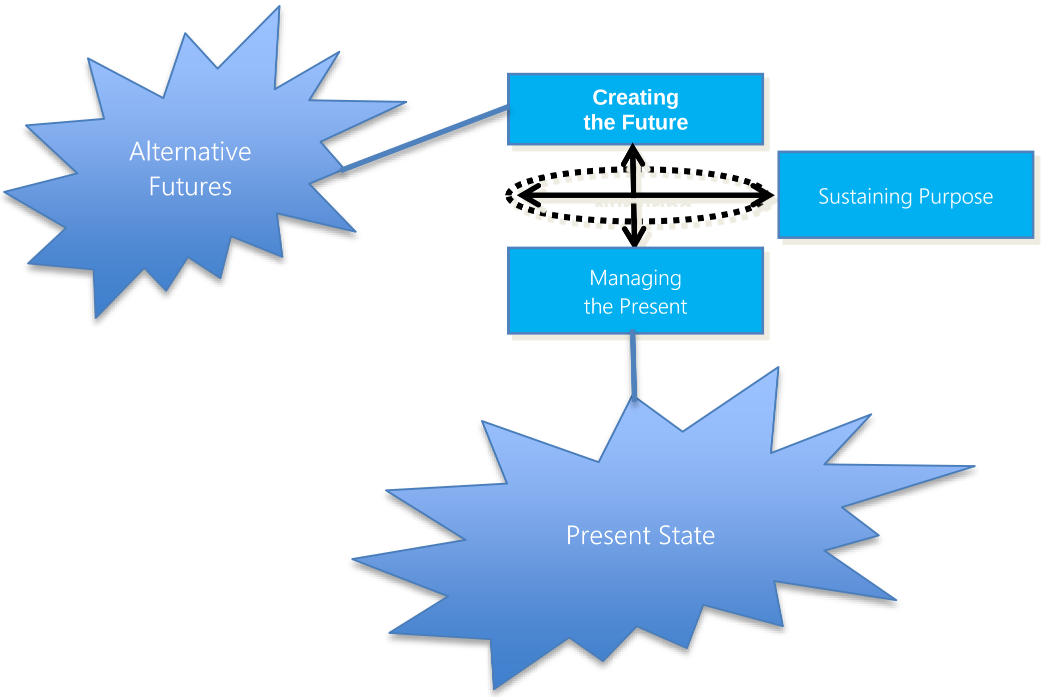
When this obligation is not fulfilled, the system is denatured. In its absence the organisation has no governing mechanism for self-questioning and thereby loses its second fundamental capability, that of 'creating the future'. This describes the continual renegotiation of its benefit exchange with its eco-system and which is an expression of the legitimacy of its existence. In the absence of creating the future the system collapses into activity which is concerned only with perpetuating its current state – 'managing the present'. The decisions made in managing therein cannot be challenged; they are seen, in the absence of intervention or information from the other two parts, as necessarily 'right'.



The Trialogue (adapted from Dudley, 2000)

The system thereby becomes pathologically autonomic – it can only do that which it has been designed to do and only for so long as it receives the resources to sustain itself but it is incapable of adaptation. The gap between things as they are outside the organisation and things as the organisation considers them to be becomes ever greater, increasing resources are required to sustain the unbalanced position and meaningful change or improvement becomes impossible. The system does not have the capability to change and it relies on benefit exchange with some party other than its operating environment to sustain itself. In the case of GB Railway it calls on higher authority (the government as ultimate owner) to provide sustenance and these take the form of subsidies and above inflation ticket price increases.

Investment funding for the railway is limited. The McNulty report, which appears to have had limited sustained effect, suggests that GB Railway is

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30% less cost-effective than its European counterparts and is therefore wasting resources although challenges to that report have been presented by the industry. Regardless, pressure will necessarily increase on subsidies and travellers will only close the gap to the point where alternative, competing means of completing their journey become less expensive, more convenient or, more likely, a combination of the two. The regulatory and franchise regimes will continue to focus attention on the relatively short term and the upshot will be that the realised strategy of GB Railway must be more of the same.

