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The future of high-speed rail

The options for high-speed rail in the UK

Research paper

By Torrin Wilkins, August 24th, 2019

Centre

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To achieve these goals, we work with people from across the UK and party politics. This includes engaging with politicians and our networks, which include academia, politics, and law.

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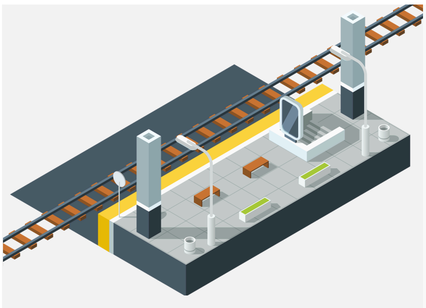
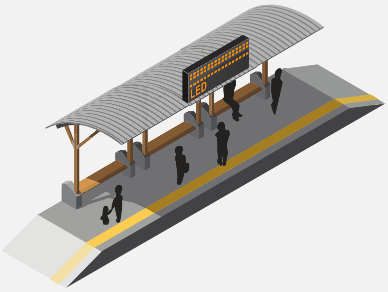
Summary



Conventional railways have decades of development behind them, and the existing HS1 line shows that the technology works in practice. However, HS2 has faced large-scale opposition and is expected to run at lower speeds than potential alternatives such as maglev or Hyperloop.



There are various examples of Maglev around the world, although it is used far less than conventional high-speed rail. However, it has higher speeds than conventional rail and runs entirely off electricity.

Hyperloop has a long history with vacuum trains first being used in 1843. The other element is the linear induction motor used for maglev, originally used for the hover train tested in the 1960s-70s. However, the technology is neither tried nor tested.

Introduction

This paper will look at the different high-speed rail options available to the UK. These include the HS2/3, a maglev line, and a Hyperloop system. This paper will not recommend a specific course of action, but it will look at the scientific background, histories, existing examples, advantages, disadvantages, and proposed routes for these proposals. This paper will also include several possible solutions for issues a Hyperloop or maglev system may need to overcome as they are newer technologies.

In introducing high-speed rail, the existing rail networks in the UK must also be considered. The UK's rail system has been in operation since the 1800s and contains a huge number of existing lines. Since then, the railways in the UK have been radically altered with the Beeching cuts, which closed a huge number of railway lines across the UK. These cuts were seen as necessary to close lines with fewer passengers, but with increasing rail usage in the UK, the picture is now very much the opposite, with a need for more railways to be built.

The system has been operated by both businesses and the government over its long history. However, today both private companies and the government have areas of ownership. The government owns the tracks through Network Rail, whilst private companies and organisations compete to run trains on them.

With the current decade of demand increases for rail services and population increases in the UK, there appears to be an argument for a new high-speed rail service. The decision to build an entirely new line, rather than upgrade existing ones, stems from the problem of slower trains sharing the same track. If a train is running on a dedicated track, then it can travel as fast as its top speed will allow it. However, if a train is running on a normal track used by slower trains, then it is limited to the speed of the slowest train on that section of track.

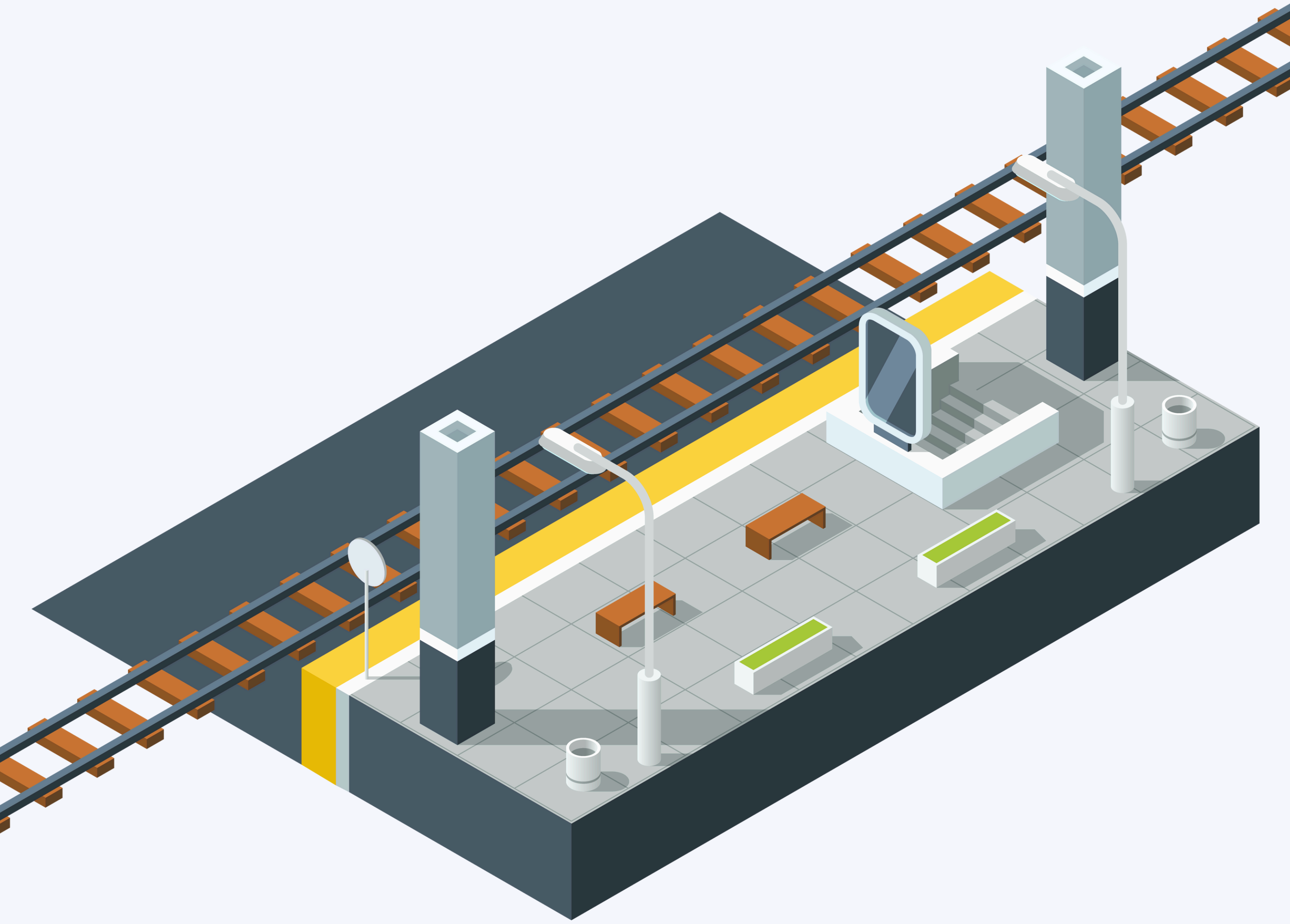
It should also be noted that there are other arguments for dealing with increased demand for transport within the UK. These are based on different routes such as the 'High-Speed UK' plan, investment in highways, increased bus services, and many other alternative ideas. However, the UK is currently going ahead with high-speed rail, so this paper focuses on the alternatives available to the UK government.

Whilst technology on UK railways has changed to allow trains to go at faster speeds and electrification of lines has modernised the UK's railways, the use of wheeled trains has not changed. Although some Asian countries seem to be moving slowly towards maglev technology, the UK appears to have no plans to use maglev technology for any large-scale projects. There are likely worries about being early adopters of new technologies or ending up with a system that doesn't work.

This brings us to the first section of this paper, the existing High Speed 1 line and the proposed HS2 and HS3 (Northern Powerhouse Rail) lines.

Chapter one

High-Speed One



The High-Speed One track is the most notable of these projects as it is part of a much larger line stretching to the north of England with High Speed Two and Three as part of the project. As a result, it may also help us understand what this project's next stages will deliver. This first stage of the track provides a link to London for the South East of England and to the Eurostar service at St Pancras station, linking London to continental Europe. It therefore has to compete with ferries travelling to France, the Netherlands and Belgium; although only the ferries to France depart from Dover.

