Presented at: 103rd **Transportation Research Board (TRB)** Annual **Meeting**
Event Number: 2226, Current Issues in Aviation
Convention Center, Hall A; Monday, Jan 08, 2024 3:45PM - 5:30PM
Presentation Number: TRBAM-24-04060; Location B655

Highly-Efficiency Low-*AR* Aerial Vehicles in Urban Transit

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A fast track to an emission-free society with reduced transit costs and times!

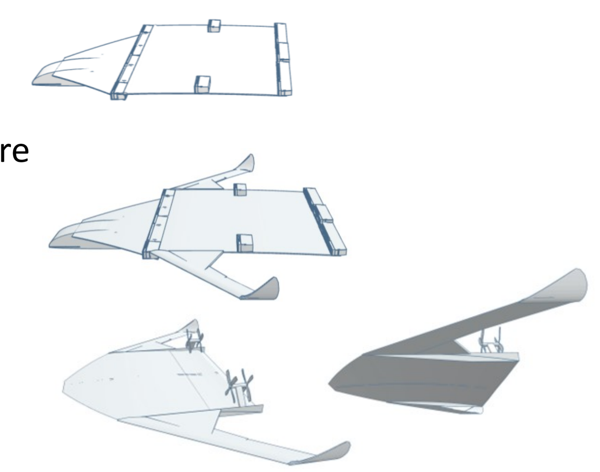
The Science

While the U.S. aerospace communities have led the world in capabilities with continuously improving performance, they have failed to be good stewards of the technology toward enabling broader-scale innovation by all engineering disciplines and beyond.

Explaining Aerodynamic Lift:
Aerodynamic lift is easy the result of higher pressures on lower surfaces and lower pressures on upper surfaces. The following five guidelines explain and quantify aerodynamic lift and are substantiated by 2D pressure profiles (see Fig. 1).

1. Air's velocity impacting a surface generates higher pressure.
2. Air's velocity diverging from a surface generates lower pressure.
3. Air expands at speed of sound from high-to-low pressure.
4. Air's velocity bends toward lower pressure and away from higher pressure.
5. A surface's ***L/D*** is the normalized surface integral of Pressure $\tan^{-1}(\alpha)$ on the surface, per:

$$Lift = \Delta P\ \Delta S\ Cos(\alpha_P); \quad Drag_{form} = \Delta P\ \Delta S\ Sin(\alpha_P); \quad L/D = \frac{1}{Tan(\alpha_P)} = \frac{57}{\alpha_P^{\circ}} \text{ at low } \alpha_P$$



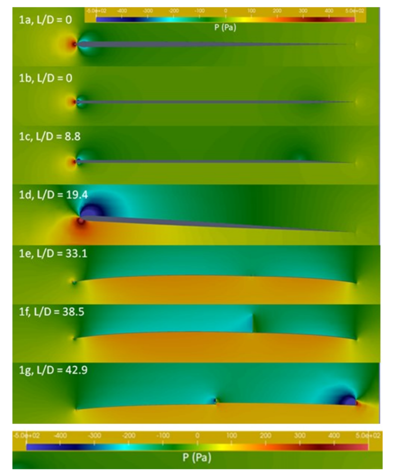


Fig. 1

Taking the Explanation to the Next Level:
When computational fluid dynamic (CFD) simulations are converted from 2D thin cambered airfoils (Fig. 1) to 3D (Fig. 2, i.e. wings) the lift-drag ratio (L/D, key metric on flight efficiency) reduces dramatically. The reduction is due to flow of air over side edges of the wing to/from surrounding air. Effective ways to reduce the impact of side-edge losses include:

1. Block spanwise air flow with fences or winglets.
2. Position propulsion sources to lift at good gain-loss ratio (see Fig. 2).
3. Generate lift forces faster with increased camber/curvature.
4. Increase aspect ratio and/or add side wing extensions.

