Quantifying the Relationship Between Air Traffic Management Inefficiency, Fuel Burn and Air Pollutant Emissions

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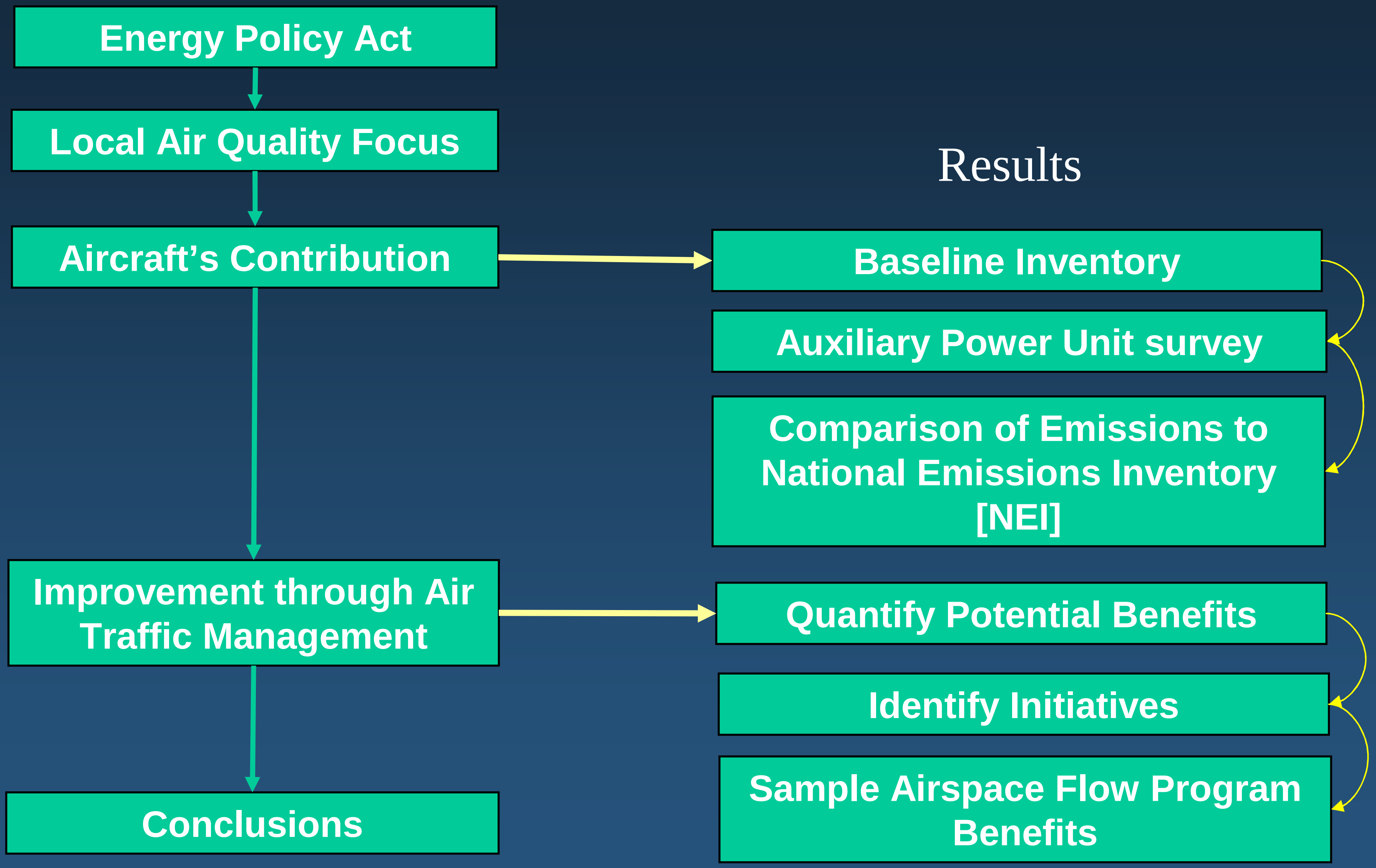
and was performed by a team that includes:
US Federal Aviation Administration, CSSI, Metron Aviation, Massachusetts Institute of Technology, US Environmental Protection Agency, and US Department of Defense

The Energy Policy Act Study is managed by Warren Gillette, FAA.