Speed - The top speed on the HS1 line of "...185mph..."[1] and although for routes within the UK trains only run at "speeds up to 140mph"[2] they are still the fastest trains operating within the UK. However, this higher speed has not reduced journey times for all passengers on the line. It was even reported that "In the pre-HS1 dark ages, the journey time on the traditional line from Victoria to Faversham was 66 minutes, with six stops. This was two minutes faster than the "high-speed" service now"[3] meaning that for some people the travel times have increased by a small amount. This should not, however, detract too much from the increased speed of the new line.

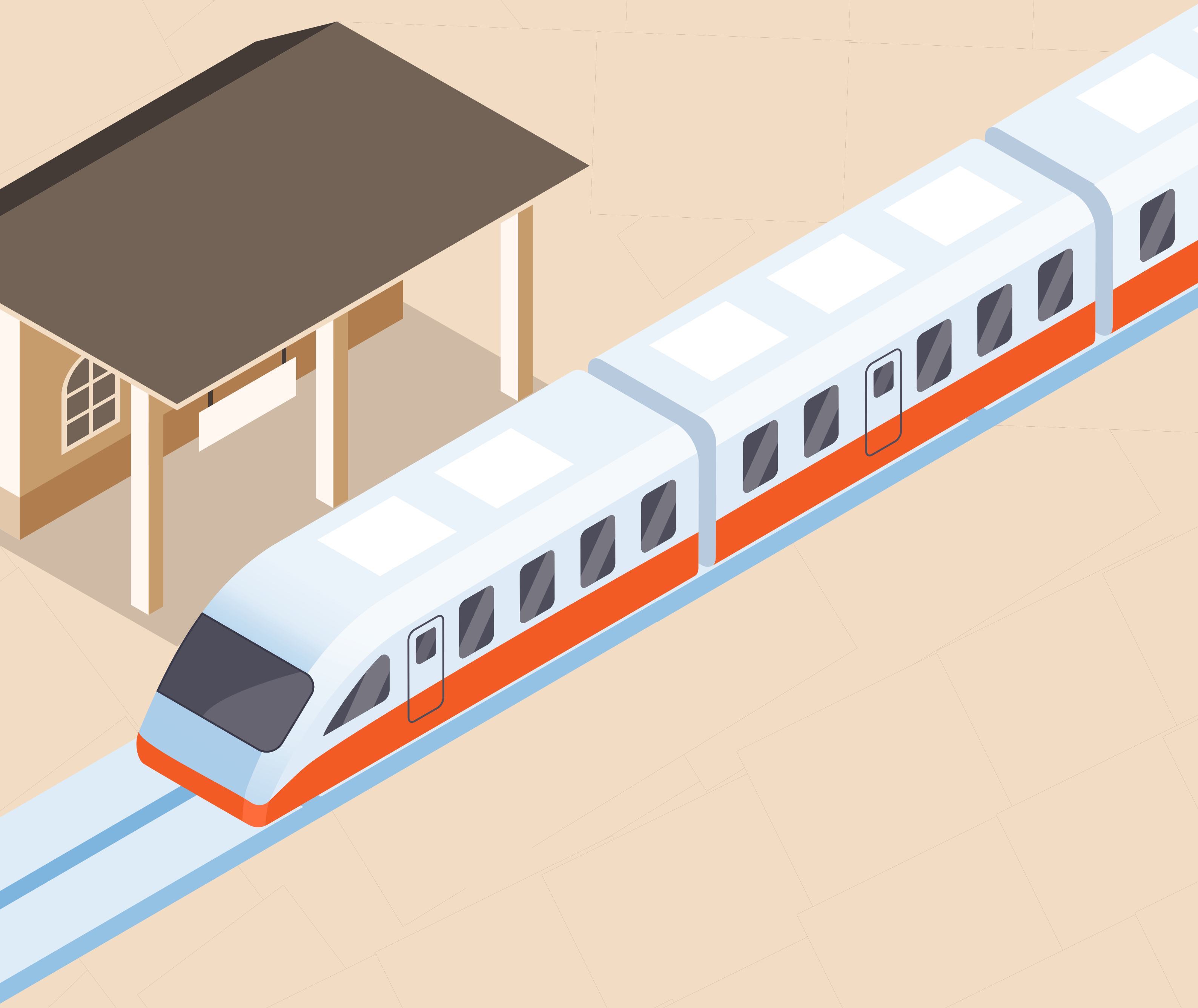
Ridership - The predicted number of people riding on HS1 was overestimated. In total "... 25 million passengers a year were forecast by 2006, compared with 14.8 million expected this year..."[4] which was in 2011.

Cost - The cost for the HS1 project was "...£5.8bn..."[5] which was "...18 per cent higher than LCR's combined contract targets for both sections which LCR funded in part from contingency. The line fully opened in November 2007, within the overall timetable to complete the project by December 2007 but 11 months later than the target"[6]. The line was therefore not just over the target budget but also later than was targeted.

Whatever the advantages or disadvantages of this track it has already been built. Any new track should at least take into consideration this line as an existing railway. In the future, the government can link this line to a larger network, upgrade it to a new type of unconventional railway or leave it as an individual line.

Chapter two

High-Speed Two



High Speed Two is the government's proposed rail system to link London and the 'Northern powerhouse'. Unlike the HS1 line, it has not yet been built, so most areas are projections rather than actual figures or the realities of the project. The High Speed Two line will link to the existing HS1 line and will link up Birmingham, Crewe, Manchester, Sheffield, Leeds, and the East Midlands. This essentially works to link up the North and South of England, with the trains running on the existing lines to Glasgow and Edinburgh to link up with Scotland.

Speed - Trains running on phase one of the High Speed Two line will have a maximum speed of "...225mph..."[7], which would make them the fastest trains in the UK, being much faster than HS1 domestically. Simply compared to existing railways in general, this is an extreme difference.

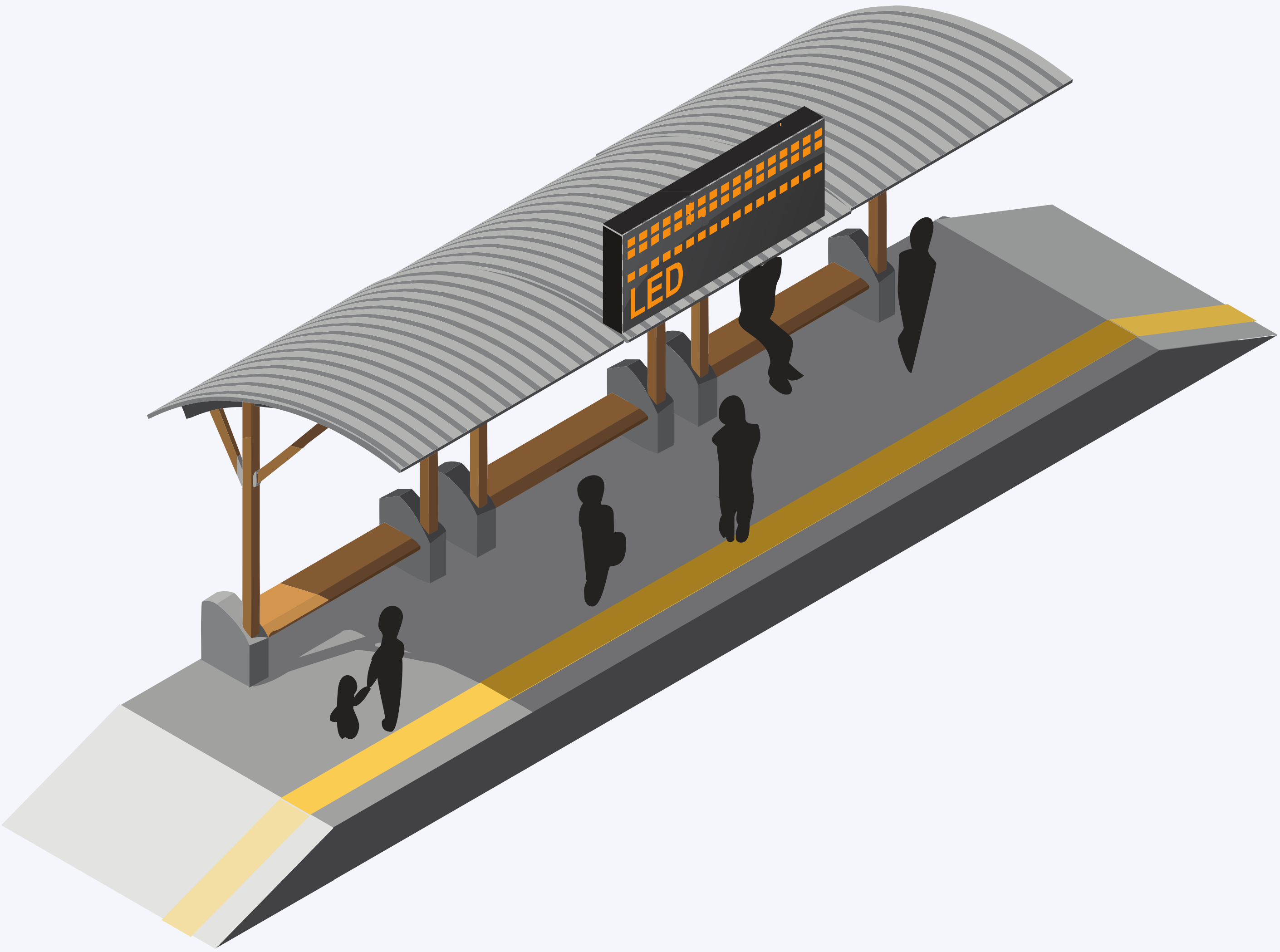
Ridership - t is projected that HS2 will carry "...300,000 people a day[8]," which would amount to over 100 million passengers per year. This is, however, a prediction, and the real figure could well be either higher or lower than this estimate.

