HL1 and ET3 compared

For ET3 reference: JMT-Mar2011-pg42-50.pdf (doi: 10.3969/j.issn.2095-087X.2011.01.007); US pat 5,950,543; and US pat 10000892B2; ET3history.pdf; etc.

Hyperloop One (HL1) was built in LasVegas at 2/3rds scale (11' diameter vs 18' diameter required to accommodate shipping containers). If compared to typical cars, trucks, and jets (over the HL1 target distance 100 miles to 400 miles), HL1 may even be cost effective for a small number of routes that have high enough travel demand. HL1 is also likely to be safer than cars, trucks, and jets for the following reasons:

- much better control of the vehicles (almost impossible to leave path of travel,automated so almost free from human errors, etc.)
- much better control of the conditions of travel by isolating vehicles (in a tube)away from outside forces and barriers such as: ice, snow, fog, wind,rain, hail, blinding sun, etc.; and/or errant vehicles, animals, or children on the path of travel.

However HL1 is far from value optimized and if HL1 is compared with much better researched, developed, (and patented) systems that are value optimized, (such as Evacuated Tube Transport Technologies (ET3)(tm)); HL1 is not likely to be as cost effective or as safe.

Consider some value and safety related comparisons between HL1 and ET3:

	HL1	ET3	
empty vehicle weight:	about 20 t	0.2 t	(100x more material for HL1 veh.)
max cargo weight	about 20 t	900 lb	
cargo accommodation	98%	94%	
loaded vehicle weight:	about 40 t	0.6 t	(HL1 is over 5x levitation and LEM cost)
tube diameter	11' *	5'	(HL1 model is 5X the material of fullsize ET3)
capacity (veh/sec)	0.025 max	over 10	(ET3 offers greater capacity)
networking	switch ?	interchange	(undisclosed by HL1, pats. by ET3)
non-stop range limit	600 mile	16,000 mile	
vacuum Level (%)	99.9%	99.9999%	
vac pump kW (per veh)	300kW continuous	10kW for 30 sec.	
max speed	760mph	4,000 mph	
seats	28-40	1-6	
passenger %adult male	99%	99.99999%	
toilet access	in vehicle	at access portal	
toilet wait (min/max)	60sec / 0.5hr	120sec / 0.25hr	
comfort level	bus	Limousine	
operating cost	100%	<20%	(HL1 over 5x greater operating cost)
Complexity	100%	<20%	(HL1 over 5x more moving parts)

* HL1 advertises ability to carry "standard shipping containers", however this would require an 18' tube diameter, and over 11 times more material than ET3. Also, the maximum weight of a standard 40' shipping container is more than 20 tons.

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Size: (for ref.:trains weigh 100+ tons, trucks weigh up to 40 t, cars 2 t) Studies show if fare is equal, most people choose to ride car sized vehicles instead of bus sized vehicles.

Suspension: HL1 air bearings that operated at a half millimeter clearance did not work, so they are in the process of migrating to magnetic levitation (maglev) suspension. ET3's proven HTS maglev (developed at SWJTU in China) has been transporting thousands of people in a car sized prototype for several years. Since HL1 vehicle weight to length ratio is more than 4 times greater than ET3, HL1 maglev will cost over 4X more if the same maglev is used.

Distance: HL1 is battery powered limiting the range to 400 to 800 miles. ET3 has the advantage from trips as short as 10 miles, and if local routes are all built to the same diameter, can eventually network global travel (across the Bering Straight). (NOTE: Hyperloop range is limited by compressor battery capacity).

Passenger Capacity: HLa offers one 40-seat vehicle every 10 seconds (4 passenger persecond), ET3 offers twenty 6-seat capsules per second if operating at the same 760 mph speed (120 people per second).

Complexity: ET3 uses common vacuum pumps to keep the tubes at low pressure and simple linear motor propulsion and maglev with no moving parts on the capsules.

In addition to linear motors, and vacuum systems, HL1 requires heavy batteries to supply power for electric turbo compressors that in turn compress rarefied (99.9% vacuum) air for propulsion, Mach limit avoidance, and cabin pressurization.

Quality of vacuum: Pure vacuum is not possible. HL1 calls for low quality vacuum (99% or 99.9% depending on what part of the disclosure is read). ET3 vacuum quality is optimized to result in the lowest cost transport(including pumps, pumping energy and propulsion energy costs). This calls for a medium quality vacuum between 99.999% to 99.9999%. Simple vac pumps from over 150 years ago are capable of 10 times higher quality vacuum than specified for ET3.

