Executive Insights

Volume XXI, Issue 11

Hyperloop: Coming Soon to a Station Near You?

Hyperloop, the proposed new mode of high-speed ground transportation, has the potential to revolutionize travel. Its proponents promise massively reduced journey times, lower capital costs and better energy efficiency.

The reduction in journey time is expected to bring significant agglomeration benefits — claims that, coupled with the ability to "virtualize" existing transport hubs, have caught the imagination of the market.

As with any large infrastructure project and the application of new technologies, many technical, regulatory and safety hurdles need to be overcome before the promises can be realized. Timelines, costs and requirement for public subsidy remain as uncertainties.

In light of the recent developments in Hyperloop, in this *Executive Insights*, L.E.K. Consulting examines the technical and commercial challenges facing Hyperloop, and its likely role in future transport provision.

What is Hyperloop, and what benefits can it bring?

Hyperloop, championed by Elon Musk since 2013, is a mode of ground transportation that uses magnetic levitation technology to propel a pod in a near-frictionless environment. This allows for theoretical speeds of 760 mph, resulting in dramatic reductions in journey times.

Musk originally estimated that it would cost approximately $6 billion to build a Hyperloop passenger route from Los Angeles (LA) to San Francisco (SF), suggesting lower capital costs than existing ground transport technology and high-speed rail (HSR) lines.

The proposed use of passive track technology (using a permanent magnet array) and solar panels would reduce energy consumption and overall operating costs, making Hyperloop both cheaper to build and operate than alternatives, and more attractive in this age of heightened environmental awareness. The U.S. Department of Transportation estimates that Hyperloop could use up to six times less energy on short routes than an aircraft flying the same route.

Hyperloop could also be used to virtualize existing infrastructure, exploiting its speed of service to create fast links between transport hubs. For instance, by connecting existing airports (e.g., London to Birmingham), Hyperloop could enable them to operate as a single virtual airport and leverage currently underutilized slots. By doing so, they may avoid the need for expensive runway expansion. Similarly, Hyperloop could create short city-to-city connections, allowing for city expansion without the need for significant wider infrastructure investment.

Challenges facing new modes of transport

As with any new mode of transport, there are many hurdles that Hyperloop needs to negotiate before it can become an established, safe and certified option for high-speed services. Its near-term viability is dependent on three key factors: the development of technology, the commercial feasibility of building and running an affordable line, and the time required to develop solutions, conduct testing and receive the requisite certification.

Nascent stage of technical developments

Underpinning the overall commercial feasibility and timing of Hyperloop rollout is the development of technology. Given the nascent stage of Hyperloop's technical development, there remains a range of technical challenges that any viable commercial Hyperloop system must overcome. These include:

Hyperloop: Coming Soon to a Station Near You? was written by **Andrew Allum**, Partner, **Becrom Basu**, Director and **Arie Jamal**, Consultant. They are all based in London.

For more information, please contact **strategy@lek.com**

L.E.K.

- Ensuring demonstrable human safety in passenger services
- Creating comfortable passenger environments
- Designing faster airlock systems to deliver capacity expectations
- Designing vacuum pumps that push the limits of current technology
- Accommodating the thermal expansion of the tubes while maintaining a vacuum
- Finding favorable alignments (routes that allow for minimal turns, to maintain speed)

Until these technical solutions have been developed, it is hard to know how expensive Hyperloop will be. In order to solve the breadth and complexity of these challenges, Hyperloop companies are investing up front in skilled engineering teams and committing significant time to development and testing.

