Conceptual Routing for Potential Hyperloop Fright Network Using the Freight Analysis Framework Database

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INTRODUCTION

The Hyperloop is a closed, wrapped tube or system of tubes through which a container vessel can travel almost free of air resistance or friction, carrying people and goods at high speed. While most of early studies on hyperloop routes focused on passenger transportation, the primary objective of this study is to explore potential Hyperloop network or routes that are logistically and economically feasible, based on freight movements in the United States.

- ❑ Hyperloop Alpha Profile (Tesla and SpaceX):
  - From Los Angeles to San Francisco Bay Area (I-5 Corridor)
  - Spanning 350-mile (560km) with an operating speed of 760 mph
  - Require $6 billion for a passenger-only version ($7.5 billion for passenger-plus-vehicle version)
  - The costs are likely underestimated (not including land acquisition)
  - $20 of ticket price from Los Angeles and San Francisco – this would not be able to cover its construction costs
  - Solar panels are suggested as a main power source

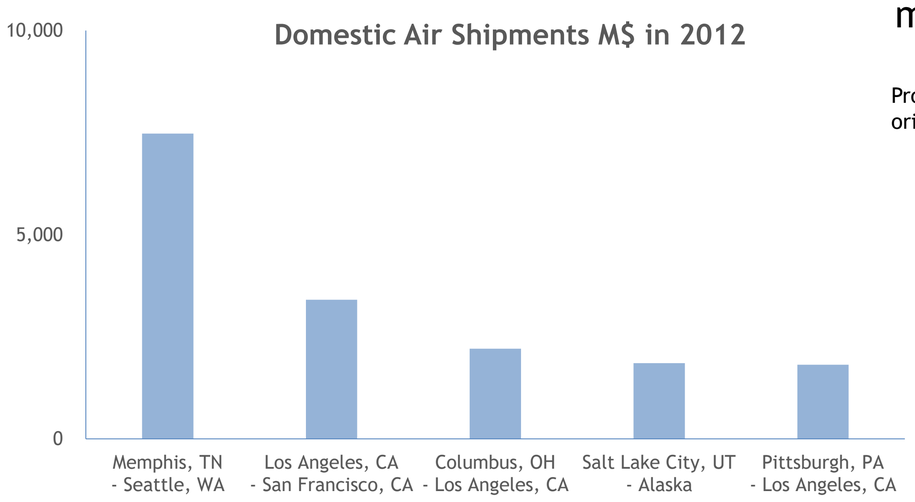
MAJOR DATA SOURCES

The Freight Analysis Framework (FAF) integrates data from a variety of sources to create a comprehensive national picture of freight movements (weight and value) among states and major metropolitan areas, by all modes of transportation. It provides a national picture of current freight flows to, from, and within the United States and projects such freight flow patterns into the future. The FAF freight movement database provides a unique opportunity to simulate and estimate the benefits and effectiveness of implementing the Hyperloop within the United States.

- ❑ Freight Analysis Framework (FAF) 4.5
  - Mainly used 2012 FAF flows (Origin-Destination-Commodity-Mode)
- ❑ 2012 Commodity Flow Survey (CFS) Public Use Microdata
  - Individual shipment records in values and tons
- ❑ ORNL CTA Transportation Networks
  - A matrix of county-to-county distances and network impedances via highway, railroad, water, and combined highway-rail paths

METHODOLOGY AND ANALYSIS RESULTS

1. Explore top OD pairs by air

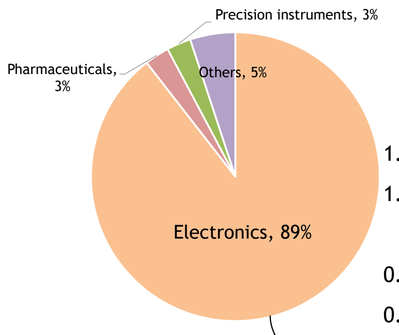


2. Construct a commodity specific model to estimate modal split

Probability of choosing transportation mode i for origin o, destination d, and commodity c

$$P_{odc}^{i} = \frac{e^{\beta_c U_{odc}^{i}}}{\sum e^{\beta_c U_{odc}^{m}}}$$

Utility or cost of transportation mode m for origin o, destination d, and commodity c