HL1 is compromised by the necessity of leaving more air in the tubes to: operate the air pressure suspension, Mach limit mitigation, and for cabin air for passengers. Cabin air will have to be exchanged, or CO2 (and H2O) will build up, and O2 will be depleted, this air exchange need is millions of times more than ET3 tubes are likely to leak, and will result in higher pumping cost despite the low quality vacuum. Each HL1 capsule will have to continuously pump HALF the air in the tube EACH trip (ET3 must pump as little as 1 liter of air per trip, but to 1000 times higher quality vacuum.) NOTE: the LIGO observatory is a 1.2m diameter tube with over 50km of welds, and evacuated to a million times higher quality vacuum than required for ET3 — it had no measurable leaks in 2 years with the vacuum pumps shut off. CERN is evacuated to even higher quality vacuum.

HLa (or HL1) does not disclose or quantify the energy required to overcome tube surface drag to circulate residual air at 375 mph ***through the entire 'loop'***. For a long route during periods of low demand, the energy per passenger (or ton of cargo) for HL1 is likely to be greater than for aircraft or HSR.

Network ability: HL1 does not disclose how or if branching can occur or if active 'switches' are needed in the guide-way (as with HSR track switches). ET3 uses an 'interchange' philosophy where the capsule selects the path of travel (like a car on a freeway interchange), this is what allows the high frequency operation, random access branching, and distributed access portals.

Accessibility: HL1 only discloses accessibility at the end points (few locations). ET3 has more granular accessibility like a car on a freeway (with frequent access points placed according to local demand). This is why automobiles do not typically have toilets installed. ET3 is like an automobile; HL1 is like a bus. All evidence in every nation proves automobiles are much more scalable than buses.

One passenger getting on/off HL1 will inconvenience 5 times more people than with ET3. If HL1 figures out how to make frequent stops, the time to let just one person on/off slows the trip to a crawl for everyone on the bus sized vehicle.

In a dense city, ET3 can fit over typical sidewalks, HL1 would require the width of a street, so ET3 can be integrated into existing city right-of-ways at much less cost, and disruption to existing services while providing more value to users.

Thermal management: Both ET3 and HL1 must absorb and carry heat generated in the vehicles (because a vacuum is good insulation). Heating of the ET3 capsules comes from 2 main sources: the occupants body heat (will melt about 2 lb of ice per hour per passenger), and the linear motor components during acceleration (close to zero if superconductor elements are used on the capsule).

Heat is generated in the HL1 vehicles from several sources: the aluminum linear motor elements used for acceleration, cooling the compressed air for passenger use, cooling the compressor motor, cooling the battery and controller, and cooling the occupants.

HL1 fails to disclose aerodynamic power and heating from circulating the air in the tubes at 375 mph (for a 400 mile route 800 tube miles - this is a very large amount of power). The HL1 vehicles must carry orders of magnitude more heat per passenger than ET3 capsules (more weight = more battery = more heat...).

Degree of development: Hyperloop Alpha (HLa) by Musk was a highly publicized 'open-source' idea published in an August 2013 paper of 57 pages. At least 3 groups claim to be developing 'hyperloop' (several of the members are suggesting specs more in line with ET3 specs).

NOTE: By definition 'open source' cannot be patented, and ANY AND ALL DERIVATIVE WORKS MUST ALSO BE ‘open source’.

Open source is subject to greater initial competition that is likely to limit initial investor ROI. (Linux is free, Apple enjoys a 40% return). ET3 is not open source, but our ‘open’ inclusive (not exclusive) license shares many of the advantages; AND at the same time honors the value of IP. Open source is only able to scale fast in software where there is almost zero cost of scale.

Investment is required to scale, and investors look for patent protection. ET3 was granted the first US patent in 1999; since then experts (including over a dozen PhDs) from all over the world have contributed to ET3 R&D, accumulating over a hundred thousand R&D and testing documents. Four ET3 patents have issued, and many more are pending.

ET3 Global Alliance Inc. (www.et3.com) is an open consortium consisting of over 380 licensees in 25 nations. Full scale ET3 capsule mockups, and maglev vehicles have been built and tested by licensees.

In spite of over $100m claimed 'hyperloop' investment spread out over 3 (or more) companies, none of the hyperloop teams have yet demonstrated working prototypes that carry people (ET3 has, but is not hyped in the news like anything with Musk on it).