Ownership - Most other railways in the UK are franchised to a company or organisation which runs trains on the track; the exception to this is Transport for London. HS2 will follow the franchise model, although a change in government may well see government-owned trains running on the tracks.

Costs - Whilst HS2 is "...scheduled to cost £56 billion, the real price will not be known until all the contractors have been established"[9]. There are even reports that the project will go over budget by "...an extra £30bn..."[10].

Chapter three

Northern Powerhouse Rail



High Speed Three is the third part of the High-Speed network in the UK and will link up cities including Bradford, Manchester, Liverpool, and Leeds, along with upgrades to existing lines. This project is a part of the larger Northern Powerhouse proposal which focuses on northern economic expansion.

Speed - It was noted that this line is not strictly a high-speed line: "We refer to 'east-west links' rather than 'HS3' in this report as there is no clear indication yet what form or route the proposals might take or if the trains will be "high speed" in the same sense as HS2"[11]. As with many of the details with Northern Powerhouse Rail, there is little in the way of exact figures, but by the sounds of it, the trains will not be running at more than 225 mph. It is likely then that the speeds reached on the HS3 line may well be similar to those currently reached on the HS1 line.

Ridership - Just as with the top speed, the number of people projected to use the service has not been released. However, a clue that passengers will want to use the services comes from the "...unsustainable levels of crowding and congestion could persist under the different economic scenarios considered in our Strategic Transport Plan up to 2050"[12] which will likely leave a large number of people either changing the mode of transport they use or using other train services. The challenge for the railway will be to convince people this new service is the best alternative.

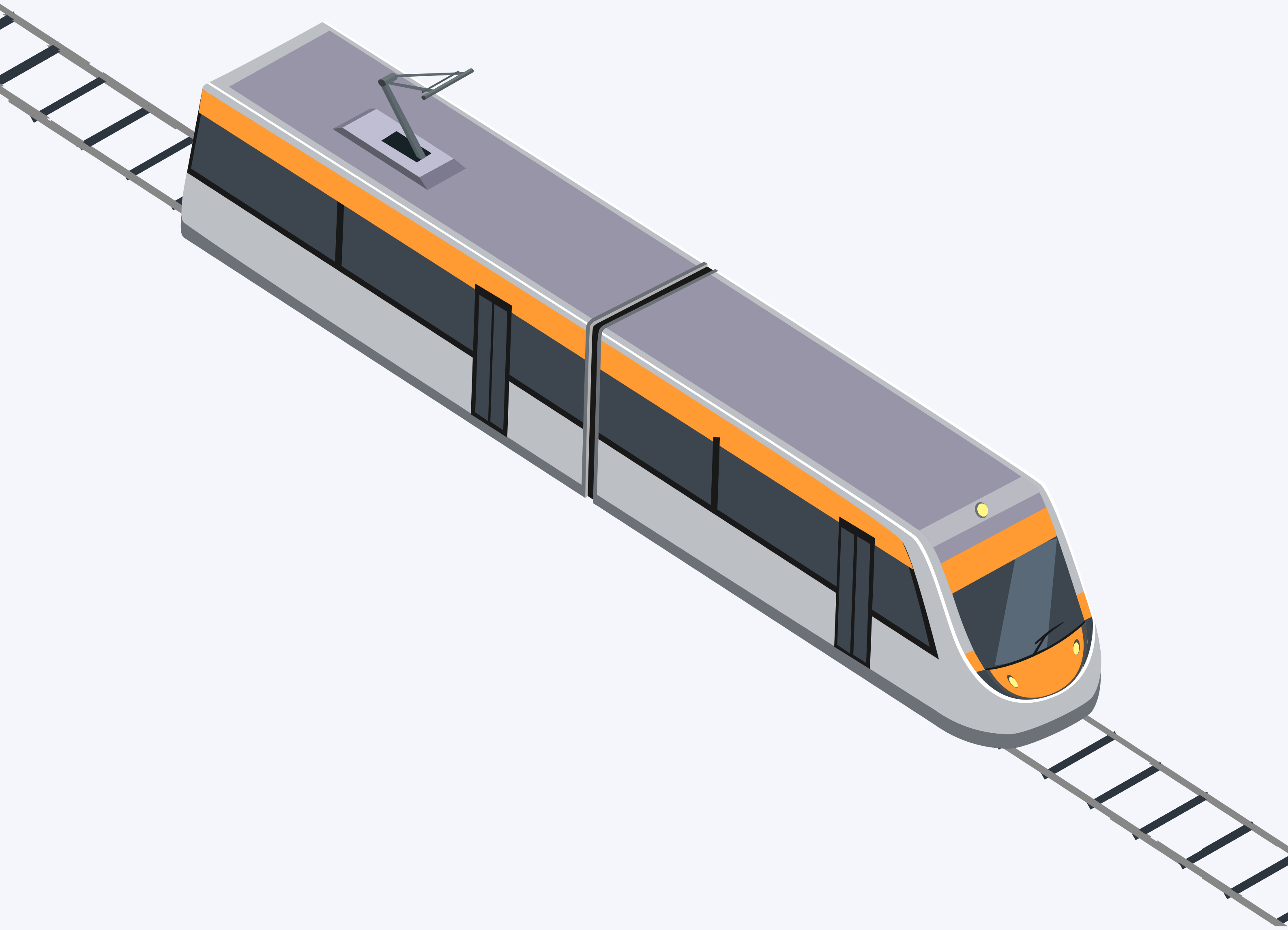
Figure 1: Simplified HS2 and Northern Powerhouse Rail map

This map is a simplified version of the HS2 and Northern Powerhouse Rail plans. It does not include upgraded lines, just the new lines being built specifically for high-speed trains.