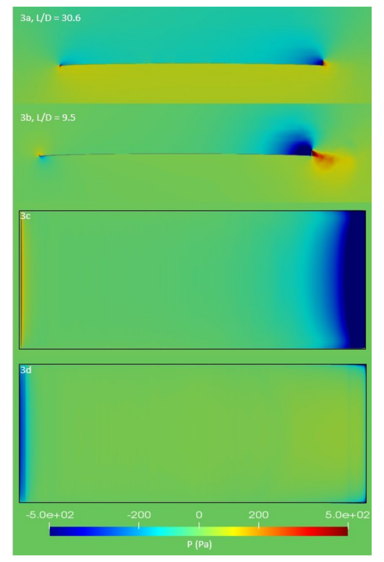


Fig. 2

Benchmark L/D Performances:
Lifting Line Theory estimates lift and drag based only on the aspect ratio; it is the opposite of L/D from 2D CFD which estimates L/D based only on the cross section of the wing. Fig. 3 compares L/D as predicted by Lifting Line Theory to thin cambered wings and to thin cambered wings (different aspect ratios) with an upper surface trailing edge sources (e.g., Fig. 2). The results identify that propulsion "Sources" are able to create substantial increases in L/D. Without a Source, the 0.04 camber wing generates lift faster than the 0.02 camber wing leading to higher L/D. However, the trailing edge Source of the 0.04 camber wing has a high pitch which limits L/D per guideline (heuristic) "5.", above.

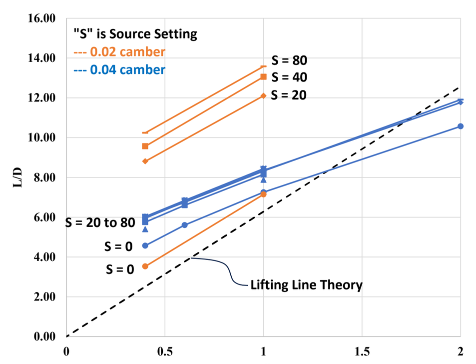


Fig. 3

Enabling Innovations:
To date, the most commonly taught theory of lift is "Bernoulli's Theory of Lift" which is incorrect at every level, from its application to a wing to its incorrect results; it predicts the same pressure throughout the upper surface when, per Fig. 1, the pressure varies substantially from leading to trailing edge of a wing. Fundamentally correct heuristics, like 1-5 above, allow trends in performance to be accurately associated with a wing or surface shape. The accurate association leads to understanding, and eventually, innovation.

Fig. 4 illustrates multiple innovations with a patent-pending status:

A **Thin Center Wing** is at the right camber is an excellent lifting body which can be a bifacial solar panel.

Bifacial Solar Panels that can be quick-connected to an airframe avoid greenfield/brownfield costs, with installed costs of 1 ¢/kWh and less, when they replace wing sections having higher fabrication costs.

Lift Span Tech is a morphing surface technology around the Source that recognizes the optimal surface shape around the source depends on the power output of the Source; hence, it is different for takeoff vs. cruising.

Other innovations include: Fence in the Shadow, Bernoulli Tubes, and glider guideway systems based on inexpensive zipline guideways using high L/D low AR vehicles travel.

