

# Aircraft Technology Modeling and Assessment

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October 9, 2018

- Purdue efforts in two areas for current phase of project to make fleet-level CO<sub>2</sub> predictions:
  - Characterizing supersonic routes
  - Including supersonic aircraft into allocation

## Fleet-Level Environmental Evaluation Tool - FLEET

- Uses a system dynamics-inspired simulation to evolve airline fleet, passenger demand, environmental impact over time
- At core is an allocation problem to simulate a profit-seeking airline
  - 1,940 routes connect a subset of World-Wide LMI Network of 257 major airports
  - Includes US domestic routes and int'l routes with direct flight originating or ending at US airport
- FLEET represents aircraft by class (number of seats) and by technology age

## Placeholder supersonic aircraft characteristics

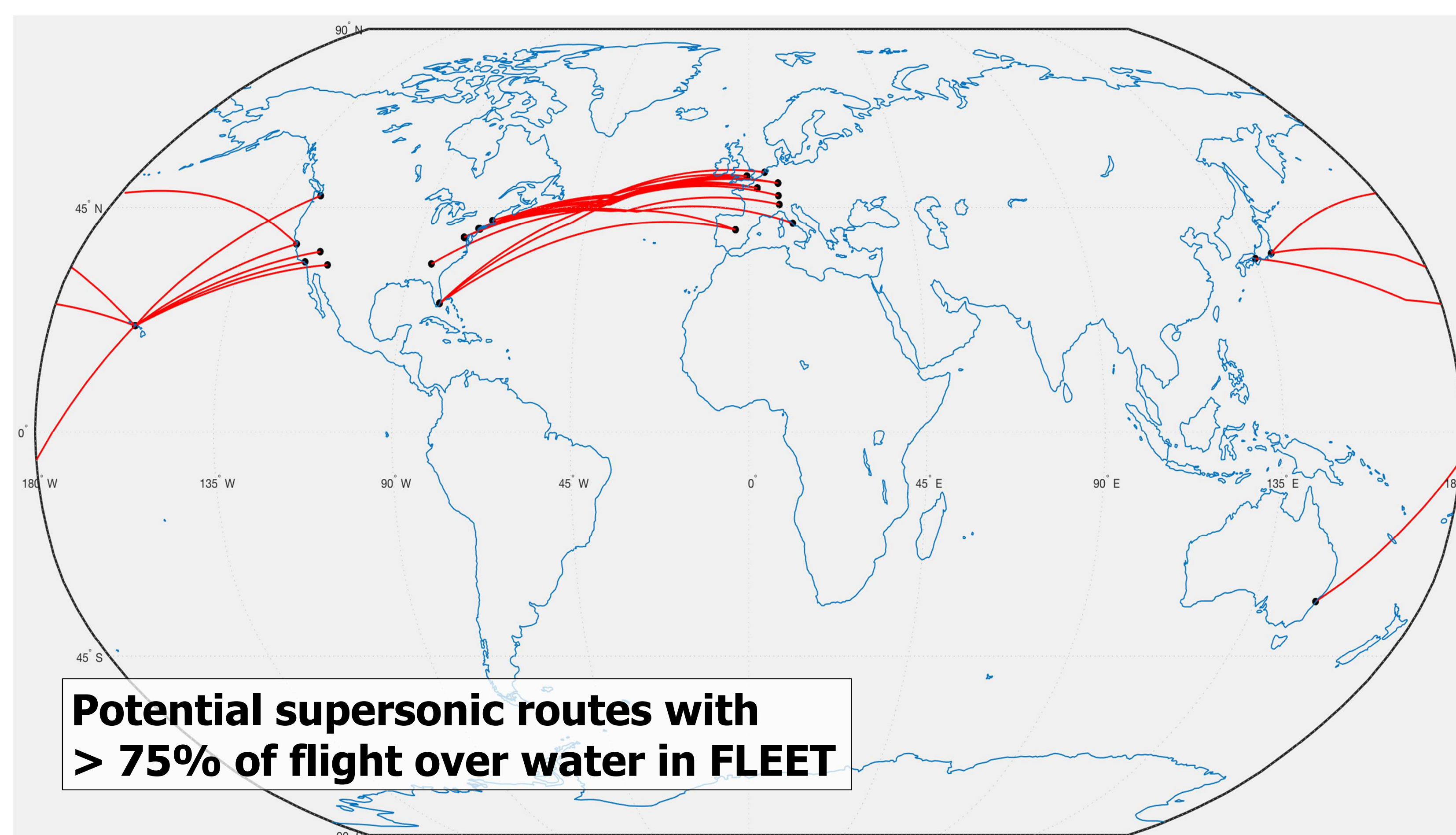
	EIS 2025		EIS 2035		EIS 2045	
	Supersonic	Subsonic LTA <sup>†</sup>	Supersonic	Subsonic LTA <sup>†</sup>	Supersonic	Subsonic LTA <sup>†</sup>
Seat capacity	69	216	69	244	69	244
Fuel burn (per pax-nmi)	0.4225	0.1346	0.4212	0.1188	0.2312	0.0652