Map [13]

Chapter four

Continuing with HS2

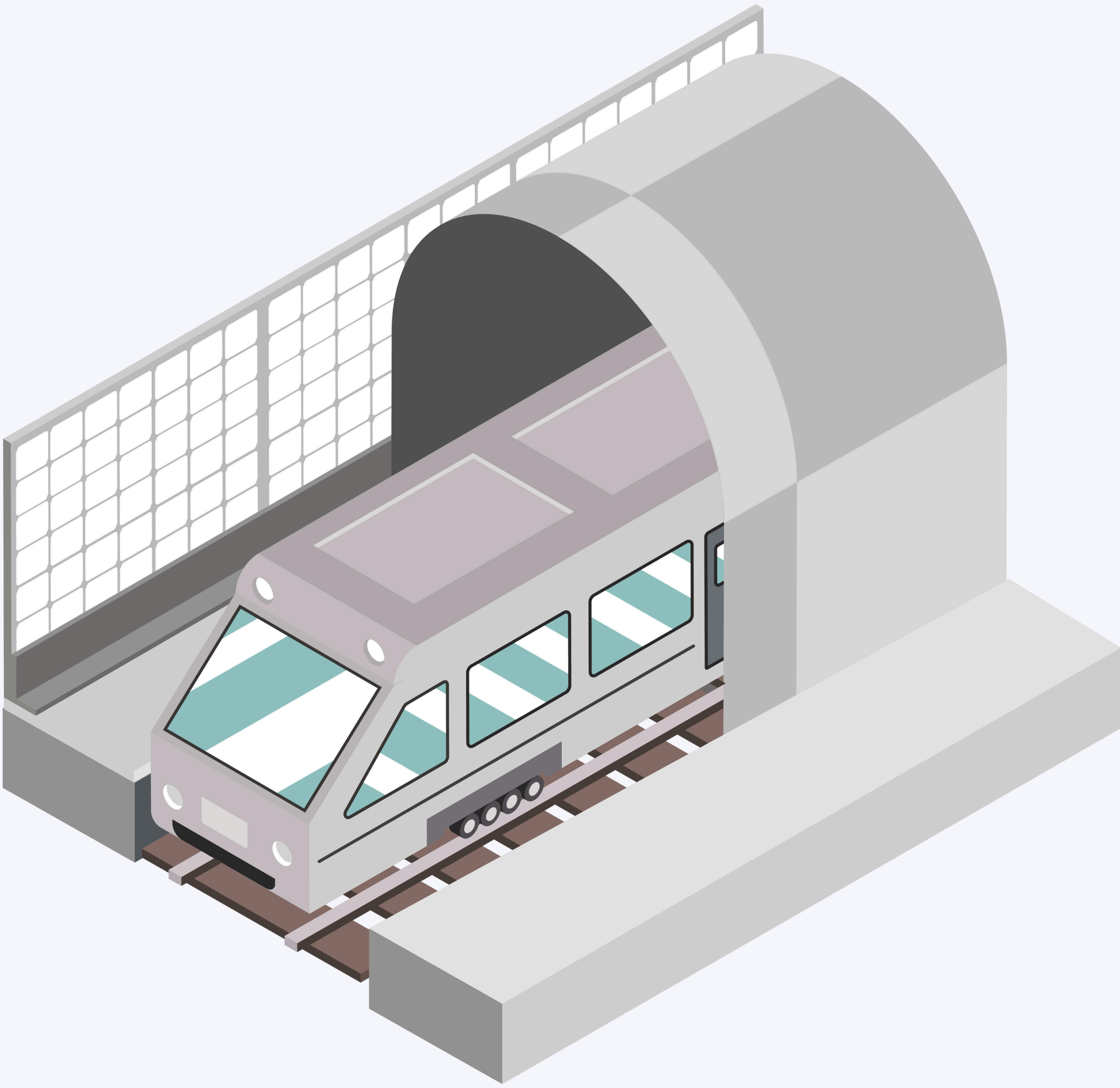


The High Speed 2 and 3 proposals have several benefits and drawbacks.

1. The High-Speed One track is already in place, and the technology for HS2 is in large part tried and tested. The trains do not rely on reinventing the wheel as other proposals for the UK's rail network do. However, this may also be the biggest issue with the HS 2-3 project. By the time the track is completed, it may well be out of date compared to other railways being built around the world, something the next sections of this paper will look into.
2. HS1 should be a warning sign when it comes to projections for HS2. The number of people expected to travel on the line may never materialise, and with the track possibly running tens of billions of pounds above budget, it may be very hard to see the money invested into the track returned. HS1 also slowed down some journeys, and it could end up with HS2 simply repeating the shortcomings of HS1. However, any project will encounter unforeseen costs with the need to build tunnels and buy large amounts of land. Newer forms of transport may add to this cost with money also being spent on research and development.
3. Just as HS1 had to compete with ferries, the HS2-3 lines will have to compete with cars and buses along the route. This may see a reduced ridership if the use of other forms of transport increases, it could also be reduced with new technologies including driverless vehicles. However, HS1 has also taken the pressure off of other forms of transport, such as flights from Europe, which can now be travelled by train. This also helps to reduce emissions that flights such as this cause.
4. The scheme is already in the works, so any change in course would cost money as money spent on HS2 and HS3 would likely not be of much benefit to a Maglev or Hyperloop line. However, continuing with HS2-3 may end up with costs spiralling out of control.
5. The main issue is speed. Although HS2 will add capacity, it will not necessarily improve journey times for all routes across the UK. This is compared to a network of either Maglev or Hyperloop trains which would both carry huge numbers of people and would travel at incredibly fast speeds. Whilst it adds capacity, when the UK has to build new railways anyway it may be better to build faster forms of transport.
6. HS2 trains can be run on other existing lines as with HS2 Javelin trains running on upgraded lines all the way to Glasgow and Edinburgh. This saves time with passengers not having to change between trains or train stations in order for them to carry on their route.

Chapter five

The history of Maglev



Although most high-speed rail projects being built are conventional trains, maglev trains are also being built. This is however still a relatively new technology, so many of the projects covered below are ongoing.

The Shanghai maglev

The Shanghai Maglev line connects the main airport with a local railway station. This track was built by the German company Siemens despite being based in China. The line is experimental but has still reached 268 mph. It also has a high capacity. "Because up to eight vehicle sections can form one maglev consist, the potential passenger throughput capacity of the system is several times greater than the adjacent six-lane airport highway..." [14] which shows that this system reduces stress on other forms of transport.

Changsha Maglev Express

This low-speed maglev train connects the Changsha airport with three stations currently in operation and two more planned for a future extension.

Beijing Subway

Part of the Beijing subway consists of low-speed maglev lines with seven stations at present and another under construction.

Chūō Shinkansen

This is a large-scale maglev project in Japan which will eventually connect the capital city of Tokyo to the city of Osaka. Currently, the only section of this line that has been built is the test track which will be extended until the full line is built. The train running on this test track is the L0 Series maglev train which broke the speed record for an unconventional train.

UK Ultraspeed

The proposed 'UK Ultraspeed' track was a plan for a maglev line in the UK stretching between London, Birmingham, Manchester, Liverpool, Newcastle, Edinburgh, and Glasgow. However, this was not picked by the UK government, which instead picked HS1, 2, and Northern Powerhouse Rail.