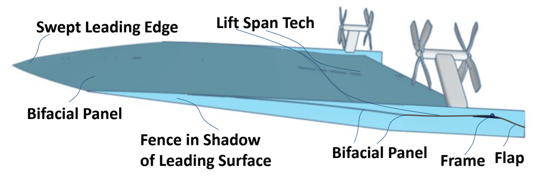
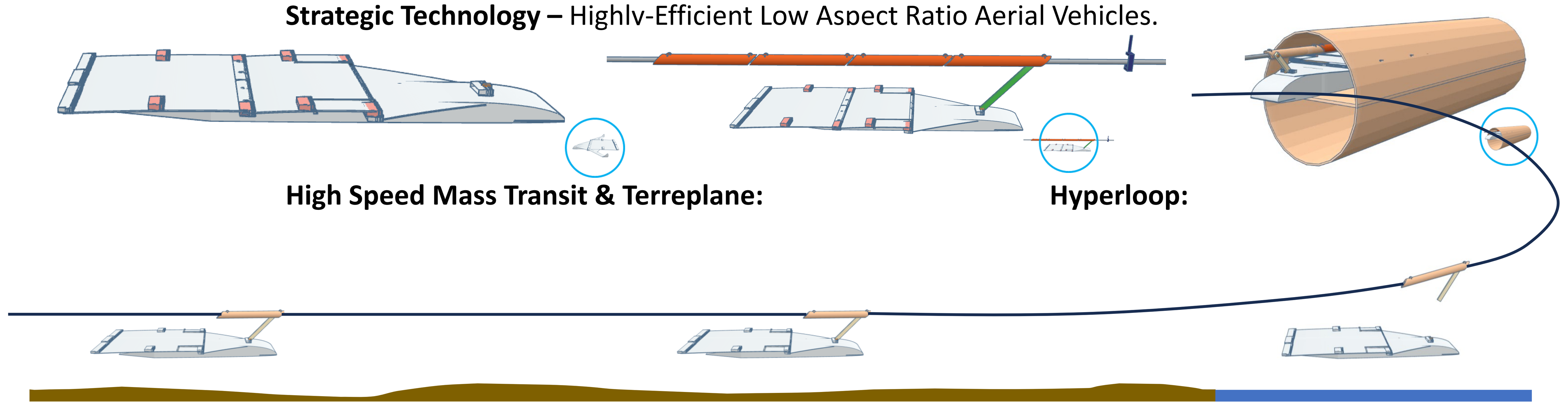


Fig. 4

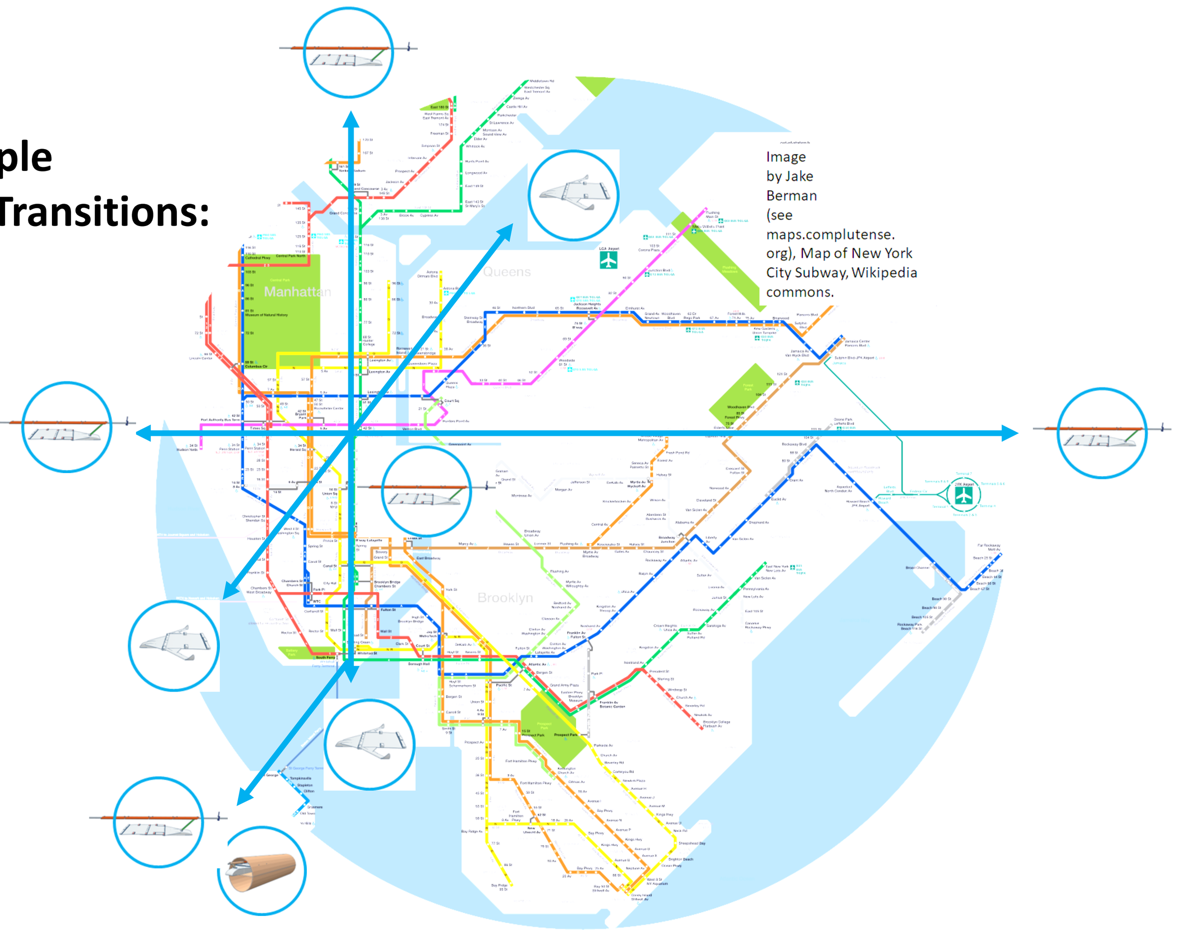
The path starts with realistic expectations on options:

