Do the Railways need a Moonshot?

August 2, 2019

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Meet the Team

I believe this nation should commit itself to the goal

John F. Kennedy speaking to Congress on May 25, 1961, calling for the USA to land on the moon. Kennedy was privately sceptical about the odds of success, despite publically calling for it.

It cannot have escaped your attention that it was the 50th anniversary of the first moon landing last month. That historic achievement was the ultimate validation of a speech first given by President Kennedy eight years earlier, when he called for the USA to "*land a man on the moon and return him safely to Earth*" before the end of the Sixties and so win the space race with the USSR.

Kennedy was calling for the impossible at the time that speech was given, requiring technologies and materials that had not been invented yet. No one could even say what the full extent of the risks and challenges were to then describe all of the as-yet-to-be-invented technologies and materials that would be required. It was a call that gave birth to the term "moonshot".

Whereas then it literally meant getting to the moon and back, today the term moonshot has come to mean something as challenging as getting to the moon and back: to strive for something that is ambitious, ground-breaking, visionary and out-of-reach.

The technological advances in the space race were, well, space age, but they were mostly confined to the space race, and so culminated in transport that took just 12 men to where they wanted to go. Now, 50 years later, we are finally talking about another literal moonshot to get back to the moon, but we are also talking about a figurative one

in more everyday forms of transport that may well take all of us where we want to go. But are we seeing that moonshot being taken by the railways?

It is a question being contemplated by the Williams Rail Review, charged with making recommendations to government about how future passenger services are going to be delivered in the UK. In considering those recommendations, the Review is thinking about future transportation, and in its evidence paper published in May, "*Rail in the future transport system*", it described some of the technological advances being made elsewhere and the existential threat they might pose to rail.

Promises, or is it threats, of the future?

For the most part, the fundamentals of how we get about today are still based on early 20th Century, even 19th Century, technologies and ideas. Hardly space age development, unless that is you count the arrival of dockless bikes and man-child electric scooters.

Now there is a global race on to create the transportation of the future. Driven by the necessity of moving away from fossil fuels, advances in power sources, engines and software could see a revolution in road and air travel, and depending on who you speak to, even a revolutionary convergence of road and air travel.

What of railways? Batteries, hydrogen fuel cells and new materials are being tested, more efficient designs are being explored, infrastructure lasts longer, needs less maintenance, is better engineered, trains themselves are more energy efficient than they were before, they accelerate a bit faster and are less polluting than they once were. You can even plug your phone charger in these days.

All of that stuff is great, but it's hardly Buck Rogers is it? If all that's promised in rail is just that bit better, incremental, when set against the potential impactfulness on everyday life of what may be about to happen in road and air travel, the railways risk not being perceived as the transportation of the future, which means they may not be the transportation of the future. "*Rail in the future transport system*" trails this possibility, setting out one possible 2040 scenario headed, "*The decline of rail*".

Space X Starship, somewhere in the imagination between London and New York.

So how real are the threats? We are regularly promised tomorrow's transportation. Manufacturers and the media are complicit in teasing new ideas that capture the imagination, if not actually capture us and take us somewhere. There are regular stories on hypersonic planes that need little runway and fly at seven times the speed of sound, or rockets that touch the edge of space before descending on the other side of the world. The most

recent of these, Space X, is touting the outlandish ability in 10 years to get to New York from London in 29 minutes. That's barely enough time for the cabin crew to throw the peanuts at you. I hope the Heimlich Manoeuvre will be part of the crew's basic training.

Fancy planes and commercial passenger rockets are still hugely speculative, but not cold fusion, perpetual motion speculative any more. Serious businesses (like ESA, Boeing and Rolls Royce) are dedicating large parts of their R&D budgets to developing future air transportation. Space X has already demonstrated its credentials in advancing commercial space travel. In recent years there have been numerous real-world validations of the new technologies that will be required, including successful demonstrations of re-usability, composites and engines. But the key to whether any of this actually happens will be whether it can be achieved at a reasonable cost to passengers. Concorde provides a salutary lesson there.

Cars give us independence, convenience and personal space. They also give us stress, a hole in our pocket and no small amount of personal danger. Autonomous vehicles might just offer us the first three without the second.

We can all imagine the potential. A car that takes you door-to-door while you relax, work, eat, drink, sleep, whatever. A mobile extension of your home/office if you will.

Not a train carriage of the future, but the interior of the Icona Nucleus self-driving electric vehicle concept.

Take things to their logical conclusion, and we might not even own a car in the future. Just an app. Cars themselves would become a form of public transport, and without a driver, a cheap (even bus/rail cheap perhaps?) form of public transport.

The Bell Nexus VTOL air taxi, part of Uber Air's future fleet. Your autonomous driver is two minutes away apparently.