<sup>†</sup>LTA – Subsonic Large Twin-Aisle Aircraft motivates placeholder, because of similar range

- Placeholder model for initial studies; **will replace with refined vehicle model when available**
  - Assumes no boom reduction technology, supersonic overwater only
  - Block time for supersonic aircraft dependent on percentage of flight overwater and overland, with cruise speed of  $M = 2.2$  overwater and  $M = 0.95$  overland
  - Aircraft operation cost modeling
    - Crew cost dependent on block time
    - Maintenance hours set as 1.5 times that of a subsonic large twin-aisle aircraft in FLEET
    - Aircraft acquisition cost, indirect operating cost, and insurance set same as that of a subsonic large twin-aisle aircraft in FLEET
  - In allocation, 80% load factor limits placeholder aircraft to 55 passengers

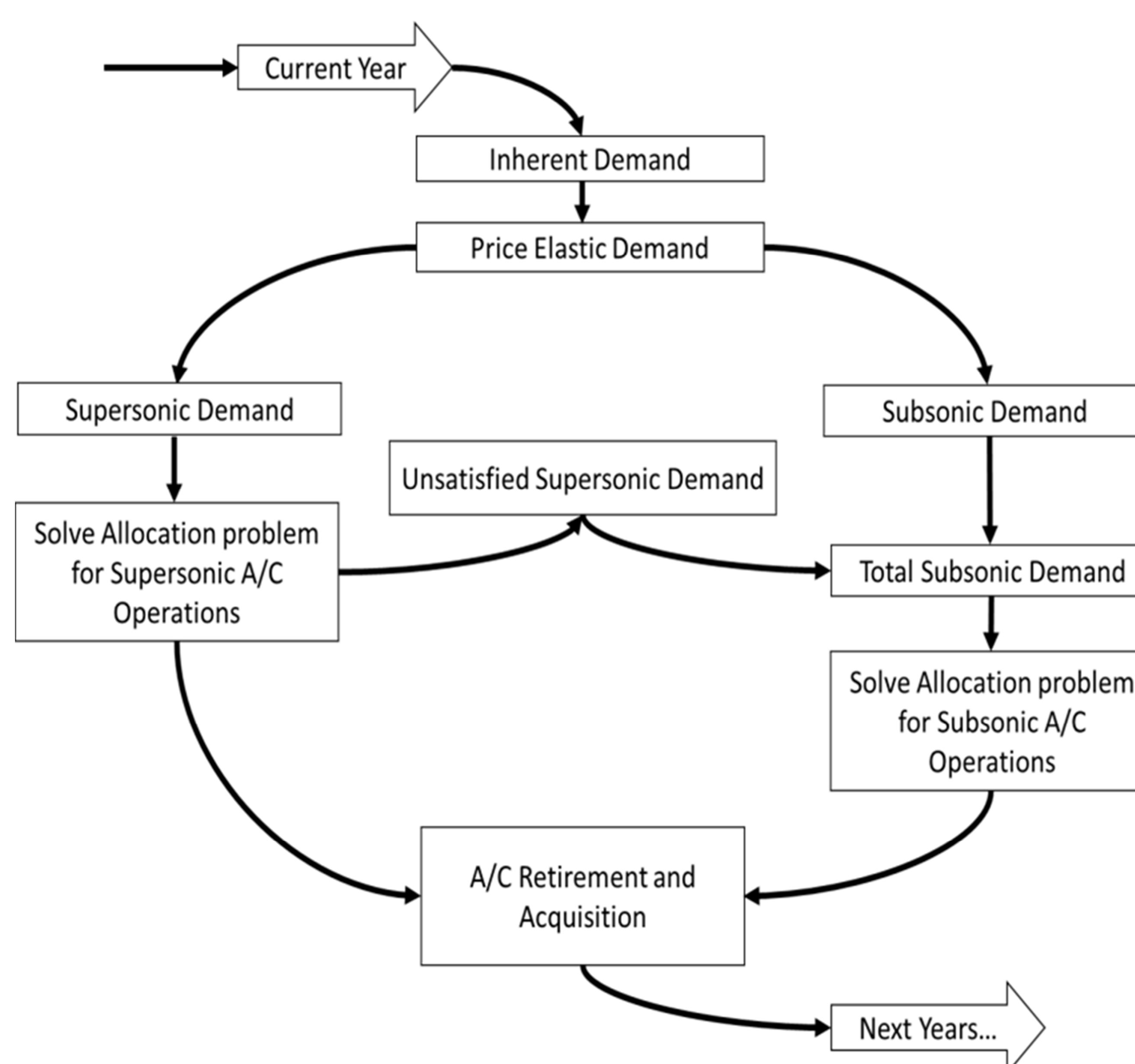
## Identifying potential supersonic routes and demand

- Demand filter
  - 5% of daily demand > 50 passengers
  - Uses Bureau of Transportation statistics reported demand in 2016
  - Assumes this 5% of demand are business or above travelers
    - 5% assumption correlates with data for domestic flights
      - All domestic flights, 4.3% of reported tickets business or above class
      - Domestic flights between 2350 and 4500 nmi, 6.89% business or above class
    - These are the only potential supersonic passengers
- Overwater filter
  - Uses deviation from Great Circle route, quick time estimate
  - Current supersonic eligible route set considers routes with more than 75% flight segment overwater
- FLEET route network is based on 2005 BTS reported operations
  - Filters identified 26 routes that have potential for supersonic flights
  - Routing includes accommodation for overwater at  $M = 2.2$ , subsonic overland at  $M = 0.95$