- **BAD OPTION** - High volumes of air taxi traffic over cities.
- **BAD OPTION** – Only elite citizen access over cities.
- **GREAT OPTION** – High speed mass transit with seamless transition to free flight, Terreplane, and Hyperloop.

Strategic Technology – Highly-Efficient Low Aspect Ratio Aerial Vehicles.



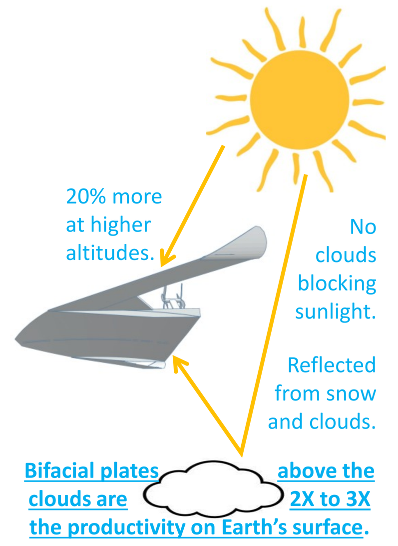
NYC Example
Seamless Transitions:



CONCLUSIONS: High ***L/D*** low ***AR*** airframes can merge the gap between transit systems characterized as vertiport, mass transit, hyperloop, airliners, and UAV technologies. A proper foundation in fundamentals enables significant advances in capabilities including improved use of solar power, reduced transit costs, reduced transit times, and a fast track to a zero-emission society.

The Technology

The Seamless Vertiport:
It is a bad option to put air taxi traffic above our cities, and airliner efficiency has increased to the point where greater transit costs and time are associated with getting to/from airline gates. Vertiports located outside dense populations will have the same problem.



The Solution:
High-access high-speed non-stop intracity mass transit with seamless transition to high-speed intercity transit. This is possible with aircraft traveling along a zipline-type guideway; debatably the lowest-cost lowest-impact guideway system possible.

Importance of Low AR and High L/D:
Low aspect ratio is important to minimize the width of the transit corridor. High L/D reduces energy costs and reduces tensile stresses on zipline. Straight zipline guideways are needed for high speed and are possible with underspanned suspension cables.

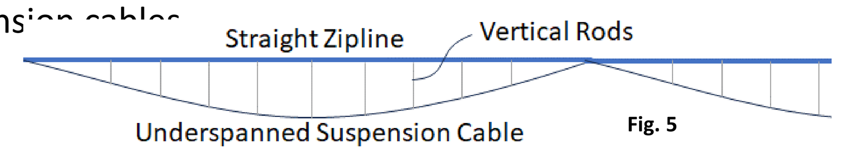


Fig. 5

Aircraft – The Most Efficient Transit Option:
Fig. 6 is a summary of emissions and efficiency of various transit options as compiled by data from the U.S. DOE and UK. At speeds greater than those of ferries and ships, aircraft emerge as the most efficient option.