This 'more of the same' strategy must be implemented against the background of public spending reductions, The EU 2011 Transport White Paper, modal shift, still increasing passenger patronage, and a desire for more freight on rail. The compounding dilemma is how to provide for this growth on a mixed traffic railway (75mph freight trains competing with 125mph passenger services for paths; little or no freight south of London as the lines are principally commuter focussed), managed with outdated technology and operating a timetable which because of fragmentation at least partly driven by notional competition is sub-optimal in terms of maximum potential capacity. The timetable gives every appearance of being progressively redesigned to make it easier to achieve performance targets; many journeys today are longer than 20 or even 50 years ago as contingency has been built in and numbers of stopping points has increased albeit that in daily operations the attribution of delays and the consequent cost drives towards the lowest cost solution for the operators – which is not equivalent to the best outcome for the passengers.

All of this means the perpetuation of a railway run largely on the current basis, the continued use of ageing rolling stock in certain instances, continued reliance on dated technology for signalling, power delivery, user management and infrastructure. For the infrastructure it means increasing vulnerability to changing climate and further exposure to extreme weather events (wind, precipitation, heat, cold). Current enhancement projects, such as Reading Station, Birmingham New Street Station and Great Western Electrification are all built on old technology and, far worse, the new railway, High Speed 2, will have embedded in it many of the inadequacies of the existing railway. With the advances in technology over the last 50 or so years it is ludicrous to consider building a new railway with current collection technology older than the authors of this paper. That new railway will be expensive to build and even more expensive to maintain over its 100 plus year life and it will start with the disadvantage of a fundamentally 1900s current transmission design.

This result will be the embedment for the next generation of travellers all of the inadequacies of the present system. There are, of course, structural things that need to be done to the organisation of GB Railway in order that it can be managed as a coherent system and not just a rough assemblage of badly interconnected parts – a machine that almost but not quite works – but addressing the limitations of current thinking would be a good start. Alliancing, as being trialled in Network Rail's South West Route where management is carried out jointly with South West Trains, the franchisee,

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is seen as one model for the future, however the fact that DfT has a programme for franchise re-letting tends to suggest that ideology has the upper hand. Qv East Coast and the re-letting of a company that has successfully performed in the public sector. In all this, it can be argued that whilst there is a need for a controlling mind attending to the long term strategic future, this must be coupled to an appropriate level of autonomy at the operating level. The rubric 'as much autonomy as is consistent with cohesion of the whole' (Beer, 1985) provides the measurement framework for this whilst Henri Fayaol (1916) admonishes that the balance of centralisation and decentralisation is continually shifting – a reminder that the dynamics of the system must be understood and reflected in its organisation.

It is fair to pay tribute to the people and organisations that deliver a generally good service across a complex network using inadequate tools. Whilst acting to address its challenges we should marvel at how well GB Railway works as testament to its operators and engineers.

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5: Re-inventing the Railway

This paper so far has offered a critique of GB Railway. It has shown how the railway has moved from innovation and world leadership to a fragmented organisation, focused on short term operational matters, heavily subsidised with an aversion to technology change and an absence of long term policy and effective leadership. This section of the paper assumes that ultimate collapse of GB Railway is not an outcome that can be countenanced and considers a range of alternatives. It proposes what a re-invented railway could look like and offers suggestions for a way forward, to re-establish leadership, capitalise on technology innovation and focus on effective fulfilment of purpose. Progress has to start somewhere and going backwards by not moving forwards does not look like a great thing to do!

In the absence of a ministerial policy that determines the purpose of GB Railway this paper has adopted this simple statement:

> 'to move people and goods to and from locations on the system'

5.1 An Effective and Efficient Railway

If the chosen definition is to hold, it is essential to determine what is meant by effectiveness within that definition and how, overall, the performance of the railway is to be measured.

As Beer suggests (op. cit.) effectiveness is about fulfilment of purpose, so an effective railway is one which does this. However, within effectiveness there is a need to be efficient, the railway must extract maximum value from the resources it employs whilst maintaining effectiveness; these measures are not competing but complimentary. The railway must fulfil its purpose in a systemically efficient manner, failure to do this will be unaffordable for stakeholders and will itself threaten the viability of the whole.