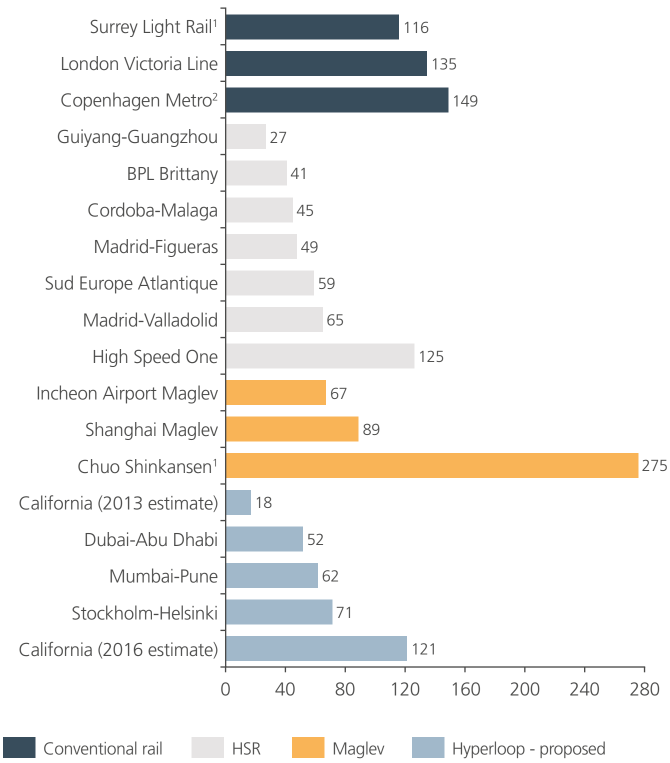
Commercial feasibility

While initial construction costs were estimated to be lower than those of HSR projects ($50 million to $120 million per mile, or $30 million to $75 million per kilometer, see Figure 1 for realized costs), these published estimates have risen rapidly. Capital projects often exceed original estimates for nascent technologies, and they could rise further.

Figure 1

Cost of constructing rail routes (stated project costs)

Millions of 2016 U.S. dollars per mile



[1] Planned; [2] Phases 1-3

Source: World Bank; KPMG; Hyperloop Alpha white paper; press articles

Musk originally suggested that an LA to SF Hyperloop would cost approximately $6 billion, or $18 million per mile; however, this is likely to be an underestimate. More recent estimates have indicated a California route could cost up to $120 million per mile. Experts suggest that this figure still omits important elements such as pods or stations — meaning that the final costs could be considerably higher. Furthermore, technical solutions, R&D costs, safety systems and certification cost are still uncertain. In Figure 1, we can see that realized cost per mile varies significantly because specific alignments, local topography and land prices heavily influence costs.

As with any commercial transport operation, the optimal business model needs to be developed. For example, companies can charge low fares in order to win volume, or adopt a premium strategy that charges higher fares for a more exclusive offering. Notional proposals indicated a ticket price of $20 each way for LA to SF, which would provide passengers with good value given the short journey time and attract a larger number of sales.

However, even at 100% utilization (assuming each pod seats 28-40 customers, and peak-time departures occur every 30 seconds, slowing to every two minutes during off-peak hours), it could take a significant amount of time to pay back the capital. This would be an unattractive proposition to many investors. A potentially more profitable strategy would be to charge a significant premium for peak-time services, but L.E.K. estimates suggest that even at a $200 average fare the internal rate of return would be low — still not an attractive prospect. Under these circumstances, it is likely that Hyperloop will need significant public subsidy to become a reality. Wider economic benefits (e.g., agglomeration effects) may have to factor heavily in any business case, which are harder to substantiate.

Hyperloop companies looking to create a profitable operating model that also minimizes the need for public subsidy must resolve cost uncertainties, develop a thorough assessment of likely passenger demand and undertake detailed analysis to determine the right commercial model.

It should be noted that these estimates do not take into account the potential benefits of virtualizing existing infrastructure. Leveraging Hyperloop's speed to connect cities, airports and logistics hubs could allow for expansion while reducing the need for additional infrastructure investment, supporting the business case for Hyperloop.