Chapter six

The science behind Maglev

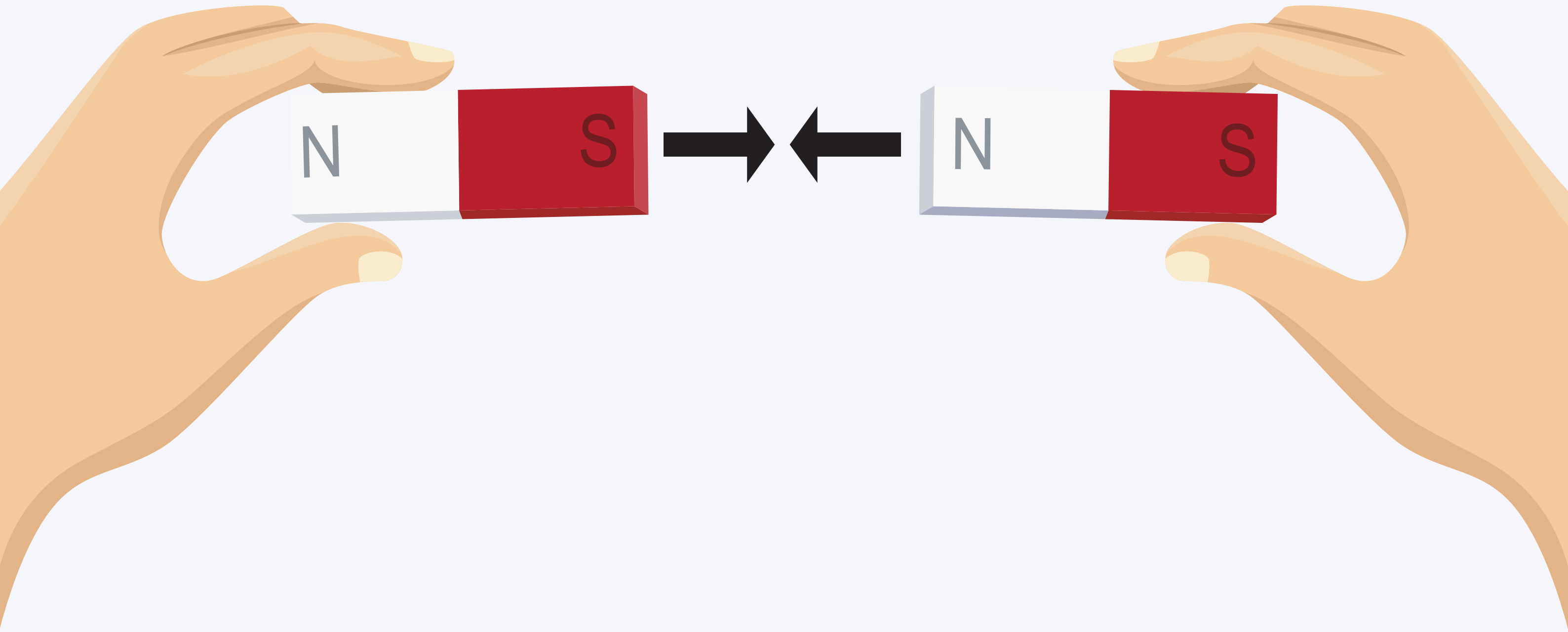
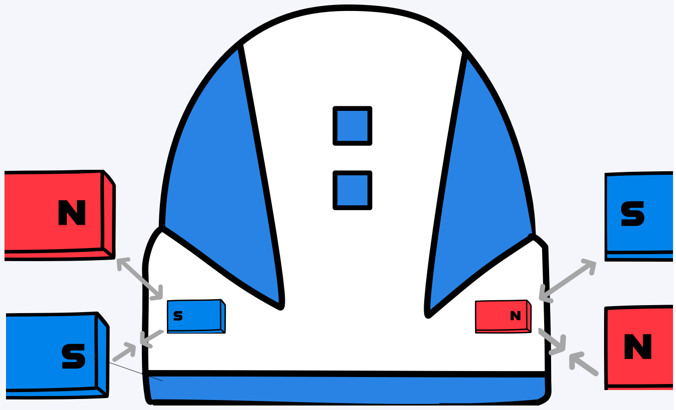


Figure 2: Levitation

Some railways use both repulsion and attraction, which is the system used on the Japanese LO Series maglev train. Each side wall has both north and south magnetic poles on them, with one magnet attracting the train's magnet and one repelling the magnet on the train, which balances the two out. This causes the train to levitate.

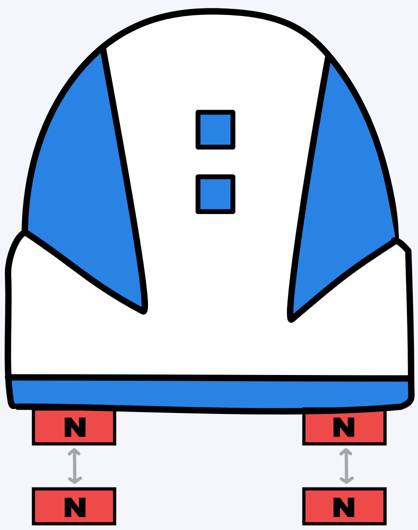
Diagram [15]



Maglev trains sometimes use the repulsive force from magnets to levitate objects. This works because magnets have two poles, north and south. If the north face of one magnet is placed near a magnet with a south face, then they will be attracted to each other. The opposite happens when two north-facing magnets are placed together, they repel each other. Therefore, if a magnetic track with its north pole facing upwards and the bottom of a maglev train with its south pole facing downwards were to be placed together, then the train would be repelled from the track.

Figure 3: Magnetic levitation

Whilst air resistance is an issue, friction between the train and the ground is also significant. To solve this Maglev trains, use magnets to float trains above the track. This diagram shows two north-facing magnets repelling each other causing the train to float.



However, some railways use both repulsion and attraction, which is the system used on the Japanese LO Series maglev train. Each side wall has both north and south magnetic poles on them, with one magnet attracting the train's magnet and one repelling the magnet on the train, which balances the two out. This causes the train to levitate.

Figure 4: Linear induction motor

Both Hyperloop and maglev lines use a linear induction motor to move the train forward. This involves a row of electromagnets with alternating poles positioned beneath the train. The motor propels the train forward using magnetic attraction. It works by always facing the track with a magnet pole that attracts the next electromagnet on the track as shown in the diagram above. This constant attraction propels the object forward.

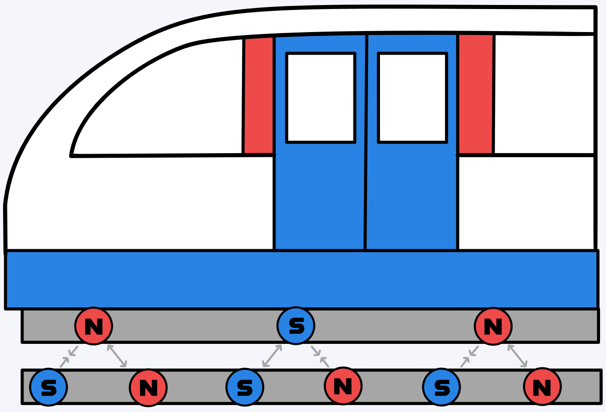
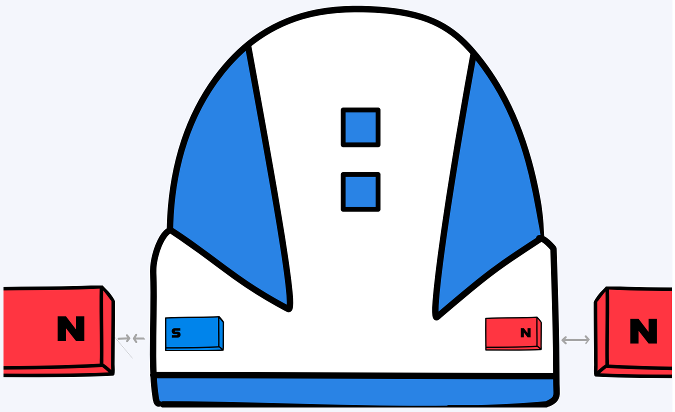


Figure 5: Guiding magnets

Along with levitation, magnets on the sides of the train are used to stop the train from swerving to one side when travelling at high speeds. This uses repulsion and attraction to achieve this.

Diagram [16]



Chapter seven

Maglev as an alternative

Maglev has several advantages over Hyperloop and HS2. Firstly, it does not use a vacuum tube, which reduces the amount of testing needed for this system compared to Hyperloop. Maglev trains also reach incredible speeds although they still have to deal with wind resistance. They are also environmentally friendly with the ability to run fully off electricity.

Environmental impact

The environmental impact of a maglev system is mainly dictated by whether it runs off renewable energy or generators. However, even with this in mind, "...Maglev consumes less energy while providing the same output as high-speed railroads"[17] so even with the current situation a maglev train would be more environmentally friendly. Alongside the UK's large-scale adoption of renewable energy, this makes for a clearer mode of transport.

Air resistance

Whilst the resistance between the wheels and the track disappears with a maglev system, the resistance with the air remains. Whilst the benefits of removing friction with the ground should not be underappreciated, the air resistance still limits the top speed of a maglev system. This also means that the system would also use more energy to counter wind resistance.