How High Can Efficiency Go? NASA and the U.S. Air Force have placed a renewed emphasis on the blended-wing-body (BWB) aircraft citing a 40% increase in L/D versus airliners (at L/D = 17). Morphing surfaces afore engine intakes can further increase efficiency with anticipated doubling of efficiencies (i.e., L/D > 34). This modified BWB design is not low AR. Optimal designs will depend on application.

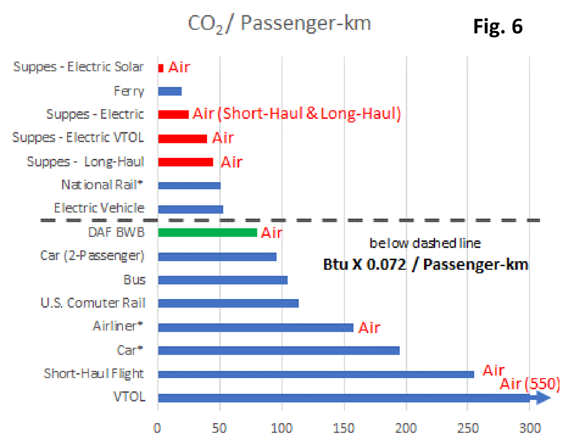


Fig. 6

Solar Energy Factor:
Solar panels are THE low cost energy option at 1 ¢/kWh. The barrier to realizing these low costs are: a) brownfield, greenfield, and other construction costs, b) competing with grid electricity. On aircraft fuel at battery weights and costs are directly displaced; they cost in excess of 18 ¢/ kWh (shaft work, annualized or actual as appropriate). Also, the solar energy above the clouds on bifacial panels is 1.5X to 3X that on Earth's surface. Instant technology is toward direct use of solar panels as thin cambered wing sections with zero or negative installation costs (see Fig. 4); the results transforms what is possible with solar power (see Fig. 7)

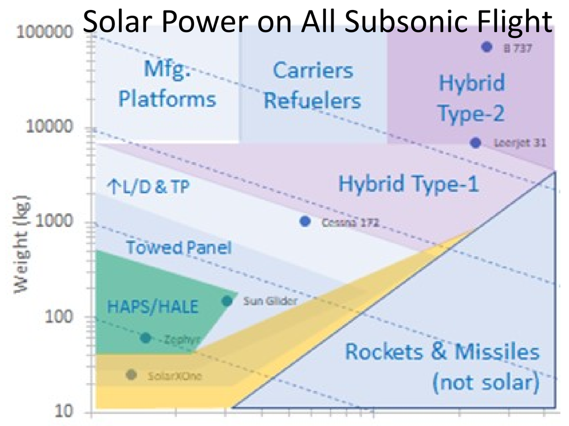


Fig. 7

Terreplane – Errs and Emergence:
Glider guideway concepts have been around for decades, but only with the Terreplane system introduced in 2015 (i.e., WO2016109490A3 - Terreplane transportation system) did low-cost low-footprint zipline-type guideways emerge as a distinct competitive advantage. The high L/D low AR vehicles of this paper make Terreplane viable including low-footprint high-speed mass transit with seamless vertiports.

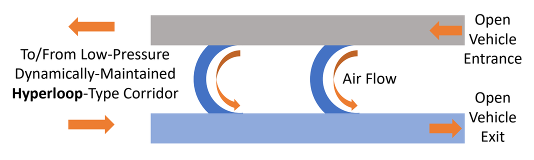


Fig 8

Hyperloop - Errs and Emergence:
Common errs made on hyperloop are specification of : a) a low pressure of operation, b) maglev suspension, and c) a closed tunnel system. The system should be open (see Fig. 8) and those specifications should be results-driven variables. The result is that any tunnel system can be modified (along with vehicles) to support lower-pressure transit with seamless connection to exterior guideway networks.

Ignorance is the Real Problem:
The most vocal of environmentalists are the greatest problem and cause of global warming and related problems. Those groups have not learned the technology well enough to become the stewards of better understanding of good technology solutions that are available to today as a fast track to a zero-emission society.

Learn more, understand, fix errs, improve! https://hs-drone.com/