Genichi Taguchi, a Japanese quality guru, considers the 'cost of non-quality' (Beckford, 2010) which might offer an alternative proxy for systemic efficiency:

> 'the loss imparted to society from the time the product is shipped'

Interpreted broadly across multiple dimensions of performance rather than narrowly looking purely at monetary value, this allows employment of his 'quadratic loss function' as a mechanism for reliably, reputably measuring value for each measure. These could be integrated through Beer's Potentiometer (Beer, 1985) to allow for the meaningful comparison of disparate things. Taguchi's work is systemic in perspective, embraces the notion of society as the beneficiary and stakeholder of the railway, considers the whole system and the long term view and focuses on minimising loss in all dimensions. Given that mass transport systems globally are notoriously reliant on subsidy and that there is a desire to address non-financial aspects

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of transport such as carbon emissions and congestion, this looks a useful starting point.

Measuring performance over time means a need to reflect in performance measurement the varying capital cycles of the industry not simply the short term exigencies of parliamentary elections, regulatory control periods or the arbitrary lengths of franchises. It is also necessary to consider possible new business models and embrace the fact that the capital cycles in GB railway are highly variable in length. Whilst a structure may have a life in excess of 100 years with a 30 year maintenance cycle, information technology components often have a life of only 5 years with, quite possibly, a maintenance philosophy based on 'break-fix' and replacement of complete sub-systems rather than repair of components.

Some useful measures of performance, many of which already exist (see ORR website), could be aggregated into an overall measure of effectiveness which might include:

Safety
Customer Satisfaction
Employee Satisfaction
Network Optimisation
Timeliness/ Punctuality
Carbon Emissions
Cost per Vehicle Mile
Cost per passenger journey mile
Resilience

Taken together these things might define both what we want a railway to do and the performance envelope that bound its success. It is notable that profit is not amongst them. That GB Railway as a whole must balance income with costs is not in question and that should include the idea of generating sufficient funds to sustain investment in itself. Whether a shareholder, profit oriented business model is most appropriate given the purpose we have outlined will be explored in section 5.3

5.2: A High-Technology Railway

The opening vignette provides a vision of how a railway could be operating in 2035 and that vision relies on technologies which, by then, will be at least mature and may have been superseded.

For rail travel, there are substantial opportunities arising from significant progress in transport, propulsion and control technologies. The latest generation of aero engines and aircraft are providing substantial gains in fuel efficiency. The Airbus A350 halves fuel consumption compared with its predecessor, while car manufacturers are embracing a wide range of technologies to improve fuel use and reduce emissions ranging from improved aerodynamics to simple 'stop-start' applications, high efficiency internal combustion engines and hybrid propulsion systems involving batteries, energy recovery systems, range-extending electrical generators

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and hydrogen fuel-cells. European legislators are developing ever tighter carbon emissions protocols for the vehicles of the near future. Manufacturers are responding very effectively to these demands and the rate of progress and change is astounding. Meanwhile, whilst carrying out some innovations, the railway continues to rely on 1950s technology. That is unsustainable.

While it is accepted that the cost of rail vehicles is such that they necessarily have a life of 30 years or more, it is nonetheless the case that a wholesale reappraisal of vehicle design and technology application is overdue. That GB Railway is commissioning new vehicles which employ fundamentally the same design and core technology as those of the 1950s is disconcerting. Good engineering design could mean that the 30+ year life of rolling stock might be sensibly confined to the body shell, which might itself be lighter using aluminium (as is now being done) and carbon fibre, with sub-systems and components designed for more frequent upgrading following technological advances.

Bogie design has advanced with low-track-force variants in use although, with the exception of some improvement in aerodynamics, changes to vehicle design have been primarily in supplementary technologies, e.g. doors, air-conditioning, toilets, seating, rather than in the core of the vehicle. By comparison road vehicles, in addition to even greater changes in supplementary technologies, are seeing significant advances in the deployment of new, strong, lightweight materials. Aluminium is now widely employed to add strength with lightness (Jaguar, Land Rover, Audi, BMW, Mercedes), whilst carbon fibre is being employed in both body tubs and panels (McClaren, Alfa Romeo, BMW) being both very strong, rigid and light. Associated vehicle weight reductions contribute greatly to increased vehicle performance for a given power, enhanced dynamics and reduced emissions. It seems that all of these materials might offer great gains to the rail industry provided, as they do for road vehicles, they can provide the appropriate level of crash-worthiness.

There has been progress on the railway, especially in the use of electronic vehicle control and monitoring systems. While these deliver some benefits in reliability and availability they also bring challenges and they are particularly vulnerable to ingress of moisture which compromises vehicle performance. Such technologies bring new vulnerabilities as the ‘Eurostar’ services discovered in the winter of 2010 when the temperature shock arising from a train passing from frozen air into the Channel Tunnel at 20+ degrees Celsius melted the ice accumulated around the vehicle causing failures at critical power transmission nodes. The control technologies and domestic services aspects of rail vehicles could be tackled through adopting technology solutions already employed in cars and aircraft which are addressing many of the same issues.