Speed

The planned top speed of HS2 is 42 mph slower than that of the Shanghai Maglev, which is currently in operation. However, although it was for an earlier plan, a route from "...central London to central Birmingham where the door-to-door journey time for a Transrapid passenger, from Heathrow and Birmingham airport, would, in all probability, be longer than that for someone travelling by Pendolino at today's speeds"[18] which means it may well end up having the same issues as the HS2 line on speed.

Curves

The Shanghai maglev system has a curve in it which shows that the trains can manage corners. It would also help if banked turns were introduced on any future lines to reduce the force of going around corners.

Adaptability

A large concern with new forms of transport that do not require wheels is whether they can be used on normal tracks to continue their journey. Whilst this could be achieved using wheels on maglev trains, it would also slow them down. As a result, this may well be a larger obstacle than it is a solution.

Development costs

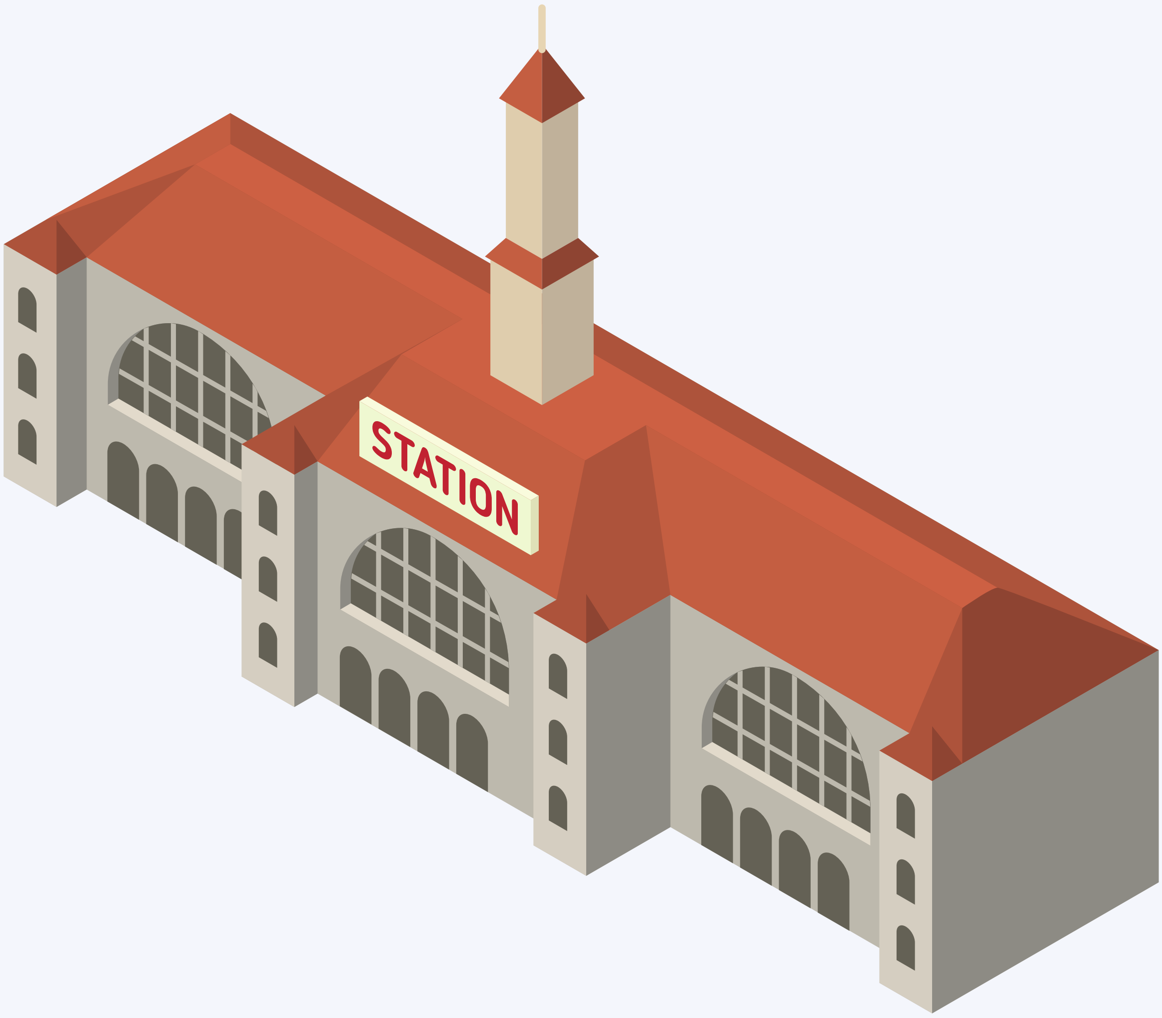
We propose a cooperation agreement with Japan to develop the maglev system, with the Japanese Chūō Shinkansen maglev line under construction and research along with development already undertaken.

Building costs

Whilst maglev trains will require large-scale initial investments, they will likely be cheaper in the long run. They will also help to ease the UK's transport system, with pressure taken off roads, flights, buses and other train services. Secondly, with the higher speeds, it would be more possible to place stations outside of cities rather than in the middle of them. This would reduce construction costs and create hubs on the outskirts of cities.

Chapter eight

The science and history of Hyperloop

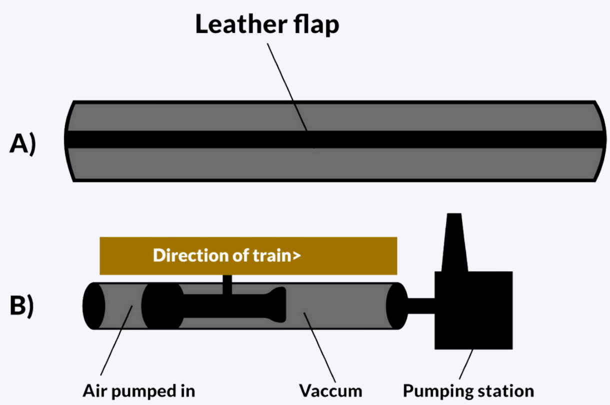


Whilst Elon Musk proposed the idea of a hyperloop system back in 2012, it has a history stretching back more than 150 years. Rather than being just a single idea, its different elements have been in the works, in some cases for hundreds of years. In that sense, it is combining a large number of proven technologies. Vacuum tubes, linear induction motors, and magnetic levitation have all been tested or used in railways to some extent. More than that, all of these elements, from the vacuum tubes the hyperloop pod will run into the maglev system that will allow hyperloop pods to float, have all been in development for years.

Figure 6: Dalkey and Brunel atmospheric railways

A) The leather flap on top of the tube allowed a metal plate from the train to be inserted whilst still keeping the pipe relatively airtight.

B) The pumping stations were powered by boilers or steam engines which drove pumps. These pumps sucked the air from the portion of the tube in front of the train sucking the train forwards. The section of the pipe to the rear of the train was at normal air pressure.



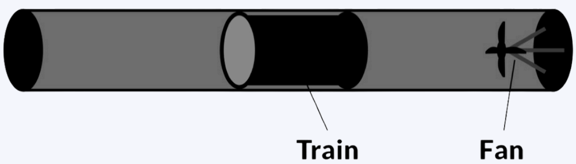
Dalkey Atmospheric Railway (1843-1854)

The Dalkey railway was the first atmospheric in the world and was based in Ireland. It ran from Kingstown to Dalkey using a vacuum tube. This tube sat between the tracks and used a vacuum to draw the train forward. However, this train had several difficulties, not least with the problems encountered trying to maintain a vacuum. Perhaps the most symbolic issue for this train was the method for the trains to arrive at the station after a return journey. This simply used gravity to pull the train down the track; however, “If the train failed to reach the Dalkey terminus under its momentum, 3rd class passengers were expected to dismount and push the train into the terminus as happened on several occasions”[19]. The line was eventually closed after just over ten years of service and today some of this line runs conventional trains.