Overview


Energy Policy Act
Local Air Quality Focus
Aircraft's Contribution
Improvement through Air Traffic Management
Conclusions
Results
Baseline Inventory
Auxiliary Power Unit survey
Comparison of Emissions to National Emissions Inventory [NEI]
Quantify Potential Benefits
Identify Initiatives
Sample Airspace Flow Program Benefits

Congressional Mandate
Energy Policy Act of 2005

Requires FAA and EPA to:

- Conduct a study to identify the impact of *aircraft* emissions in areas of poor air quality
- Identify ways to promote fuel conservation to enhance fuel efficiency and reduce emissions

Focus: Air traffic management inefficiencies

Congressional Mandate
Energy Policy Act of 2005

Requires FAA and EPA to (cont.):

- Issue a report that:
  - ❖ Describes the results of the study and
  - ❖ Recommends ways to reduce fuel use and emissions affecting air quality. *

* (1) Must not adversely affect safety and security or increase individual aircraft noise. (2) Must take into account all aircraft emissions and the impact of emissions on human health.

Local Air Quality Focus

- Energy Policy Act focuses on poor local air quality
- Based on National Ambient Air Quality Standards (NAAQS) for CO, Pb, NO_2, SO_2, PM_{10}, $PM_{2.5}$, and O_3
- Local air quality is effected by emissions below the mixing height (3000 feet)
- Emissions below 3000 feet focus the study to the airport level
- At the airport level, consider opportunities to improve ground based operations to decrease emissions below 3000 feet