The traditional modes of electrification, overhead wire and third rail, bring with them reliability challenges under normal circumstances. Overhead wires are fragile and critically vulnerable to tensioning, wind, heat sag, ice accumulation and moisture, all factors likely to be exacerbated under

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anticipated future climate conditions. Third rail, in addition to its inherent safety risk from intruders, is seemingly unable to deliver the quantity of power required for high speed trains, is inefficient owing to low voltage current losses and is vulnerable to flooding and icing.

Advances in hydrogen fuel cells, battery technology and hybrid propulsion systems seem to offer potential in rail. Whilst the GB Railway 1970s experiment with gas turbine technology may not have been successful, there is a >8mw gas turbine locomotive running in Russia, reportedly capable of hauling 16000 tons (http://eng.rzd.ru/) The relatively low weight of a high speed passenger train (perhaps 500 tons) would offer a significant trade off in additional speed from such a turbine and, coupled to reduced vehicle weight through advanced materials, a high speed train powered by a gas turbine would appear a real possibility.

Development of a rail vehicle employing some appropriate mix of advanced materials and propulsion systems, perhaps a gas turbine running on hydrogen, would allow GB Railway to reduce or eliminate reliance on connected external energy supply whilst also enabling the elimination of expensive, high maintenance cost and unsightly overhead power provision and high risk, low performance third rail supply. The vehicles, whilst not in traffic, could also potentially supply energy back to the grid enhancing the resilience of national energy supply. This would be in line with the recently adopted energy strategy of utilising back-up generators at hospitals, factories and other similarly equipped sites. Accepting that there would be an initial investment cost to develop such a rail vehicle the benefits would be returned in a lower cost of maintenance for the life of the railway (in excess of 100 years) and a reduced environmental impact. Savings could perhaps be reinvested in increasing structure gauge to accommodate double decker passenger trains and double stack freight vehicles, generating further increases in network, vehicle, freight and passenger capacity. Whilst deployment of hydrogen powered vehicles may be considered a risk, there is a UK company 'pelletising' hydrogen (Ref: Cella Energy), rendering it both inert and transportable which addresses that risk. The UK Government has already committed £400m to support the development of a hydrogen distribution network over the coming years. Linking that development to the development of hydrogen powered trains would offer synergistic benefits to all parties.

The scale of the design and development challenge and the necessary testing and evaluation means that little of this can be delivered in the very short term. However, the approach outlined above could also be addressed to the existing rolling stock as it goes through cycles of maintenance and refurbishment over its life. It would be appropriate to review and overhaul the maintenance regime for both infrastructure and rolling stock so that progressive upgrades of vehicles and systems would take advantage of the technologies now available with refurbishment/re-engineering of existing vehicles perhaps being more cost-effective than new build.. The current level of sophistication is such that type approvals and route approvals for many vehicles are limited. To operate an optimised railway with optimised timetable and vehicle use would mean progressively upgrading the rolling

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stock to maximise flexibility in deployment. This will act to further increase utility and minimise overall costs.

Looking beyond vehicles and propulsion systems to the wider railway system, the opportunity already exists to move towards exploiting technology in different ways. While Eurotunnel and airlines have already moved to ticketless travel GB railway continues to use paper tickets with all the concomitant costs associated through ticketing systems, machines and revenue protection systems. A shift to a simpler, more coherent fare structure (perhaps based on cost per mile) would in concert with ticketless travel offer a step change in both the cost base of the railway and in the traveller experience.

There are both threats and opportunities arising from technology. A significant threat, particularly to business travel, arises from use of communications technology as a substitute for travel. With the increasing availability of high speed internet links and both 3G and 4G communications many business journeys are already being replaced with video-conferencing and net meetings through applications such as Skype and FaceTime. Whilst, perhaps, not a complete substitute for face to face meetings, they nonetheless offer advantages in cost and ease with which rail travel will struggle to compete.

It is almost certainly the case that there are a number of, relatively, quick wins to be achieved in the areas of smart ticketing, management of overcrowding and punctuality which might free up resources to support the investment case for change.