Brunel's Atmospheric Railway (1847-1848).
Isambard Kingdom Brunel's attempt to build an atmospheric railway was perhaps the most well-known attempt with the longest line built. This railway could climb at a steeper angle than a normal train and had trains running at speeds of up to "... 70 miles per hour, but normal speeds were usually about 40 mph"[20]. This system worked but just like the Dalkey railway line it also shared many of the issues. Firstly, as the power for the train could not be controlled very well from within the train, any delays meant wasting large amounts of energy. Secondly, there were huge issues with the vacuum chamber as the flaps proved unreliable, rats were attracted to the tallow used on the pipes and "...the valve was...subject to the vagaries of the weather, especially to being soaked by rain and frozen by frost"[21] which meant that the costs for the line ended up making the project unsustainable compared to steam trains. However, one of the biggest issues with this line was perhaps building an experimental line in an area with the coast so near to it.

Probably the largest issue with the Dalkey and Brunel Atmospheric Railways was when they were built. Just a few years later the "Lubrication of the sliding seals and choice of materials were questions to which the answers also arrived..."[22]. Technological advances after these railways were abandoned could have helped them to succeed. Had they been built a few years afterwards they may well have worked; in fact, the airport Salgado Filho has a railway which runs on the exact principles of the Atmospheric Railway running today created by the company Aeromovel. Whilst to some this may be viewed as a failed project the technology is now around to create vacuums, something which will help with the creation of Hyperloop.

Figure 7: Underground pneumatic railways
At one end of the railway was a fan which would either suck air out of the tunnel or blow air into it. The train formed an airtight seal with the tube, so when the fan started blowing air into the tube, the pressure would build up behind it until it moved away from the fan. When the fan was sucking the air out of the tunnel, this would create a vacuum behind the train, drawing it towards the fan.



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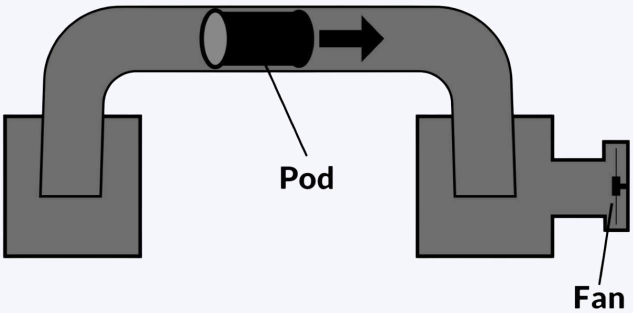
Crystal Palace Railway (1864)
The Crystal Palace Railway was built solely within the grounds of Crystal Palace Gardens. Unlike the designs of Dalkey and Brunel, this train used a large fan to push it forwards and then "...the fan was reversed to create a vacuum that would suck the carriage backwards." This meant that rather than pulling something attached to the train, the train itself was pulled by the vacuum. It achieved a vacuum by using bristles on the outside of the train to form a seal with the tunnel. However, after less than a year of service, the track ceased operations with no further lines built.

New York Underground Pneumatic Subway (1870-1873)
Alfred Beach built a pneumatic subway under New York City. This used the same system as the Crystal Palace Railway, which involved a fan to propel the train either towards where the fan was or away from it. This train did not have a destination; it simply set off from the station and then returned. Unfortunately, despite proving that the concept could work, it was never expanded and was eventually closed.

Pneumatic Tubes (1853-present day)
These were even used on a larger scale with the London Pneumatic Despatch Company transporting mail across London. The pneumatic tubes were also used for smaller items in offices, factories, post offices, hospitals, banks, supermarkets, and when connecting different buildings. Whilst these tubes have mainly been replaced by email and social media, they are still used today in some buildings.

Figure 8: Pneumatic tubes

Pneumatic tubes contain a loading bay and a receiving bay. At the receiving end, there is a fan that sucks air towards it. When a pod is placed at one end and the fan is started, the rubber seals on the pod create an airtight seal with the tube. This means a vacuum is created in front of the pod, so it is drawn towards the fan. This can also be reversed with the fan pushing the pod to the other end of the tube.



Hyperloop
Hyperloop is planning a route between Mumbai and Pune within India with a new framework agreement being signed. A new line is also being considered for Saudi Arabia and a large "...35km track..." test track is now planned for construction which may end up being the beginning of a route from Dubai to Abu Dhabi.

Chapter nine

The science behind Hyperloop

Figure 9: Maglev vacuum train
The idea of Vactrain, which is also known as the vacuum train, involves placing a train inside a vacuum chamber. The idea behind this stems from an issue all forms of transport face on the ground, wind resistance. Everything from rockets to cars is streamlined to reduce the effect air has on them as it slows them down. Even with streamlining, the fuel used to move a car or rocket forward is still huge compared to what it would be without air resistance. With a sealed tube where the air is pumped out, anything travelling inside can reach a much higher speed.

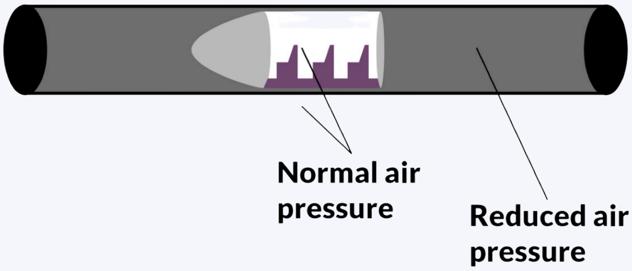
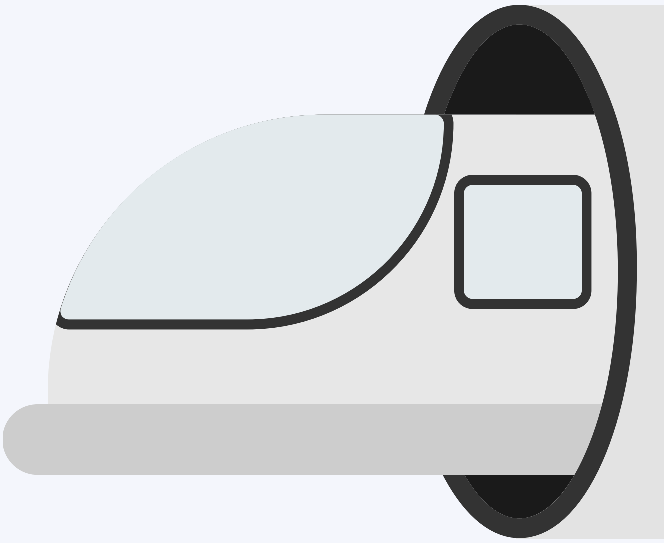
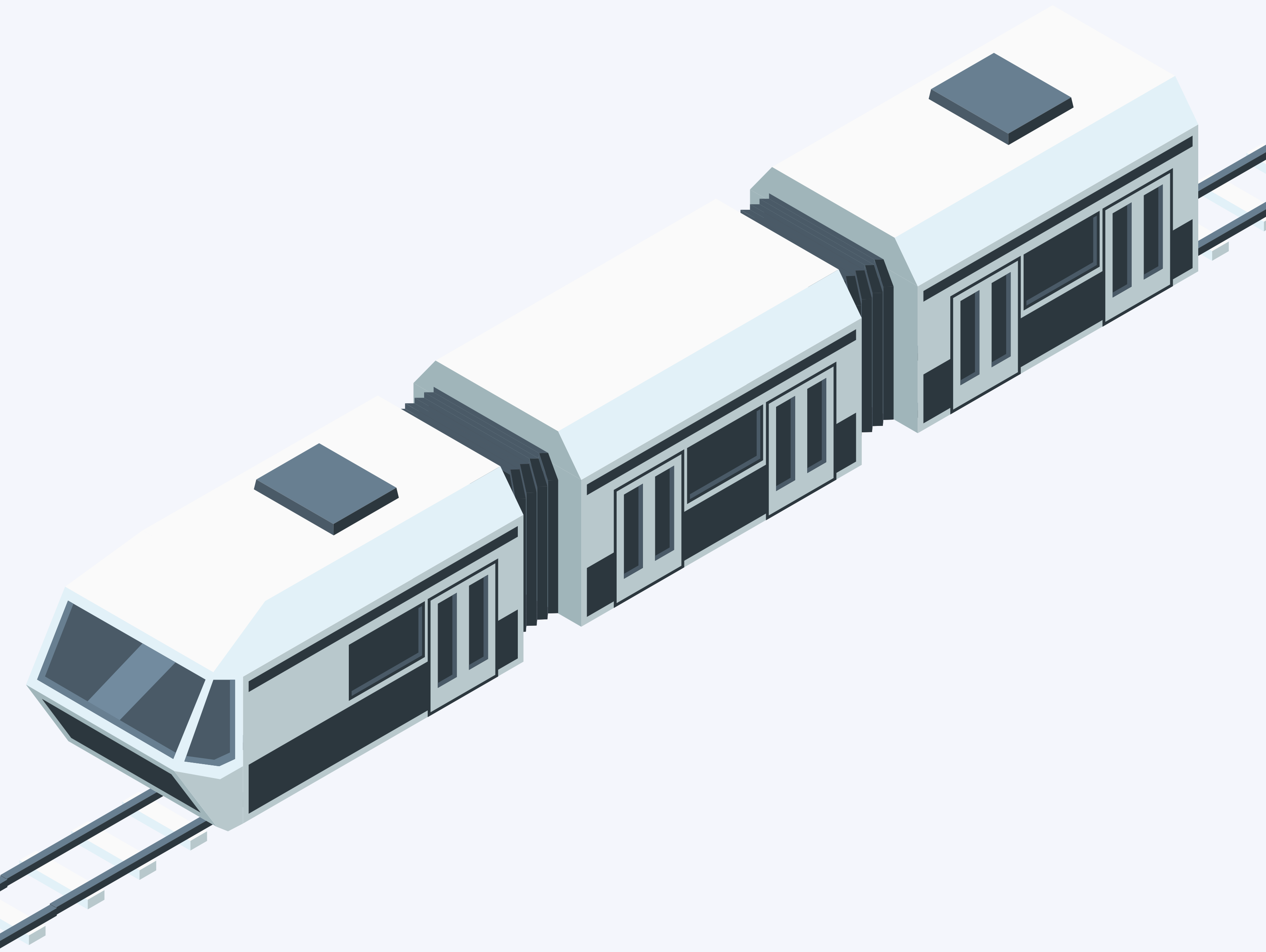