Safety similarities and differences of HL1 and ET3:

- Both systems are tube based (advantages: isolation from unpredictable weather & other vehicles, not possible to 'run off the road', or hit wildlife or children, and vehicles not vulnerable to specific targeting by terrorists, etc. therefore likely to be much safer than planes,trains and automobiles).
- Both systems use partial tube vacuum to reduce drag forces, so will be very quiet and agriculture friendly.
- Both systems are electrically powered (preferably by sustainable sources).
- Both systems are private and open developments that need your help if they are to replace and cars, jets, or high-speed-rail.
- Vacuum tech is well developed, and millions of miles of natural gas pipes are proven to be almost leak free in spite of many times more pressure difference.

Value is determined by a ratio of benefit and cost. Maximum value for maximum users = maximum scale-ability.

- HL1 cargo: relative operating value is: 98 / 5 = 20; ET3 cargo: relative operating value = 94 / 1 = 94; So ET3 offers almost 5 times greater cargo operating value (94/20) -- available for only 10% royalty).
- Initial cost advantage for ET3 is between 5.7 and 11 times greater value for ET3.
- Passenger capacity advantage of ET3 is about 30 times greater than HL1, so 30 times

5.7 is over 100 times maximum value potential advantage for ET3 investments on the heaviest use routes.

In Summary: HL1 is likely to function, however it does not maximize scale-ability potential. HL1 is likely to be very safe, but when compared to ET3, HL1 safety is limited due to very high complexity, and chained dependencies that ET3 eliminates by design.

Would YOU rather ride in a bus that cost 10 cents per passenger mile, or a limousine costing 2 cents per passenger mile? If both HL1 and ET3 were available today, and YOU owned the most profitable transportation route in your nation, what system would you put on your route HL1, or ET3 ? (c) Daryl Oster 2016-2020

Some of the references for the data used for Hyperloop One:

http://www.travelandleisure.com/travel-tips/ground-transportation/first-look-hyperloop-track

By Cailey Rizzo March 22, 2017

“Each capsule will be capable of carrying between 28 and 40 passengers, for an estimated daily total of about 164,000 passengers. The capsule itself is about 2.7 meters in diameter while the elevated tube measures 3.3 meters across. “

https://arstechnica.com/cars/2017/03/hyperloop-one-shows-photos-of-its-test-track-being-built-in-nevada/

Megan Geuss - 3/7/2017, 1:25 PM **Email** megan.geuss@arstechnica.com // **Twitter** @MeganGeuss

“The test track is going to be 500m (or about a third of a mile) long and 3.3m (almost 11ft) wide. A press release from the startup said that it hopes to do a public test in the track in the first half of 2017.”

http://mashable.com/2017/03/07/hyperloop-one-starts-building-devloop/#mlZUCNeqsPq3

3.3m dia tube

http://www.cnbc.com/2016/05/11/hyperloop-one-tests-transportation-tech-in-first-ever-demo.html

The company will start to produce the cargo tubes in a couple of weeks, Lloyd said. These steel pods, 11 feet in diameter, will be magnetically suspended on a track and able to reach up to 760 miles per hour.

Lloyd said Hyperloop is slated have a full-scale project in progress in 2017. The pods are set to move the first freight in 2019 and the first passengers in 2021.

http://www.telegraph.co.uk/technology/2017/03/07/future-travel-first-photos-hyperloop-test-track-built-nevada/

The 500 metre-long Hyperloop test structure, which has a diameter of 3.3 metres, is located around 30 minutes from Las Vegas.

http://www.foxnews.com/tech/2017/03/23/hyperloop-race-heats-up-as-one-startup-begins-building-full-size-passenger-pod.html

By Clayton Moore Published March 23, 2017HTT is working with Carbures S.A., a Spanish company that builds components and systems for use in aeronautics, defense, space and other complex technical industries.

The HTT passenger capsule will seat between 28 and 40 people, and is being designed to travel at more than 700 miles per hour. The commercial capsule, so reminiscent of The Jetsons, will be about 100 feet long, with a 9-foot diameter and a weight of 20 tons.

https://mdao.grc.nasa.gov/publications/AIAA-2015-1587.pdf

https://github.com/OpenMDAO-Plugins/Hyperloop

http://gizmodo.com/a-hyperloop-is-the-perfect-way-to-move-goods-not-people-1762062290

https://arstechnica.com/civis/viewtopic.php?p=32260035

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http://gizmodo.com/it-looks-like-weve-got-ourselves-a-good-old-fashioned-h-1725484968

https://www.forbes.com/sites/bruceupbin/2015/02/11/hyperloop-is-real-meet-the-startups-selling-supersonic-travel/