5.3: A 21st Century Business Model

It has been argued that GB Railway needs to be managed as a systemic whole rather than as a collection of functional silos. This implies, if not vertical integration, then at least a consistent and coherent performance regime in which the parties sharing a facility, whether it is a station, a track or the wheel-rail interface can only succeed by working together; they must be aligned for mutual benefit. As arrangements currently are, it is often the case that one can only win if the other loses. Contractual arrangements need to be such that winning and losing are mutual. It may be that the ownership model and industry structure does not work.

With increasing cost of car travel coupled to the recognised lower carbon emissions from rail travel (when rail vehicles are well occupied), there is a socio-economic driver for further growth in use of the railway. There appears to be a generational shift, perhaps partly arising from reported improvements in railway performance, which is likely to see continuing increases in demand for rail travel, but that will be accompanied by a need to improve all aspects of the experience, cost, punctuality, comfort, catering and station facilities. If the railway does not at least match alternatives in these regards then there will be a fall-off in demand over time. Encouraging short haul air-travellers to travel by rail would probably be beneficial in

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emissions terms while there is also potential for a shift from business travel to increased leisure travel which will have consequences for much of the current railway marketing and pricing regime.

There is a policy driver from the European Union to seek modal shift to rail, with an aim to move 50% of passenger and freight traffic to rail by 2050. On a congested network running at capacity around our cities and with containment and reduction of government spending set to continue, we should perhaps think of Ernest Rutherford:

> 'Gentlemen, we have run out of money. It's time to start thinking'

It can be argued that the franchising model in use since the mid 1990s is in conflict with the desired outcome of an effective railway. A cumbersome, expensive and sometimes failing process, franchising by 'line of route' means that competition is largely illusory. Many regular passengers, especially on short haul commuter routes, have no meaningful choice of operator and with fare rises linked to 'official' inflation rates, they have no meaningful control of their travel spend. Further distortion is introduced to the system by various grant and subsidy regimes at national and local (Public Transport Executive) levels and the debt burden of Network Rail at around £40bn is a substantial challenge. Meanwhile, operators who have committed to franchises which turn out to be unprofitable seem able to relinquish them without meaningful penalty, e.g. GNER, National Express East Coast, First Great Western. While a greater level of competition might be introduced by franchising at the level of individual services, this would generate substantial new complexity around vehicles, leasing, depot and maintenance arrangements. It would also make timetabling and scheduling fraught with new challenges.

If rather than in competition with itself, the railway is viewed as being in competition with alternative modes of transport then 'lines of route' could be let on a management fee basis. This would mean a management contract in which the operator is funded at a set level while earning a premium in relation to those characteristics of performance (see section 5.1) which are deemed most important. Fares and grants would be offset against the funding level. A close model for this already exists in the health and social care sectors in which service commissioners include both service delivery and management elements in the funding, income being derived through other mechanisms. This could encourage the optimisation of the whole timetable against travellers' priorities of perhaps timeliness and cost rather than the somewhat dubious marketing regimes currently seen. A simple regime that provided for a break-even management fee with bonuses for on-time performance, reductions in cost per train mile and reducing carbon emissions might be more effective. This would necessitate establishment of an agreed costing model to deliver equitable arrangements. It would only reward operators for doing the right things right, and agreement about the definition of purpose of GB Railway would be a critical factor. It would be worth considering within this model whether, across the whole network and measured in the broad terms suggested in section 5.1, there is net benefit to GB Railway and the UK economy as a whole from fare collection. It may

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be that the cost of ticketing, ticketing systems, revenue protection, gating systems, marketing and the consequent necessity to police the whole may generate, at least on certain lines, more cost than it does revenue.

A commissioning based, service delivery only model, would restrict to the core (the Department for Transport (DfT) as things currently stand) certain rights and obligations, such as vehicle design, acquisition and allocation, ownership of the cost model and the performance regime. The increased buying power of such an approach, coupled to a sharp focus on cost per mile would also allow the core to be held to account for its own performance, something which is notably absent from the current arrangements. The strategic, long term view of the development of GB railway would be the primary concern of this body.

The network infrastructure operator could be continued, with a renewed performance regime, or, as with the operators, be parcelled into a series of operational management contracts. These could be vertically integrated with the operators. The strategic long term view of infrastructure would, as with operations, be held by the DfT.