I was going to stop short of talking about flying cars because I can feel the eye roll, and in any case, if you can fly everywhere, who would ever need the car bit? But flying taxis are close – sort of drones for humans – with Uber, Boeing and others invested. And while these involve taking off and landing on purpose-built landing pads you must still travel to, they may be a bridge to what people really imagine flying cars to mean – the ability to take off and land from anywhere at will without restriction.

Autonomous road vehicles and flying taxis seem inevitable, such is their proximity to realisation and the scale of efforts to get there. It's merely a question of how ubiquitous they become and how far the technology will go in challenging the hegemony of existing modes as public transport solutions.

Are the railways keeping up?

Yes, if you think High Speed 2 – a conventional, 300kmph high speed railway – represents the cutting edge of transportation progress. If built (and "if" is very much the operative word at the moment, currently being under review by the Government) the railway would enhance connectivity between some of the UK's major cities. But at a current official price tag of £55.7bn, it suffers from being labelled the most expensive railway per kilometre in the world.

What High Speed 2 trains might look like if we ever build them. We don't do long noses here.

In fact, the project's own sponsor, the Department for Transport, challenged the scheme costs itself in 2017, asking for an independent estimate. But when, using conventional railway costing methodology, the answer came back that it was in fact the most expensive railway in the world (even more so than hitherto acknowledged), the DfT promptly failed to recognise it[1]. Presumably the number sits in a drawer somewhere, along with other things the government has failed to recognise, like Jean-Claude Juncker, or Boaty McBoatface. Sir Terry Morgan, the former chair of HS2, clearly didn't have access to that drawer, because he told the economic select committee in January that the final cost was unknown:

"nobody knows what the number is ".

But despite not knowing what the number is, or maybe because he could not point to it, he got his recommendation in before the select committee inevitably did :

"I think the triangle of scope, cost, and time, something has to give. Something will have to give."

Rightly or wrongly, the public perceive HS2 as a railway that does not appear to deliver benefits that justify the costs. That may be as much a failing of messaging as design. But rather than addressing that perception by focusing on the benefits, inevitably, here we are, seriously talking of reducing operating speeds and train numbers, stopping the railway at Birmingham, not terminating at Euston and even scrapping it all together. Rest assured, if it survives in any de-scoped form, it will still be perceived as over-priced until it's actually built, then we'll forget about the costs and wonder how we ever did without it. Such is the way of things.

The Japanese continue to maintain a true vision for high speed rail. The Shinkansen, is still futuristic over 50 years after it was introduced. Why is that? Part of the response to that question is because it continues to work, which comes down to how it is run. But another part of it is how it looks, how it is branded. The "bullet train" went like a bullet when it was launched and it continues to go like a bullet today relative to more modern railways. Now it's set to go even faster with the introduction of the Alfa-X, the next generation of bullet train, with a top speed of 360kmph. And while the 22m, longer-than-a-cricket-pitch pointy nose may not be entirely necessary for

aerodynamic purposes, it is entirely necessary for maintaining the perception that it will get you to your destination as fast as a bullet.

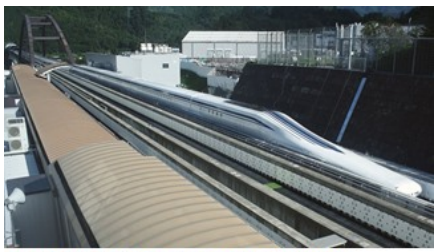
The new Shinkansen Alfa-X. Look at it! With a nose longer than some of our trains.

Let's face it, with a nose that long, the train is half way there before it's even moved.

However, we don't seem to be going for really pointy noses for HS2 and there won't be the infrastructure to get anywhere near 360kph even if we did. But, the Shinkansen is still "just" a conventional railway. It still follows the same principles that moved the first passengers between Stockton and Darlington in 1825. So it doesn't perhaps move the needle compared to the possible Jetsons-like future of road and air.

What if you had a blank piece of paper?

Is there anything in rail that's as visionary as passenger rockets and driverless living rooms? Well yes, but sadly no one seems to be trying them here.


Testing of a L0 series 5-car maglev train on the Yamanashi Test Track.

Maglevs still project the future. Magnetic levitating trains have been with us for over 40 years and some have even been built. Mostly, it must be said, at airports in Asia. With the train travelling on a cushion of air, track/train friction is eliminated. So are maintenance and operating costs, noise levels and other pollution, or at least greatly reduced. Speeds that can be achieved are incredible, with the current record standing at just over 600kph.

Japan is building a 505kph one between Tokyo and Nagoya, which is due to open in 2027 and China's train manufacturer, CRRC, just announced a prototype train that will regularly match the record if it can find some track to float over.