Figure 10: Maglev vacuum train
Hyperloop is not just a single idea but a combination of two separate ideas. When Maglev and Vactrain technology are combined, they create a system with no friction with the ground or the air in front of the train. Together, you end up with a train with no resistance with either the air or the ground, a train capable of going at speeds of over 600 mph.



Chapter ten

Assessing Hyperloop



Despite the history behind the technology going into hyperloop, this does not mean there aren't still issues to be solved with the system. Whilst the technology has existed as individual systems, it has not existed as one system. This section will look at obstacles that face a hyperloop system and will propose some solutions to these issues.

Cornering

With the speed of hyperloop, one of the large issues is being able to go around corners. Hyperloop has not been tested with a curve, so this area still needs development. One solution for this issue may be found in existing railway engineering on the Shinkansen line with banked turns to reduce the effects on the train. For Hyperloop, extreme banking may require the pod to tilt almost sideways. The lead-up to this curve can be extremely gradual to reduce the stress on the train. It should also be noted that high-speed lines often need straighter tracks anyway, and this will be no different with hyperloop.

Development costs

We propose a cooperation agreement with India to develop the technology. Any research and development will cost money, so sharing the cost will benefit all the countries involved.

Building costs

The building costs of a hyperloop system will require research and development. Whilst hyperloop will require large-scale initial investment, it will likely be cheaper in the long run. Firstly, it will help to ease the UK's transport system with pressure taken off roads, flights, buses, and other train services. Whilst the initial costs of research, development, and the cost of the tubes themselves will be high, this should be outweighed by long-term savings. Secondly, with the higher speeds, it would be more possible to place stations outside of cities rather than in the middle of them. This would reduce construction costs and would create hubs on the outskirts of cities.

Adaptability

A large concern with new forms of transport that do not require wheels is whether they can be used on normal tracks to continue their journey. Whilst this could be achieved using wheels on the hyperloop pods, it would also slow them down. As a result, this may well be a larger problem than it is a solution.

Tube damage

Damage to hyperloop tubes is one of the main concerns raised. If a tube is pierced, the air will simply escape, slowing down the pods. However, prevention is also useful, and tubes can be surrounded by protective materials such as metal to protect them against damage. To help with access to tubes or with evacuation, tubes must, however, be accessible. A walkway alongside the tube may well be the answer to this issue.

Tube misalignment
If the tubes on a Hyperloop system misalign or separate altogether, this could cause a train to crash into the side of the tube. This would both require heavy monitoring and emergency braking if a large disruption in the earth beneath the tube took place. However, any disruption such as this would also likely disrupt any other form of transport including other high-speed trains travelling over bridges.

Capacity
For areas with a large number of passengers, ensuring there is enough capacity within the Hyperloop system will be necessary. This can be solved with regularly departing trains and increasing the number of seats within pods. There is also the possibility of building one tube directly on top of another. This may well allow multiple tubes stacked on top of each other, something not possible with conventional railways.

Terrorism
As with any form of mass transport Hyperloop may be a target for terrorists. An explosion may damage the outside of the tube allowing air to rush into the tube and for pods to fall out. This would both damage the pod and harm passengers. Firstly, strong nets beneath the line could soften or stop the fall of any pods ejected from the tube. Secondly, any attempt to cut these could warn of an attempt to breach the tube. Thirdly if the pressure was reduced in the tube any other trains would slow down as a result of the air rushing into the tube. Thirdly scanning passengers on their way in may also be useful for preventing any terrorist strikes on Hyperloop lines. Finally, although measures against terrorism can be put in place, all systems of mass transport may end up being targets and unfortunately hyperloop is no different.

Environmental impact
The system could run off electricity using solar panels at the top of the tube to power the system. This could result in using less energy than either maglev or other more conventional types of high-speed transport. Another advantage is the use of tubes which allow the system to exist above, within, or below natural habitats.

Construction
The tubes in this system can be built off-site and can then be added into place, decreasing the construction time and limiting disturbance for people in the local area.

Competing with aeroplanes
To compete with aeroplanes, Hyperloop will need to compete on cost and speed. Whilst speeds can be increased over time, the costs of such a system will depend on a number of factors. These include the population near the stations, the development costs of Hyperloop, the costs of keeping the track operational, and the demand for the service.

Chapter eleven

Maglev and Hyperloop in the UK

Rather than a large project such as HS1, a new Hyperloop and maglev network will need to be installed gradually as older lines go out of use. Rather than repairing the old lines, the focus would be on replacing them with either Hyperloop or maglev lines.

To start off with, the main replacement lines would be low-speed maglev lines as are currently being used in China. If this is successful, then a larger Hyperloop track can be built, as is shown below. This would run on the same maglev systems as the low-speed maglev trains, meaning trains could easily move between the maglev and Hyperloop systems.

Part of the reason for using both maglev and Hyperloop lines within the UK is that they both have different advantages. Hyperloop is more useful for longer routes where the reduced journey times will be more noticeable. Therefore, for shorter journeys, standard maglev trains would be more cost-effective. It also considers the fact that Hyperloop has had less testing than maglev trains. If Hyperloop is unable to be utilised for any reason, there can simply be a high-speed maglev route built instead.

However, the advantages of Hyperloop when building a track include its ability to sit above objects and its ease of placement with the ability to make the tubes before adding them to the route. This design could make future expansions quicker once the first track is laid. The first route would sit alongside roads including the A1M, M11, M4, M6, A74 (M), and the M8. This map also includes the existing HS1 line which could be integrated into the line.

Conclusion

The proposed HS2/3, Maglev, and Hyperloop lines in this paper all have long histories and, with enough development, they are all plausible solutions. However, the big question is one of new technology against older tested technology. As the possibilities for better technology increase, so too does the amount of time spent developing and perfecting it. This is perhaps the main point to take away from this paper.

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