It may be considered appropriate to leave only the Transport Policy function within the direct gift of government and to constitute an arms-length body charged with delivering the future GB Railway. This would need to be established on a basis and with a performance regime consistent with the desired outcomes. Its effective functioning is probably not within the individual competences of the existing train or network operators, regulators or government departments since the breadth and depth of knowledge and skills required embraces all of those functions.

5.4: Optimising the Network

There seem to be, at least, three challenges to optimising utilisation of the rail network. First is the operating model, second is franchise based timetabling which acts to optimise the individual franchises rather than the whole network. Third is the network maintenance and adaptation strategy.

5.4.1:Operating Model

The traditional 'static block' control coupled to lineside signalling absorbs an estimated 15%-60% (TOSCA WP5) of potential vehicle capacity and the need for increased vehicle capacity is reported as a significant driver of the HS2 project. A shift to 'moving block' control with transmission based signalling has the potential to release this capacity – a substantial gain. It is important to stress that this is vehicle capacity because passenger (and freight) capacity are not direct functions of vehicle numbers but functions of the capacity of the vehicles themselves. It may be possible to increase passenger capacity by more than the increase in vehicle capacity and that could deliver substantial revenue and performance gains to the railway at a lower cost than that of building a new railway. This might be achieved through longer or, where possible, double decker trains – although both would require investment.

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5.4.2:Timetabling

The current process for timetabling is understood to be driven by individual franchise commitments, to be inhibited by 'grandfather rights' on certain train paths as franchises change hands and conflicts which arise in relation to pinch points and crossovers on the network and increases in stopping points. Timetabling decisions are understood to be made on the basis of the benefit to the individual franchisee, and a revenue allocation system which is dated. Neither of these will necessarily align with the interests of the passengers. Open access and freight services also impact on timetable effectiveness.

Given that limited capacity will be a long term feature of the railway, it seems that a more useful approach to the challenge might be to optimise the timetable against known and anticipated passenger requirements (volume, timing, frequency), taking care on a busy network not to exacerbate existing issues. To reduce overall journey time priority could be given, in a nationally set optimum timetable, to long-distance, higher speed, services over short distance, lower speed services. This might, in part, obviate the need for HS2 but, more importantly, could deliver benefits to passengers in the 10-15 years before HS2 is available. Coupling this with a shift to moving block and transmission based train control could provide significant gains against relatively low investment. It would also kick start the regeneration process for the locations to be serviced by HS2.

The potential disadvantage imparted to short distance, slow trains by this timetabling strategy could be mitigated by a sharp focus on the development of multi-modal interchanges and a fresh impetus on light rail, tram/train, guided bus and other already available alternatives to decongest main lines and offer cost effective suburban services. Indeed many of the recent large station refurbishments have lengthened the journey time by making passengers take a longer pedestrian journey on embarking or disembarking, e.g. St. Pancras domestic terminal, and more time is lost in queuing and negotiating the ubiquitous ticket gatelines. GIS tools and modelling techniques could be employed (as they have been by Transport for London) to understand the effects of the changes and identify pinch points across the whole system, this would enable the industry to allocate resources to challenges based upon the performance priorities established earlier. This would mean, for example, integrated timetabling at key interchanges to ensure availability of buses, underground trains and trams upon arrival of long haul, high speed services.

Further exploitation of this revised system might be achievable by encouraging the use of selected passenger stations in congested cities as overnight freight delivery points, removing trucks from the roads, decreasing urban congestion and pollution and noise.

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5.4.3:Network Maintenance and Adaptation

It has already been noted that the current maintenance regime for the network is fragmented across the recently adopted 'line of route' organisation created within Network Rail and managed in functional silos within that route.

Above all other transport systems, because of its high levels of interaction and interdependency, the rail network needs to be understood, managed and maintained as a whole. To a very significant degree it either all works or none of it works. GB Railway faces two major network challenges over the coming years. It has to improve reliability and availability under normal conditions and it has to adapt to the additional demands and risks anticipated as arising from climate change. The big risk, partly driven by the silo'd structure, partly by line of route organisation and partly by lack of a systemic approach to engineering, is that it will continue to address these as two separate problems, with significant implications for the cost of solving them.

To challenge this it is suggested that the railway should adopt an integrated maintenance and adaptation philosophy, one which is focused on delivering agreed performance outcomes of the 'effective and efficient railway'. This we have chosen to call 'LAMP' – Lean Adaptation Management Protocol.