So why aren't we building them? They sound brilliant. Unfortunately, so are their price tags, which seems to cut the conversation dead whenever you mention them. But as we've seen, the costs of HS2 (whether the recognised ones – £100m per km – or the unrecognised ones - £250m per km) make you wonder why we never really seriously considered doing one of those instead. Who knows, perhaps we will if HS2 is shoved in the drawer with its supposedly prohibitive costs.

If we did start over with a blank piece of paper, what might we put on it besides a maglev? What about Seamless Interchangeability, or SI? SI involves:

"*...the running of a non-stop 'train', known as the 'prime train' between*

terminal stations. To serve intermediate stations, autonomous powered carriages couple/uncouple from the front/rear of the prime train."[2]

In other words, trains as we know it split apart and reform in transit, allowing carriages to separate and head off in different directions before joining up with other carriages heading in the same directions.

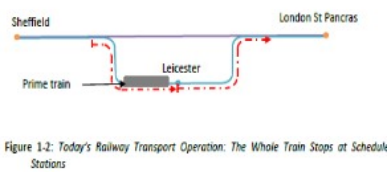
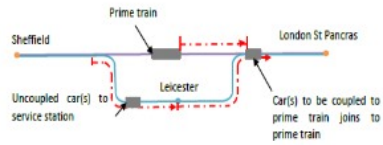
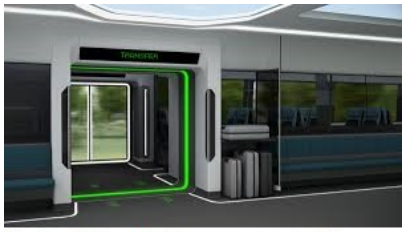


Figure 1-2: *Today's Railway Transport Operation: The Whole Train Stops at Schedule Stations*



An example of Seamless Interchangeability, taken from the Final Report, July 2016.

SI is intended to solve capacity constraints, optimise journey times and reduce interchanges, making much better use of the infrastructure we already have, and thereby avoiding the need to build more to create more capacity. While only modelled, the study did find that there were marked capacity and cost improvements brought by SI.



Moving Platform docking arrangement, with two trains side-by-side.

Or tackling the same issues in another way, something called, Moving Platforms, where high-speed trains pull up alongside local trains, "dock" while passengers transfer from one to the other, before separating and carrying on their separate journeys. The trains operating "*in effect, as...moving station*[*s*]".

Both are technologically possible, requiring dynamic coupling/connecting, a signaling overhaul and military precision to ensure carriages/trains are in the right place at the right time to join up and peel off. SI might also require a GCSE in getting in the right carriage and Moving Platforms might be a bit stressy if you have luggage or small children – good luck with either on the Friday night vomit comet slot.

The problem for both is, how do you get from where we are now – with static coupling, our analogue signaling and often far from military precision – to where you'd need to be to implement either? Neither represent a discrete solution, like building a separate high speed route, so appear to result in system-wide impacts. On that basis, calling for either truly would be a moonshot and so perhaps for now, Sci Fi is a more accurate moniker for them.

Speaking of sci fi. Hyperloop. Maglev or some sort of frictionless technology in near-vacuum tubes. Hyperloop or the fundamentals of it are not a new idea. 'Atmospheric Railways' have been talked about for over 200 years. But is Hyperloop, as currently imagined, actually a railway? I suppose to the gricer, not really. The tubes won't carry trains, but pods. The largest pod size spoken about has 50 seats. Not even a busload. So Hyperloop won't be a mass-transit solution. It won't deliver the same number of passengers per hour as HS2 (unless it can achieve a 9-second

headway with 400 pods operating per hour[3], which seems challenging at best).

And the other challenges are just as daunting. There remains about a Hyperloop of distance between theory (everyone seems to agree it is theoretically possible) and reality (everyone seems to agree that it is really, really difficult). The naysayers, and there are many who say nay, point to the problems of, to name a few, maintaining low atmospheric pressure over vast distances, forces and stresses of confined supersonic airflow and bends (Hyperloop is something of a misnomer – Hyperlinear might be more accurate). The DfT certainly isn't convinced. It thinks the technology is at least 20 years away, despite some calls as we reconsider HS2 to back the technology.

Hyperloop One.

But these challenges have not daunted the yeasayers elsewhere. There are teams around the world (India, Scandinavia, Holland, the UAE) working on being the first to deliver a proof of concept – the Dutch team just broke their speed record for the fourth year in a row – 463kmh. And conventional railway businesses such as SNCF and Deutsche Bahn are taking a look, even if it is just as a hedge.

But whether Hyperloop is technically a railway or not, or even a mass transit solution, it represents an aspirational view of the future.