Timing of rollout

Even after the development of a technically feasible and commercially viable system, some experts suggest that, due to regulatory hurdles, it could still take up to 20 years before a passenger Hyperloop route is in regular operation (see Figure 2) in North America or Western Europe. This implies a launch date no earlier than 2035-2040.

As demonstrated by HSR routes, the process of securing rights of way, raising capital, and convincing regulators and the public of system safety requires engagement with multiple stakeholders and takes time. Hyperloop will be subject to the same requirements.

Consequently, to avoid lengthy timelines, Hyperloop companies are prioritizing development in non-Western economies, where differences in individual property rights and regulatory regimes may allow for faster implementation. In order to fully benefit from its unique speed and avoid excessive g-forces, Hyperloop alignments will have to avoid even the smallest bends. Consequently, favorable locations will need to be found or they will face greater costs to maintain straight routes.

Future of Hyperloop

Some of the Hyperloop companies have published goals of operational systems as early as 2021. Test tracks have been built and more are under construction, while initial trials have reached speeds of over 200 mph. It would appear that progress is being made.

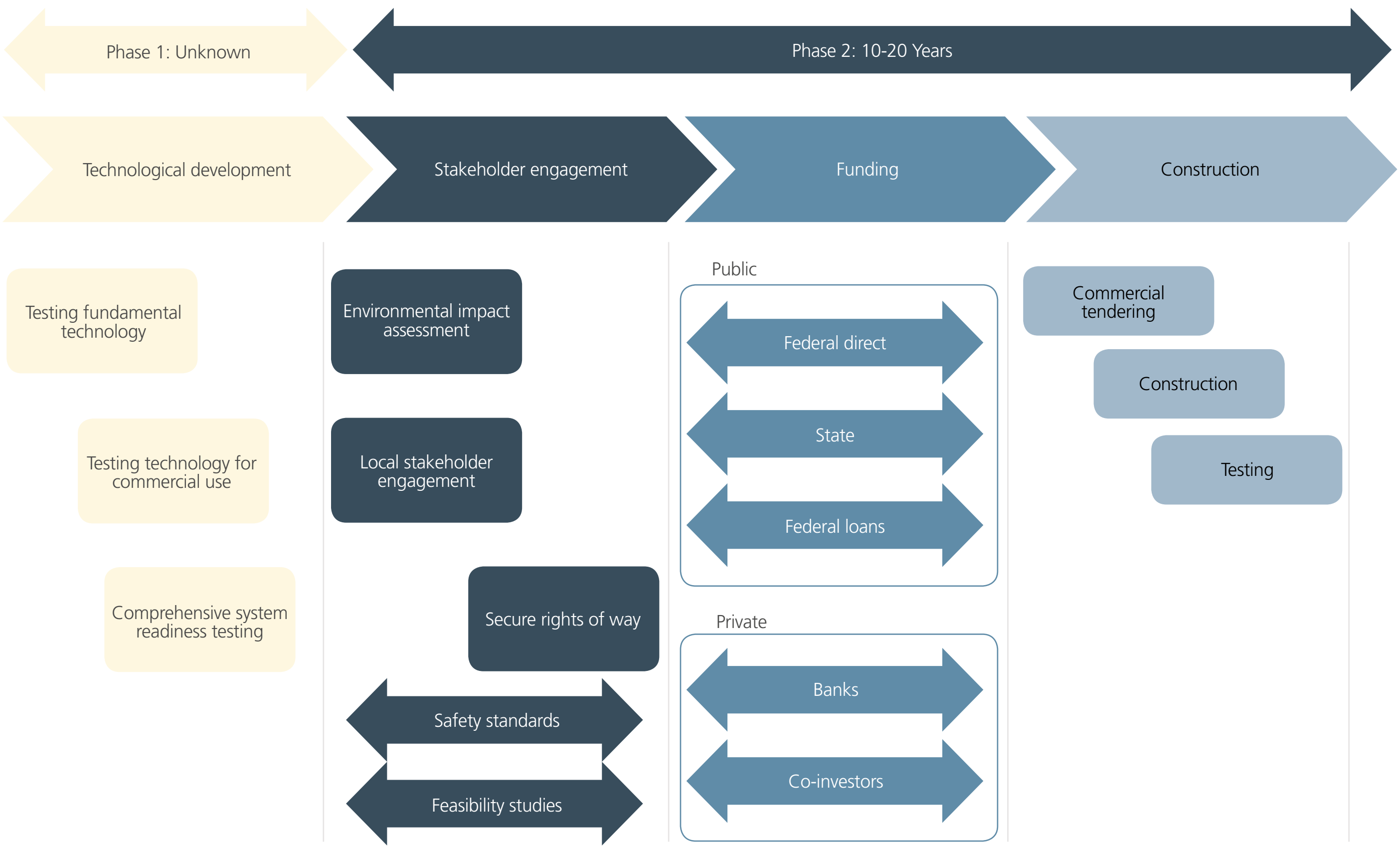
However, the reality of the technical challenges and the requirements for passenger safety and comfort mean that long-distance passenger routes are far from implementation. Refining the technology further to deliver regular, reliable, high-capacity and cost-effective services will take longer still.