Poor Air Quality Areas

Only one criteria pollutant must exceed standards

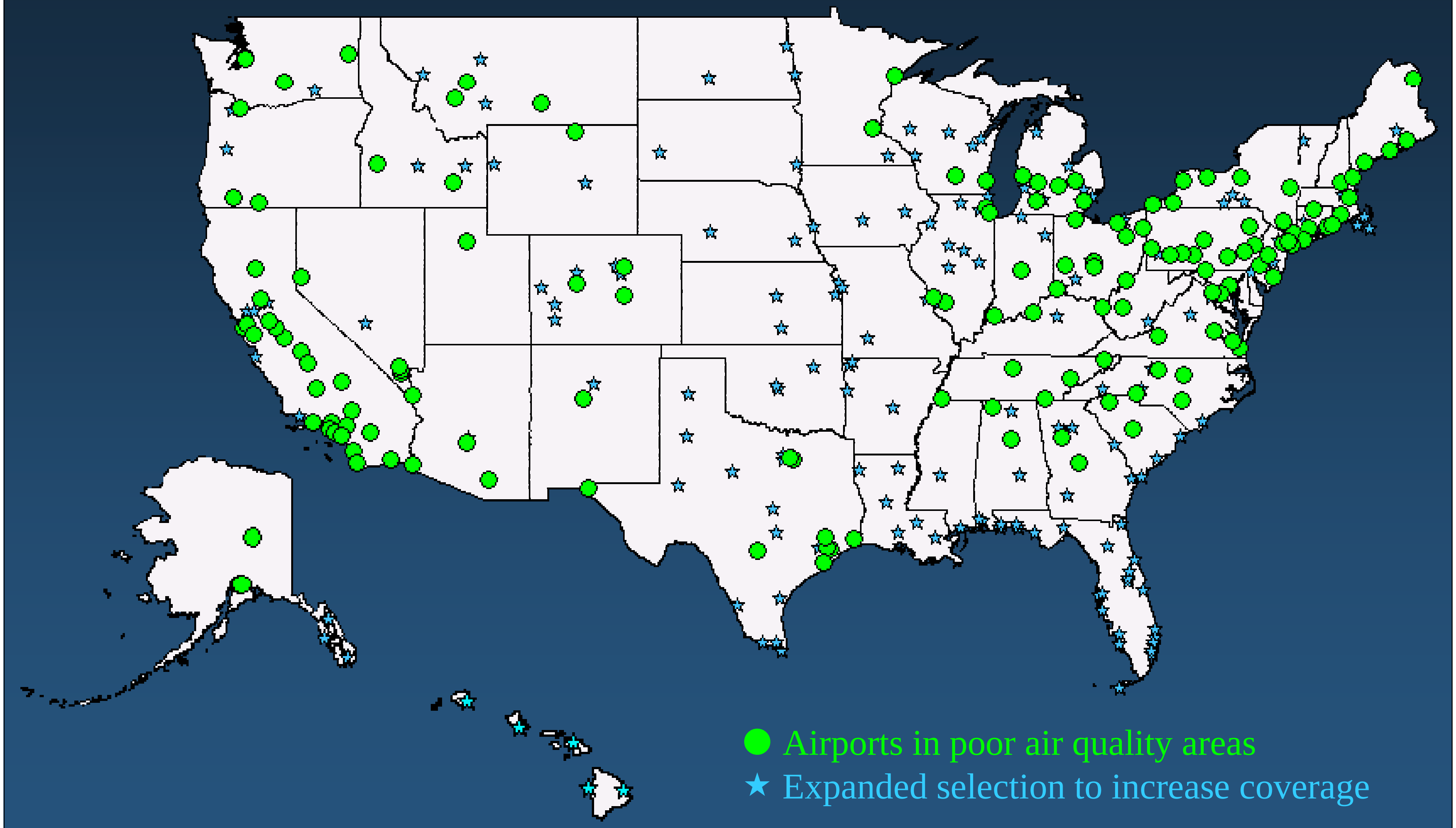
Four Analyses

1. Estimate the contribution of aircraft to emissions inventories and local air quality effects in poor air quality areas
2. Estimate the potential of promising initiatives to relieve congestion and delays, reduce emissions, and improve local air quality
3. Investigate the relationship between congestion, delays and aircraft emissions on local air quality
4. Estimate health effects from aircraft emissions