This recognises that maintenance is not a purposeful activity in its own right but one which is carried out in order to support the delivery of the effective and efficient railway. At the system level maintenance is an enabling activity. The scope and range of maintenance and the provision of resource for it should then be driven by the long-term needs of the railway, not by the short-term driver for least short term cost and its impact on operations needs to be understood.

To adopt lean thinking (Ohno 1988, Feld 2001) demands that the appropriate maintenance regime is known and understood for each asset and that necessary measurement or, if appropriate, telemetry is in place to inform the maintenance decisions. These decisions need to be made in the context of the overall railway performance regime and to accommodate the three core potential maintenance strategies of condition-based, time-based and responsive repair.

The adaptation element then emerges from the use of lean thinking and adaptation becomes built in to core activity. Any maintenance activity has an impact on the performance and life of the asset maintained. It would therefore be appropriate that maintenance, repair and upgrade of any asset is undertaken to a standard of performance and resilience that will accommodate the climate and weather conditions that are predicted during the life of the asset, i.e. an asset with a 30 year life should be maintained or upgraded to accommodate all those climate and weather conditions predicted to affect it over that life. Adopting this approach will obviate the need for a separate, and costly, adaptation strategy for the railway because adaptation will be built in to business as usual. This will reduce cost,

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improve performance and reduce complexity and conflict. This operational strategy for LAMP is called LITE – Lean Infrastructure Transition Engineering.

Conceptually, LAMP is not new; it is formalising what many good engineers have done over the years. One co-author recalls his early years in railway engineering where one of his mentors had a long-term vision and programme to increase line speeds on the Welsh Valley lines, but there was no improvement budget available to do this. Instead, realising that track maintenance machines had the capability to realign and reset track curvature and cant (the tilting of the track to equalise centripetal forces) in incremental steps, the engineer devised a plan involving the necessary realignment and cant work through the normal maintenance programme and budget; the maxim being 'it needs to be maintained so let's improve it at no cost'.

LAMP will enable the railway as a whole to address multiple needs. It will allow the 'four C's (Capacity, Carbon, Customer, Cost) to be considered within the maintenance strategy. Sustainability and resilience, both of which will need operational definitions, will be targeted as part of adaptation with whole life costing and whole system value subsumed within them. The strategies for modernisation in relation to electrification, civil engineering assets and rolling stock efficiency will be accommodated. Changes to policies, standards and the appropriate skills and behaviours of the workforce, at all levels, will be integral to LAMP.

5.5: Modernising the Classic Railway

Rail travel is generally considered to produce the lowest carbon emissions overall per passenger mile when compared with road and air transport. This assertion makes a number of assumptions about the source of energy, passenger loadings and the mix of vehicles in use. The assertion about low emissions can only be made about the rail element of a passenger journey. If other, higher emission, forms of transport are used for other elements of the journey then the low emissions from the rail element may be misleading. Emissions from rail travel needs to be considered in the context of the whole passenger journey.

Equally, each of the improvements suggested could be applied as adaptations to the existing railway and deliver many of the benefits over the same time period at lower cost:

> Move more quickly to transmission based signalling and moving block = 15 to 60% capacity increase (TOSCA WP5);
>
> Retrofit existing vehicles with 'new tech' control and propulsion systems as they sequence through heavy maintenance;
>
> Move to 'management contract' for each line of route as the current franchise expires;

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Develop a nationally optimised timetable and implement, revising franchise arrangements as necessary;

Develop multi-modal exchanges and encourage optimization and alignment of timetables;

Stimulate local light rail, bus and tram solutions;

Develop and implement ticketless travel based on airline systems;

Progressively remove existing energy delivery systems as and when they are no longer required;

Adapt the civil engineering infrastructure making it more resilient to the current and future climate in line with LAMP and LITE.

The regeneration and export opportunities would be substantial, the need to build new lines less and effective timetabling would generate similar performance gains to those offered by high speed trains.

5.6: High Speed 2

The proposals outlined in this paper may suggest to some a weakening of the business case for HS2, while others may see it as an entirely redundant project. It is widely reported that the business case for High Speed 2 is weak and worsening, it is less widely reported that it must rely on 'established technologies'.