L.E.K. expects the most likely first application of Hyperloop technology to be in non-passenger (freight) services, where lower technical and safety barriers may be overcome in as little as the next five years. The lessons learned over this period will enable aspiring passenger service providers to resolve some of the commercial uncertainties around Hyperloop and support the development of a viable passenger proposition. Initial passenger trials will likely be at slower speed and lower capacity and over much shorter distances than the stated vision. Gradual development of the technology and its subsequent maturity will be required to provide confidence and reduce costs.

These initial implementations will most likely be in non-Western locations, where government support, subsidies and regulatory regimes will be more favorable. They may also be able to secure more advantageous alignments, not easily achieved in the West, where property rights and local protests often hamper construction.

We may still have a long wait before we see the delivery of Hyperloop's potential, but the concept and what it seeks to deliver have captured the imagination of the public, governments and operators alike, and considerable work is underway to make Hyperloop a reality.

Figure 2
Length of technical, regulatory and commercial hurdles (U.S.)



About the Authors

Andrew Allum is a Partner at L.E.K.'s London office, who joined the firm in 1992. He has more than 25 years' experience in the rail industry, advising a variety of operators, infrastructure managers, suppliers and investors. His main areas of practice are surface transport and business services, with a focus on human capital sectors such as training, education and recruitment. Andrew holds a BSc (first class) in Physics from Imperial College and an MSc in Computing from Oxford University.

Becrom Basu is a Director in L.E.K.'s London office, who joined the firm in 2005. He has 13 years of senior consulting experience with L.E.K., during which time he has led many significant engagements in our transport, travel and new mobility sectors. Becrom holds a MEng in Chemical Engineering from University College London and an MBA from INSEAD. Before his MBA, Becrom held management roles at a technology start-up and Eurocontrol, the European agency for air traffic control.

Arie Jamal is a Consultant in L.E.K. Consulting's London office. Arie's experience spans the transport, retail and media & entertainment industries. He has worked on a range of engagements in transport globally across the public and private sectors, including long-term strategy development, revenue forecasting, franchise bid support, and transaction support. Arie holds a BA in Economics and Management from Oxford University.

About L.E.K. Consulting

L.E.K. Consulting is a global management consulting firm that uses deep industry expertise and rigorous analysis to help business leaders achieve practical results with real impact. We are uncompromising in our approach to helping clients consistently make better decisions, deliver improved business performance and create greater shareholder returns. The firm advises and supports global companies that are leaders in their industries — including the largest private and public sector organisations, private equity firms and emerging entrepreneurial businesses. Founded in 1983, L.E.K. employs more than 1,400 professionals across the Americas, Asia-Pacific and Europe. For more information, go to www.lek.com.