PUBLIC EDITION / PRE-FEASIBILITY

HYPERLOOP ALPHA WHITEPAPER

What an uncrewed test track can tell a host country about the engineering, energy and cost of low-pressure transport.



CONCEPT VISUALISATION

THE FIRST DECISION

A government can nominate a transport contact and a candidate research site for an initial review. Any land allocation, funding or permission to build would follow a separate local decision.

01 / DESIGN BASIS

The starting assumptions

An early passenger-only intercity concept put numbers against four linked choices. Together they explain why a test programme must start by narrowing the question.

CONCEPT PARAMETER	REFERENCE ASSUMPTION	WHY IT MATTERS
Tube pressure	100 Pa absolute	About one-thousandth of standard atmospheric pressure. This sets the duty on the tube, seals and pumps.
Circular tube bore	2.23 m inside diameter	About 3.91 m^2 of cross-section. The vehicle took up roughly 36% of it, constraining airflow around the body.
Capsule layout	28 passenger seats	Cabin volume, door access and occupancy change the loading, station layout and rescue requirements.
Maximum speed	About 1,220 km/h	A local peak assumed on suitable straight sections. Route curvature and acceleration also govern travel time.

A smaller first decision

Hyperloop Alpha proposes a separately scoped, uncrewed demonstrator. A host study would set its own bore, pressure range, vehicle mass and usable track length after defining the questions the facility can answer. Passenger seating and an intercity timetable sit outside that first scope.

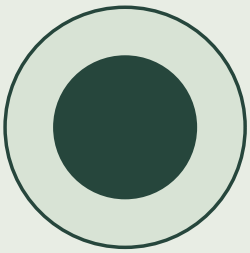
EVIDENCE FROM THE FIELD

In July 2023 the Technical University of Munich reported a passenger trial in a 24 m experimental tube. It demonstrates what a short, integrated facility can investigate. Longer-distance performance and operating economics require different evidence. [1]

02 / AERODYNAMICS

What the pod pushes aside

A low-pressure tube still contains air. When a pod advances, the air in front of it must travel around the body, through it, or accumulate ahead of it.



ILLUSTRATIVE CROSS-SECTION

36% occupied by the capsule

At a 2.23 m bore, this leaves about 2.50 m^2 of geometric bypass area. The circle represents equivalent frontal area; the actual pod shape can differ.

Where flow becomes a constraint

The narrowing beside the capsule accelerates the remaining air. At a sufficiently high speed for a given blockage ratio, that bypass can choke. It reaches its local speed of sound and cannot pass the required mass flow. Pressure can then rise ahead of the vehicle. This confinement effect is commonly called the Kantrowitz limit.

Passive clearance

A larger bore or a smaller vehicle increases the space available for air to pass. A larger structure also increases the volume to pump down and the materials to procure.

Active bypass

A nose compressor can take in part of the oncoming air and route it aft. The machinery adds vehicle mass, electrical load, heat and maintenance access requirements.

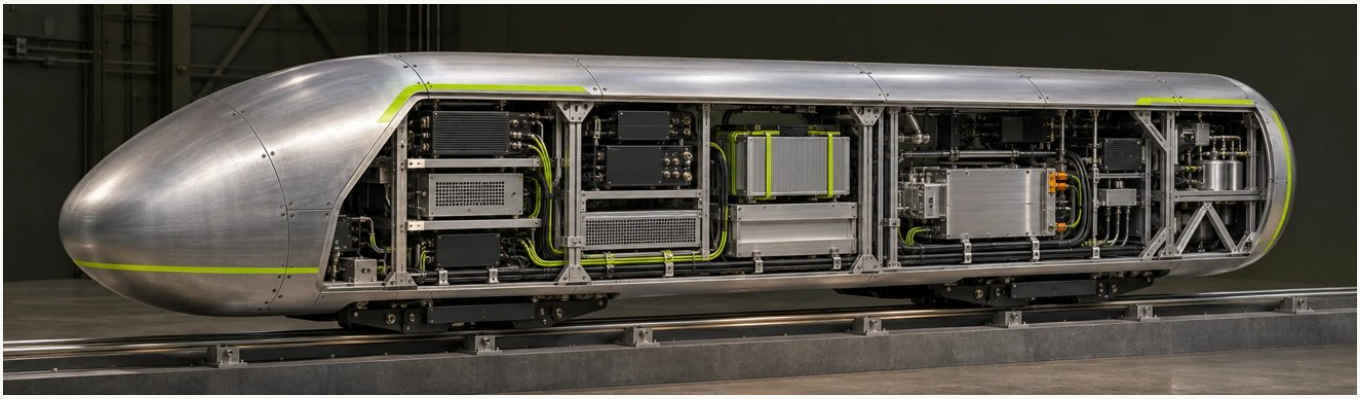
COMPARE BEFORE SELECTING

Measure pressure ahead of and behind the vehicle, along the tube and across any compressor. Compare measured drag, power and temperature at matched pressure and speed, with uncertainty recorded for each sensor.