We are choosing to interpret this latter admonition as requiring reliance on technologies which exist but which may not have been deployed or integrated in a rail vehicle. The admonition is interpreted by the industry as being a limiting statement. However, if we take our definition of effectiveness and efficiency as our guide then the call for 'established technologies' can be taken as an enabling one, an invitation that says "go out and find technologies that are in use elsewhere and bring them together to help constitute a state of the art railway".

High Speed 2, in conjunction with the modernization strategy outlined, offers the UK a route to re-establish itself as the world leader in railways – operations, technology and performance. It simply requires the imaginative use and integration of existing projects and technologies – and it could fulfill the vision outlined at the commencement of this paper.

The HS2 Pathway could provide a route for the hydrogen distribution network;

Gas turbine and/or fuel cell powered vehicles could eliminate overhead lines, their costs and their limitations;

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‘On vehicle’ power generation would eliminate reliance on both vulnerable and expensive external power supply over distance and high emissions sources;

Advanced materials could be employed to develop strong, lightweight, corrosion resistant vehicles;

Advanced control systems could be deployed in the railway;

Customer service advances in ticketless travel, occupancy management, yield management and catering could be developed and tested for HS2 then deployed across the railway;

The much vaunted potential for HS2 to stimulate regeneration of parts of the UK economy could be accelerated by the engagement of engineers, researchers, designers and manufacturers from across the UK in the development of the new model railway.

The consequence would be substantial new export opportunities for both manufactured goods and a wide variety of services.

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6: Conclusion

This paper does not set out to provide 'the answer' to the challenges facing GB Railway but to stimulate thought and debate. The proposals here are, however, consciously neither complete nor costed. They are all feasible from a technology and engineering perspective. Unlike Kennedy's speech at Rice University in September 1962 in which he stated that the space vehicles would be "made of new metal alloys, some of which have not yet been invented", nothing needs to be invented, no blue-skies research is required, just some honest reflection on the state of the railway, a vision of how it could be and the will to deliver it.

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References

Beckford, J., 2010, Quality, 3rd Edition, Routledge, London

Beer, S. 1966, Decision and Control, Wiley, Chichester

Beer, S., 1985, Diagnosing the System for Organisations, Wiley, Chichester

Cella Energy, Daily Telegraph, 27th May 2013

Churchman, C. West, Wicked Problems, Management Science, Vol. 14, No. 4, December 1967.

Dudley, P., 1998 "Food for trees: Man's place in the tapestry of life on earth", Kybernetes, Vol. 27 Iss: 2

Dudley, P., 2000, Quality Management or Management Quality, PhD Thesis, The University of Hull

Fayol, Henri, 1916,

Feld, W., 2001, Lean Manufacturing, Taylor & Francis, Boca Raton

Gladwell, M., 2000, Abacus, London, The Tipping Point

Kennedy, John,F,, 1962, Rice Stadium Moon Speech, Rice University

Maturana, H., and Varela, F., 1987, The Tree of Knowledge, Shambhala, Boston & London

Ohno, T., 1988, Toyota Production System, Productivity Press, New York

Psaraki-Kalouptsidi, V., Pagoni, J., Fröidh,O., 2011, Tosca: WP 5 Report ,Technology Opportunities and Strategies towards Climate friendly transport, National Technical University of Athens, Royal Institute of Technology

Taleb, N.N., 2007, Black Swan, Penguin Books, London

Web:

BREEAM http://www.breeam.org

http://news.bbc.co.uk/1/hi/uk_politics/election_2010/8654338.stm
18 Governments

http://en.wikipedia.org/wiki/Secretary_of_State_for_Transport
38 Secretaries of State

http://eng.rzd.ru/newse/public/en?STRUCTURE_ID=15&layer_id=4839&id=105768.

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EU Transport White Paper 2011 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0144:FIN:EN:PDF
Double rail's capacity

NR Earthworks Strategic Business Plan http://www.nce.co.uk/news/transport/rail-structures-suffer-after-network-rail-cash-squeeze/8641207.article

http://www.futurerailway.org/RTS/About/Documents/RTS%202012%20The%20Future%20Railway.pdf

http://orr.gov.uk/statistics/published-stats/statistical-releases

http://www.therailengineer.com/2013/11/28/class-317-half-old-half-new/

http://www.bettertransport.org.uk/blogs/rail/government-pricing-people-off-train

http://ec.europa.eu/transport/themes/strategies/2011_white_paper_en.htm

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