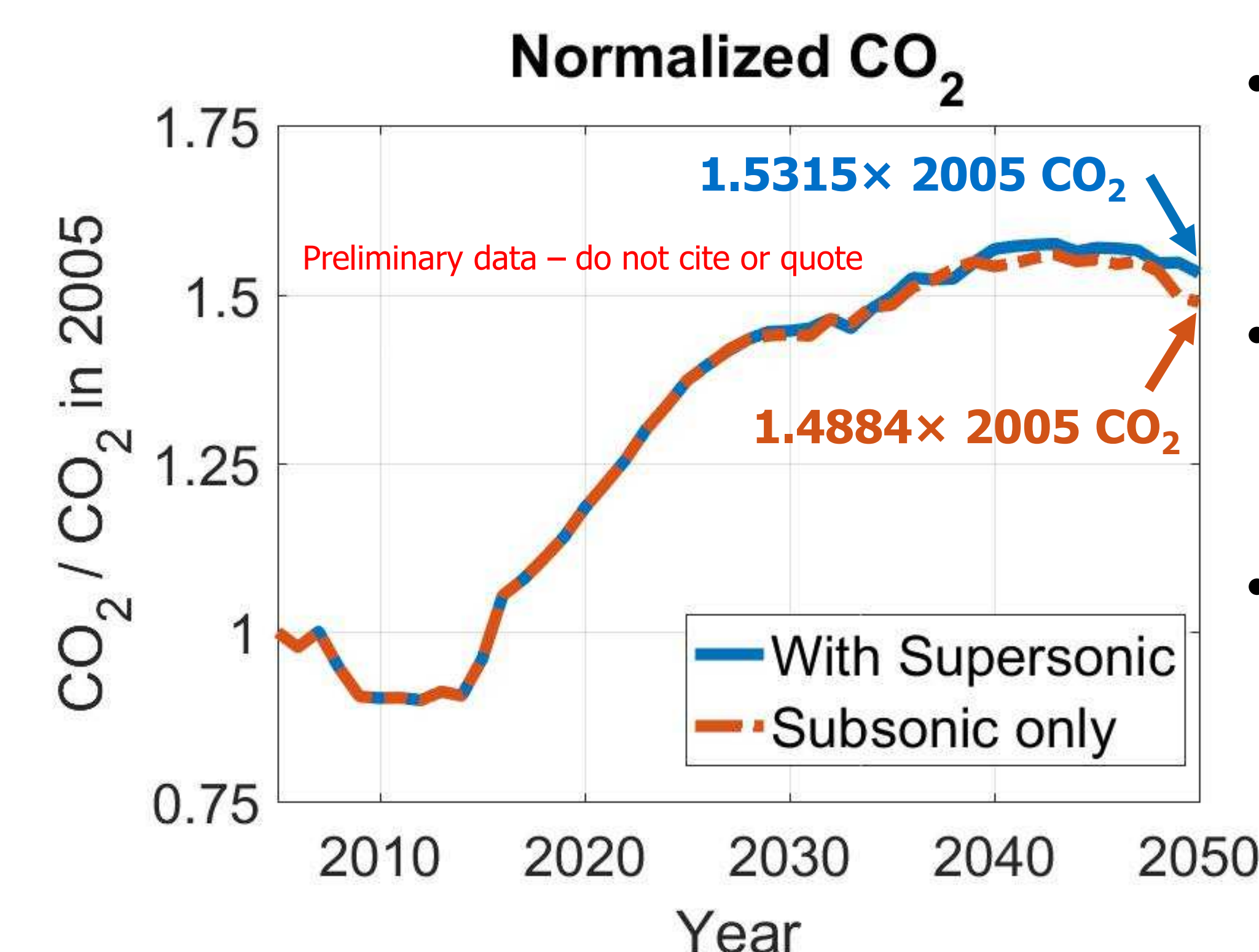


## FLEET implementation

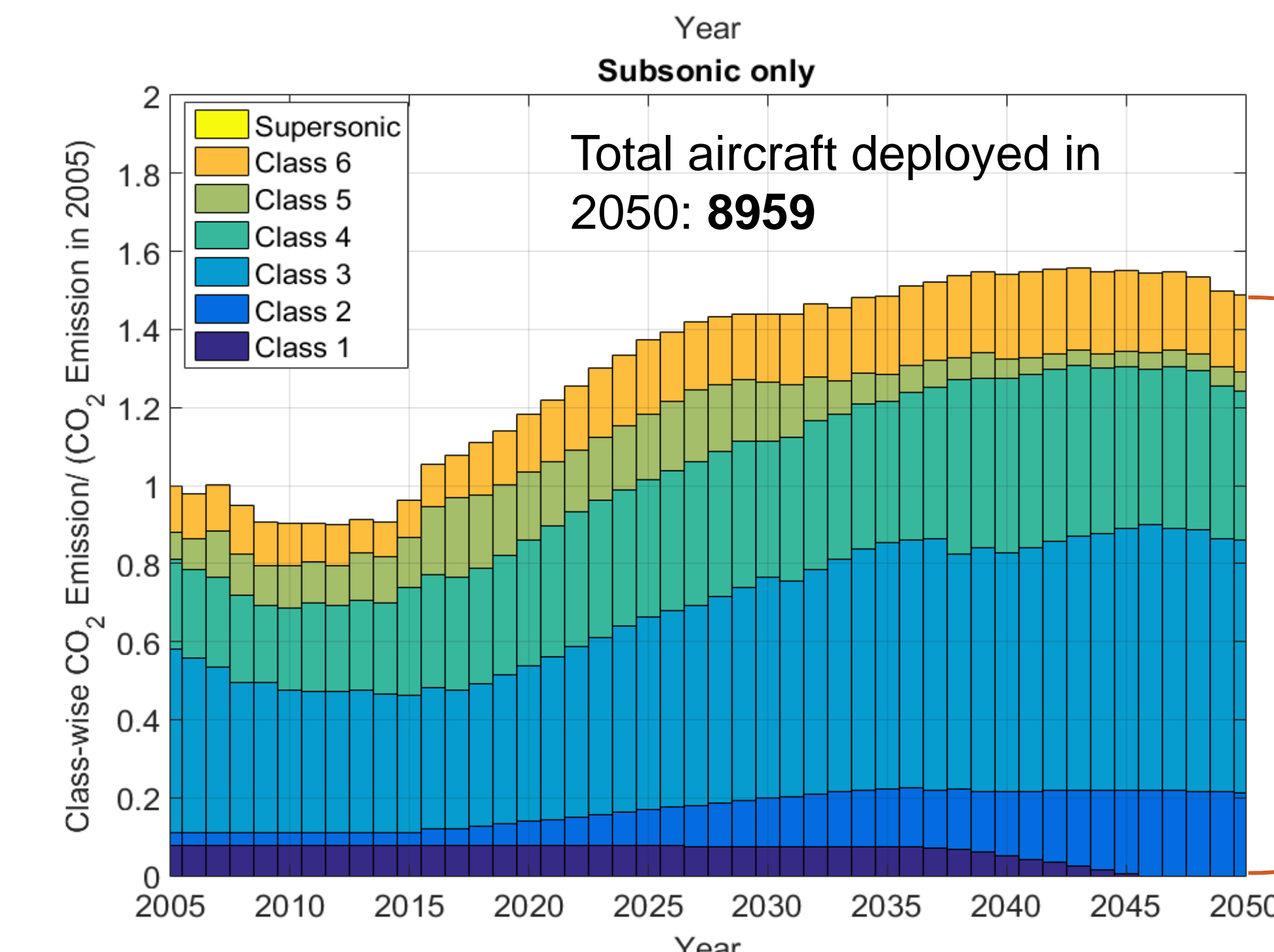
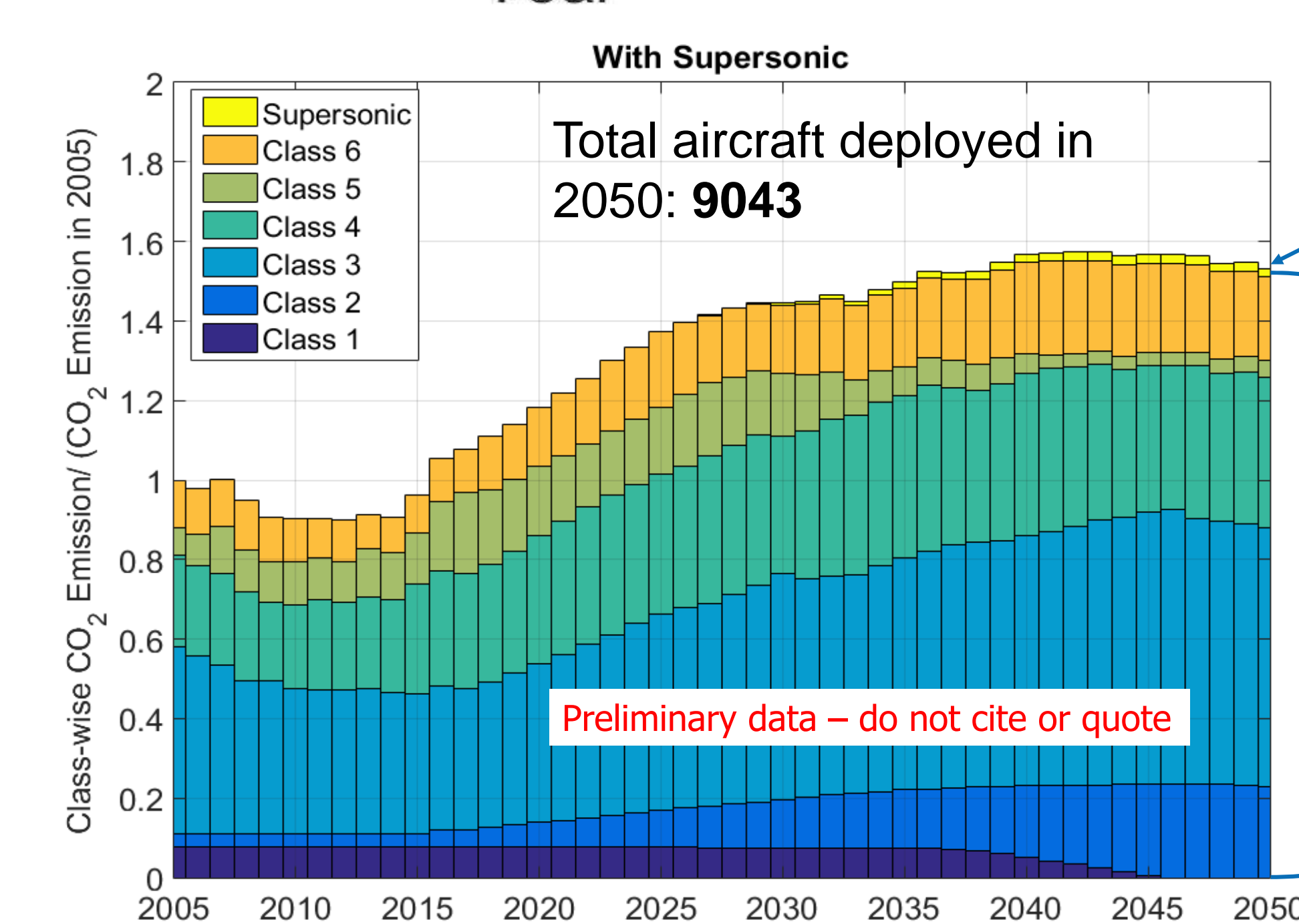
- First, solve the supersonic aircraft allocation problem
  - Airline serves premium (supersonic) demand first before other (subsonic) demand
  - Supersonic aircraft deployments have higher priority than subsonic aircraft
- Merge unsatisfied supersonic market demand with subsonic market demand
- Solve subsonic aircraft allocation problem



## Fleet-level CO<sub>2</sub> predictions with supersonic aircraft – demonstration



- 2050 fleet CO<sub>2</sub> emissions higher with supersonic aircraft than subsonic only
- Some years show *slightly* lower fleet CO<sub>2</sub> emissions with supersonic aircraft
- Supersonic aircraft changes use, retirement and acquisition of subsonic aircraft**



Fleet Aircraft Scheme	Passenger nautical miles flown in 2050
With supersonic	2.4292E+09 (7.2268E+06 supersonic)
Subsonic only	2.4263E+09

## Future work

- Develop and test passenger choice model and ticket price model to update FLEET allocation problem
- Investigate other scenarios in FLEET to reveal how environmental metrics evolve when supersonic aircraft are available
- Conduct sensitivity studies for drivers (e.g. ticket price) that impact supersonic travel