03 / SYSTEM INTERFACES

Four systems, one vehicle

A credible test must show how the support system, drive, pressure plant and controls behave together. Their energy paths and failure responses are different.



CONCEPT VISUALISATION / REPRESENTATIVE CAPSULE LAYOUT

SUBSYSTEM	ENGINEERING CHOICE	EVIDENCE TO CAPTURE
Support and guidance	An air-bearing option feeds a thin film beneath the support pads. A magnetic system is a separate candidate.	Measure lift, clearance, alignment sensitivity, vibration and power across the chosen test range.
Linear drive	A wayside linear induction motor can exert longitudinal force on a conducting element carried by the pod.	Measure commanded and delivered force, acceleration, braking distance and electrical losses.
Pressure equipment	Tube seals, pumps and isolation sections establish and maintain the test pressure.	Record pump-down time, pressure recovery, leak trends and power between runs.
Controls and recovery	Vehicle and trackside controls must agree on position, motion authority and equipment status.	Time-align independent measurements. Rehearse the recovery of a stationary, uncrewed vehicle.

One important coupling is the air supply. If the same compressor supports aerodynamic bypass and bearing lift, a single fault can affect both. Separate bench tests and an integrated fault review would precede any decision to share that function.

04 / TRACK SIZING

How much track does speed take?

The useful straight length is the length left for controlled motion after reserving space for access, isolation, recovery and independently assessed stopping margins.

A SIMPLE LENGTH CHECK

For constant acceleration a from rest and equal deceleration back to rest, the two moving legs together use $L = v^2/a$. There is no cruise or dwell segment in this calculation. Adding a cruise of t seconds requires an extra distance of $v \times t$.

PEAK SPEED	ACCELERATION LEG	BRAKING LEG	TOTAL MOVING LENGTH
20 m/s (72 km/h)	200 m	200 m	400 m
30 m/s (108 km/h)	450 m	450 m	900 m
40 m/s (144 km/h)	800 m	800 m	1,600 m

Example assumptions

The table uses 1.0 m/s^2 for each leg. Doubling speed quadruples the idealised distance. Holding 30 m/s for ten seconds adds 300 m, taking that example to 1,200 m before any allowance for transitions or reserve distance.

What a short facility can tell us

A shorter enclosure can establish repeatability of pressure control, valve operation, alignment checks, instrumentation and low-speed vehicle recovery.

What a site study must add

Designers need the usable length, gradients, ground conditions, physical access and local operating constraints. Actual braking limits and margins require their own evidence.

These examples illustrate scaling. Hyperloop Alpha has yet to select a track length, acceleration limit or test speed.

05 / VALIDATION

What a test must demonstrate

Before motion, the host and project team would identify the responsible authority, agree who can stop a test and record the evidence required to resume. Each test would use an uncrewed vehicle.

TEST FAMILY	OBSERVABLE RESULTS	DECISION BEFORE PROGRESSING
Static enclosure	Calibrated pressure readings, leak trend, power demand and isolation status over time.	Investigate unexplained drift or an inability to isolate a section. Establish repeatability before introducing motion.
Vehicle motion	Synchronized position, speed, commanded force, clearance, vibration and temperature.	Repeat within an approved envelope. Widen it only after review of the results and recorded exceptions.
Abnormal conditions	Controller response to a simulated loss of power, position signal or communications; measured stopping behaviour.	First establish the response in analysis and bench trials. The safety reviewer decides which scenarios may advance to the track.
Recovery and access	Time to locate the pod, isolate equipment, establish an accessible condition and recover it.	Resolve gaps with local responders. Demonstrate the agreed access sequence before another run.