3. Estimate potential market share of hyperloop by origin, destination, and commodity

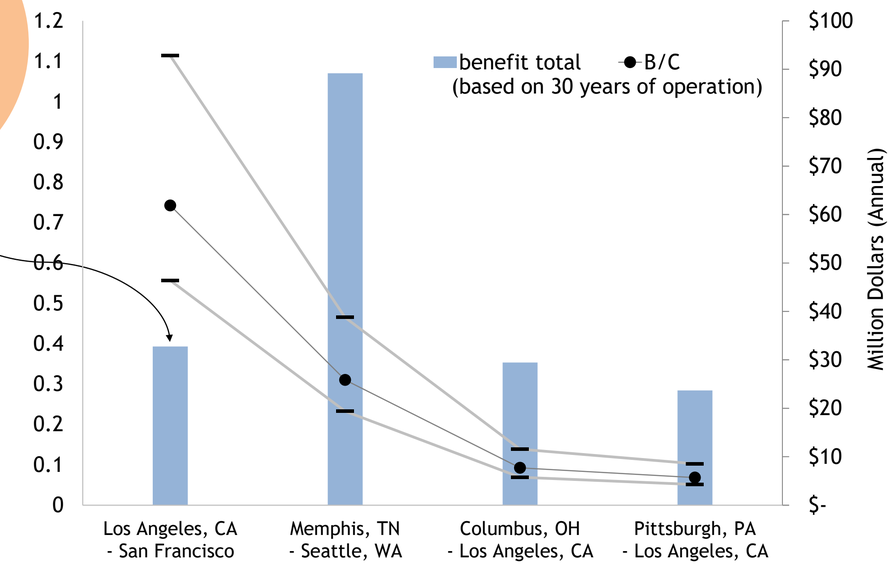
The utility/cost of hyperloop, U_{odc}^{h}, is based on its characteristics (e.g., terminal time, travel time, fare, etc.)

According to Hyperloop Commercial Feasibility Analysis by NASA, hyperloop would most likely compete with air for freight shipments. Due to the limited data availability of this new technology, the authors assumed that hyperloop would replace air shipments by 50% in this presentation.

4. Estimate costs and benefits

- ❑ Costs
  - Hyperloop Alpha estimates $17 million per mile
  - $25 ~ $27 million per mile based on Hyperloop Technologies
  - Considering land acquisition and uncertainty of other investment costs, the total cost would be assumed between $20 ~ $40 million per mile
  - Assume the cost for freight shipment would be about 20% (1.5/7.5)
- ❑ Benefits
  - Travel time reduced by 44 min for 270 miles and additional reduction of 3.3 min for every 100 miles, compared to air
  - Value of travel time savings for air cargo: $132.24 in 2002 Euro per ton-hour
  - Shipping cost: 1/4 ~ 1/10 of air (based on passenger fare comparison)
  - Benefits not quantified: emission reduction, induced demand, indirect economic impact, etc.

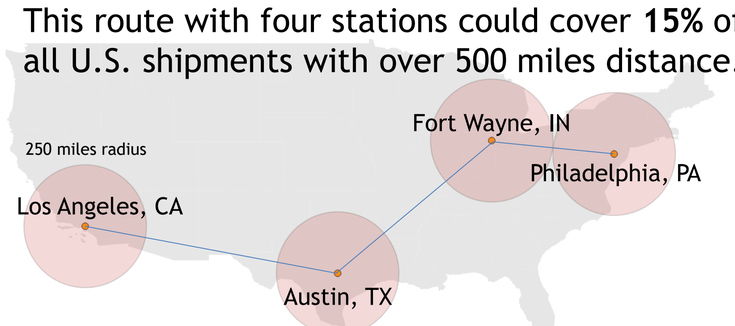
5. B/C Analysis and Route Selection



ALTERNATIVES & CONCLUSIONS

Hyperloop as multi-modal transportation hub

- This route with four stations could cover **15%** of all U.S. shipments with over 500 miles distance.



The following items are to be considered in the future, to reflect more realistic features of hyperloop routing:

- Value of time by commodity type
- Multiple stops along the routes
- Passenger demand
- Land acquisition and other costs
- Geometry and other restrictions (e.g., capacity)
- Critical use/need of extremely fast shipments

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