Kanye West

Kanye West in the Oval Office about to promote iPlane 1, along with a range of unrelated issues

Which obviously leads me to Kanye West. It was in October last year that Kanye West exhorted the values of iPlane 1 in the Oval Office to a suitably impressed Donald Trump. "This right here is iPlane 1," Kanye said, pointing to a picture of a Thunderbirds 2 homage proposed by a post-graduate student at college in Detroit, "*It's a hydrogen-powered airplane and, this is what our president should be flying. If he don't look good, we don't look good. This is our president. He has to be the freshest, the flyest and have the flyest planes*."

He then left the Oval Office to get Apple to work on the plane. Apple are yet to announce their involvement.

Part of the point I suppose Kanye was making was that aspiring to make something that is currently beyond reach, that is of tomorrow – a moonshot if you like – results in manufacturing not just that thing (hopefully) and other peripheral technologies, but also national confidence and pride. There is a value in the endeavor itself.

With the recent public backing of Northern Powerhouse Rail, our new PM

may have chosen to:

"*go to Manchester in this decade and do the other things, not because they are easy, but because they are hard…*".

But there's barely enough distance between Manchester and Leeds to get up to what might be called "high" speed and that scheme isn't enough for those who want a "Northern Crossrail" from coast to coast. And can we really say this most recent announcement is truly part of a vision for a fully-integrated high speed rail network in this country, when part of the funds for Northern Powerhouse might come from stripping HS2 back?

What instead if we did have a true high speed rail vision? One that put every major UK city within an hour of each other as Hyperloop promises at its most ambitious? How transformative would that be? Would it rebalance the UK economy and end the over-reliance on London? Would such a future represent an existential threat to whatever advances had been made in air and road travel over the same period?

Imagine instead something with less of a NASA-like budget. Sir Andrew Cook did that in a recent speech at the High Speed Rail Industry Leaders' parliamentary reception. He took the annual budget for the NHS (£120 billion) and imagined a commitment to build a truly visionary HS2, with a 30-mile tunnel under the Chilterns, a through station under London somewhere to connect to HS1, and a connection to Heathrow. The cost of one year. Compared to an arterial railway that would properly connect the country for the next 100+ years. Comparing anything with the NHS is always fraught, but it does give some perspective.

Trying to bring this back to earth a bit, it seems like we need, er, the freshest trains and the flyest railway to compete with the seemingly game-changing advances in road and air travel on the horizon.

But something tells me you need more than Kanye West to convince you of the need for a visionary commitment to rail. That even if some of these threats are on the horizon, that horizon is lifetimes away. Well, consider this. The entire period starting from when it was an oddity to see a horseless carriage in an urban setting, to the days when the reverse was true of horse-pulled ones, took just 50 years. We are already 10 years into serious autonomous transportation development. And development is often like a snowball rolling down a hill.

Just how will people perceive the railways when you can go over 3,000 miles in the time it takes you to commute by train to Romford? What will they think in 2040 of a form of public transport that you still have to go to to use and uses fossil fuels to go, which competes with another that is sustainable and solved the last mile at a comparable price? Like the horse and cart when the automobile came along I suspect.

But you might say, passenger rockets and autonomous vehicles are not mass transit solutions. So even if all that comes to pass, they won't be a threat to a mass transit solution such as rail. Well much depends on whether

China, November 2018. A Guinness World Record for the most (55) self-driving cars operating autonomously at the same time.

we need a mass transit solution in the future and that itself depends on many different factors, not least of which is future urban employment demand and how attractive that mass transit solution is compared to the alternatives. But let's assume we do. Isn't it possible, probable even, that autonomous software becomes so sophisticated that vehicles, be they road or flying ones, can safety operate at negligible headways, creating effective road or air trains. Would people use actual trains then?

Tomorrow comes soon enough

I know I'm tilting at windmills. Shouting into the wind. The upshot of this article seems to be calling for more pointier noses on trains, people being shot down a drainpipe and unrealistic spending. This at a time when there are deep-seated structural issues in the industry that stifle innovation; when there is real talk of de-scoping the only significant conventional railway infrastructure project we have on the immediate horizon; and when we do not even have a national conventional high speed rail plan, never mind railway-of-the-future plan. The Rail Review is looking at structural issues, but let's be honest, even though it has identified threats from other modes and the need for innovation to try to meet those threats, it's not going to come back and recommend rail goes all Star Trek.

But that, I fear, is what the railways needs a bit of. Something that comes out of the imagination to capture the public's imagination. A moonshot. Without one, what is to counter the scenario the Rail Review posits of the railway's decline as a 21st Century horse and cart? Somehow, an on-train USB port doesn't quite seem to cut it.

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[1] HS2 'will be most expensive railway on Earth at £403m a mile', The Independent, 16 July 2017.

[2] Seamless Interchangeability: Final Report', July 2016.

[3] With due thanks to someone else for the maths.

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