A result others can examine

Keep the vehicle configuration, instrument calibrations, software revision, test conditions and operator log under one run identifier. Record missed tests, interrupted runs and anomalies alongside completed runs. Independent reviewers need access to the evidence behind a claim.

SCOPE OF A SUCCESSFUL TRIAL

An uncrewed result can support a decision about the next experiment. Passenger operation would require a separate safety case addressing occupied cabins, evacuation, medical access, accessibility and rescue under local rules.

06 / ENERGY AND COST

Count the quiet hours

A short burst of acceleration is only part of the electricity bill. A host needs to know what it takes to keep a facility ready between runs, and how much of that cost persists when trials stop.

EXAMPLE OVER A 10-HOUR WINDOW	10 COMPLETED RUNS	20 COMPLETED RUNS
Steady site load at 60 kW	600 kWh	600 kWh
Incremental energy at 12 kWh per run	120 kWh	240 kWh
Net electricity across the window	720 kWh	840 kWh
Electricity per completed run	72 kWh/run	42 kWh/run

The values are invented for this calculation. The 12 kWh increment is additional to the steady load. The same assumed baseline is spread over more runs in the right-hand column. A real campaign would meter the full accounting period, including pump-down, idle days, losses and any separately measured energy recovered.

Capital to open the site

Price land access, ground investigation, civil works, tube and supports, power connection, pressure equipment, controls, test vehicle, instrumentation and commissioning. Include contingency and eventual removal.

Cash to keep it open

Budget operations staff, inspection, calibration, energy tariffs, insurance, spares, emergency exercises and downtime. Request site-specific ranges, with scope and pricing dates, before committing capital.

A CREDIBLE PUBLIC COST CASE

In 2025 the European Commission identified capital intensity, an uncertain business case and fragmented regulation as challenges for the sector. A local study should compare use of an existing research facility with a new build and disclose who pays if the study stops. [2]

07 / CORRIDOR ECONOMICS

Measure the whole journey

The value to a traveller is the time between the actual origin and destination. Reaching a terminal, waiting for departure and leaving the station can consume much of the time a faster vehicle saves.

ILLUSTRATIVE 300 KM CORRIDOR	REFERENCE JOURNEY	TUBE SCENARIO
Average speed over the route	150 km/h	450 km/h
Scheduled line-haul time	120 min	40 min
Access, waiting and exit	30 min	45 min
Door-to-door time	150 min	85 min

WHAT CHANGES THE ANSWER

The assumed saving is 65 minutes per trip. With a 40-minute ride, combined access, waiting and exit could reach 110 minutes before the two options tie. The example assumes equal route distances and uses average speeds, including acceleration, stops and braking.

What the host could measure now

Identify a corridor and the time of day travellers use it. Sample actual origins, destinations, fares, access modes and the spread in journey time. Compare a tube scenario with the best feasible rail, bus or road improvement. A local value-of-time estimate can convert hours to social benefit; operator revenue still depends on fares and paying demand.

In a later route study, size each station for peak arrivals, test step-free transfers and model cancellations and missed connections. The website's journey calculator lets a reader vary distance, average speed and access time. Its outputs are scenarios.

08 / HOST-COUNTRY INVITATION

The first decision for a host

A ministry, transport authority or public research body can nominate an official contact and outline a prospective test setting. The initial expression of interest is non-binding.

DECISION	WHAT TO PUT ON THE TABLE	WHO DECIDES
1 Explore	Contact office, candidate location or region, research objectives, existing transport assets and process for a follow-up.	The public body chooses whether to enter an exploratory discussion.
2 Scope a study	Land control, access, power, environmental constraints, emergency services and applicable review bodies. Compare local assets.	Both parties agree a bounded study brief, funding, data rights, deliverables and exit terms.
3 Authorise works	Site-specific engineering and cost ranges, local permits, safety review, procurement route and decommissioning plan.	The competent authorities and funders decide each commitment separately.
4 Review results	Commissioning records, test evidence, deviations, energy costs and unresolved hazards.	Designated reviewers assess the results. The host can pause, repeat, extend or close the programme.

Register government interest

Visit the host-country programme at www.hyperloopalpha.com. A ministry or agency can identify a point of contact before selecting a site. Formal agreements and public commitments would follow the relevant local process.

INDEPENDENT READING

1 Technical University of Munich • TUM Hyperloop begins test operations, July 2023.

2 European Commission • New EU study assesses progress and prospects for hyperloop technology, November 2025.