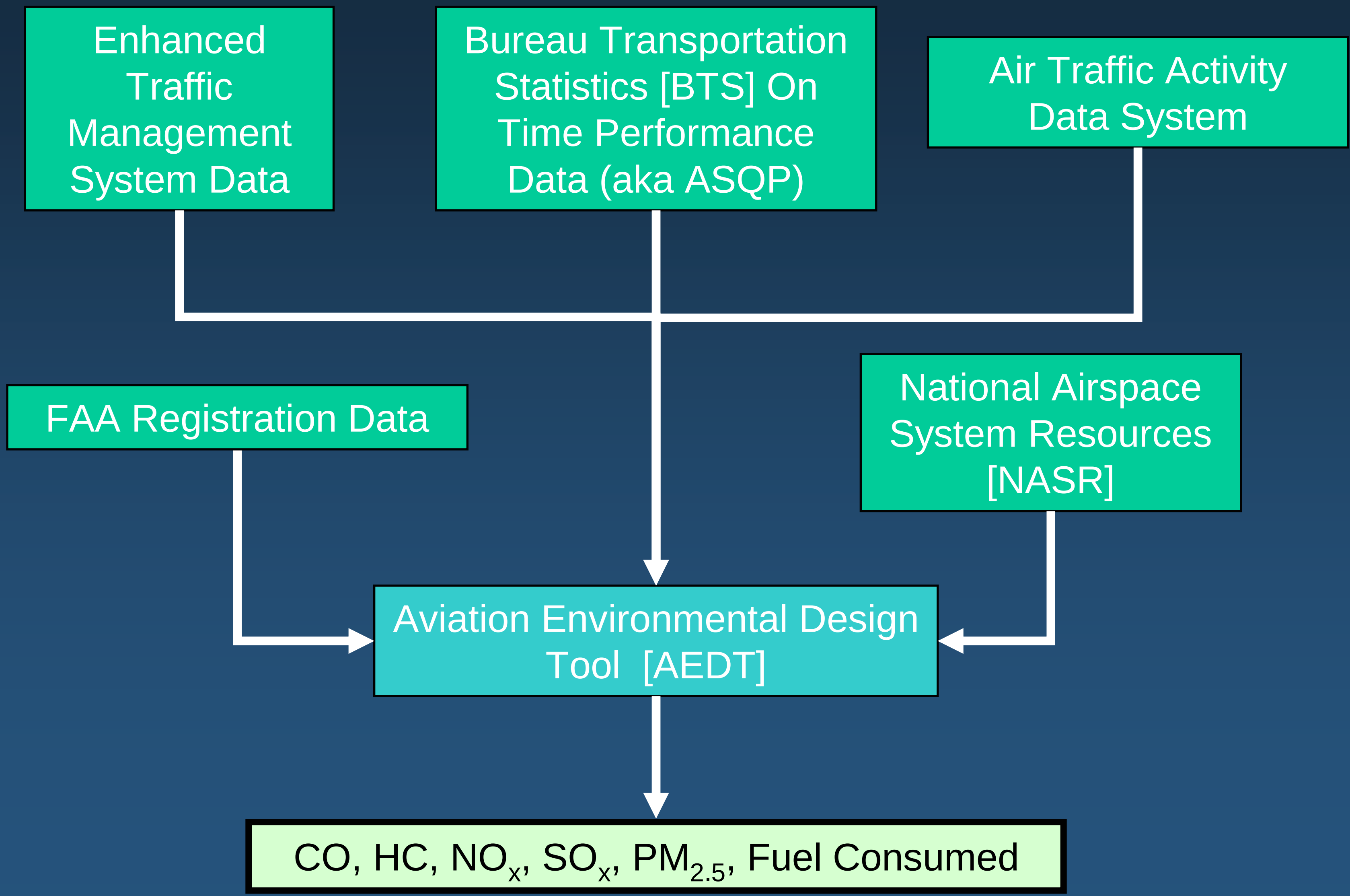
Analysis 1: Aircraft's Contribution

- Airport Selection
  - 325 airports were selected to include ~95% of commercial jet engine operations
  - 148 airports in poor air quality areas for Carbon Monoxide, Ozone or Particulate Matter
- Establish baseline inventory for fuel burn and emissions
  - Create an operational profile using as much data as possible
  - Air pollutant emissions below the atmospheric mixing height
- Evaluate effects of auxiliary power unit (APU) usage on emissions
- Determine aircaft's effect on local air quality

Selected Airports



Baseline Inventory

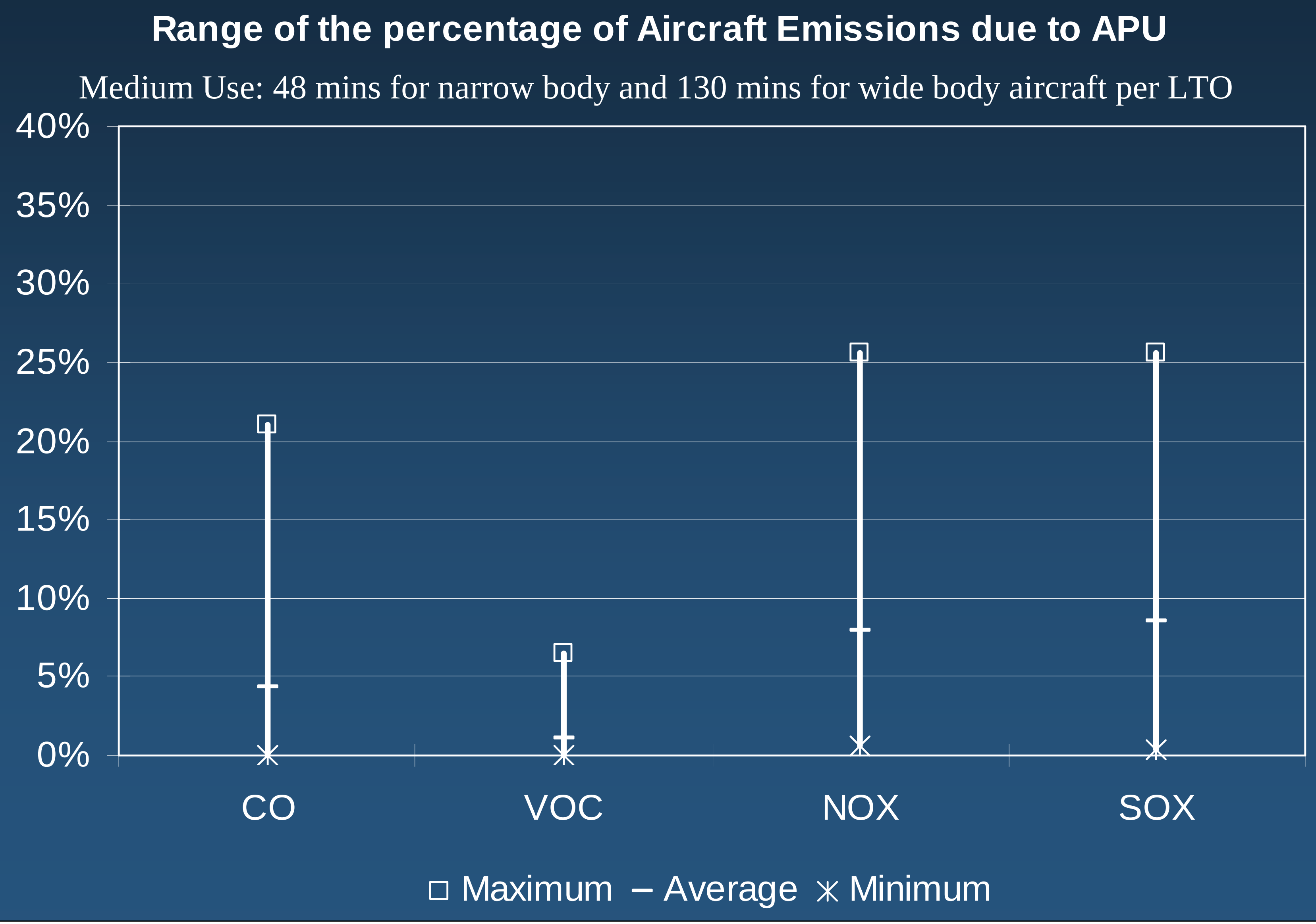


Auxiliary Power Unit (APU) Survey

- APU Usage is not reported
- Depends on the availability of powered gates
- Usage ultimately rests with the pilot
- Interviewed carriers to better model usage
  - Proprietary carrier specific data
    - departure preparations
    - departure taxi
    - arrival taxi
    - gate arrival

Minutes of APU Usage per LTO					
Narrow Body			Wide Body		
Lower	Medium	Upper	Lower	Medium	Upper
31	48	65	96	130	163

APU Effects – Medium Minutes of Use (325 Airports)



Emissions Results

- Aggregated to airport emissions by month and mode
  - Mode can be allocated to height for health impact analysis
- Reported Pollutants:
  - Carbon Monoxide (CO)
  - Nitrogen Oxides (NO_x)
  - Sulfur Oxides (SO_x)
  - Volatile Organic Compounds (VOC)
  - Non-Methane Hydrocarbons (NHMC)
  - Particulate Matter <2.5μm ($PM_{2.5}$)
- Emissions aggregated for comparison to 2002 National Emissions Inventory [NEI] to measure aircraft's contribution to local air quality

Comparison to the NEI (325 airports)

Percentage of National Emissions Inventory Due to Aircraft by Area

- 3 areas have more than 10% of at least one of the estimated pollutants attributed to aircraft
- 2 areas have at least 10% of the areas estimated emissions for three pollutants
- Targeting initiatives may provide the most benefit where aviation has a stronger influence in local air quality

SO

- For NO_x, aircraft are the source of less than 1% of the total emissions for at least 77% of these areas
- For 94% of the total aircraft related PM2.5 is responsible for less than 1% total emissions

Aircraft Emissions Contribution (%)

Analysis 2:
Air Traffic Management's Effects

- Quantify maximum potential benefits of ground delay reduction
- Identify potential initiatives that address local air quality
- Demonstrate benefit of a specific initiative

Method for Measuring Potential Benefits of Delay Reduction

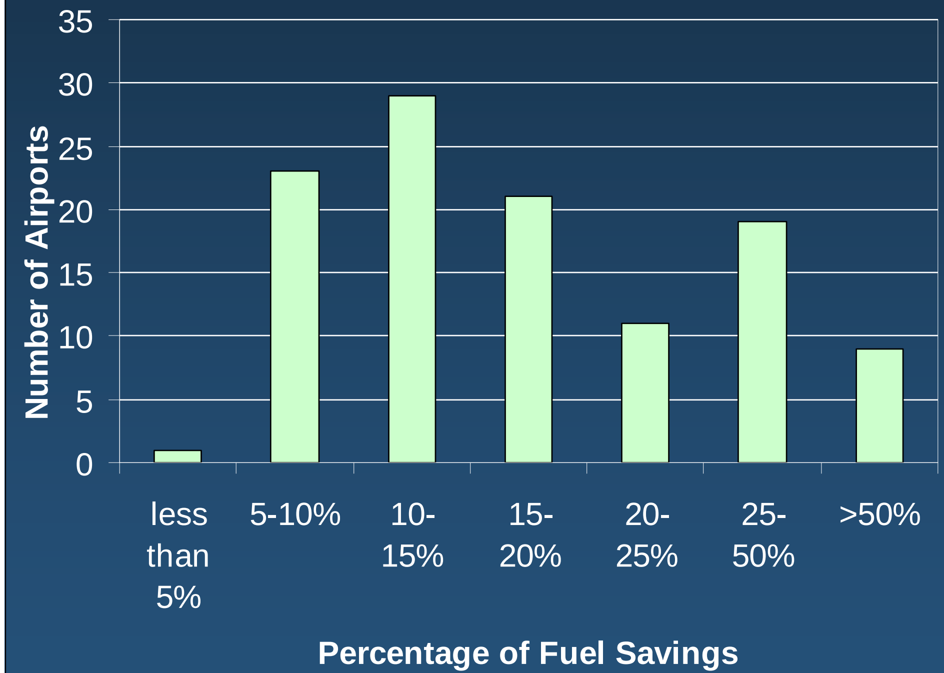
- Define the scope of emissions associated with delay:
  - Created unimpeded taxi times
  - Created a baseline inventory based on unimpeded taxi times
  - Compared the actual operations to the unimpeded operations to estimate the potential benefits of delay reduction

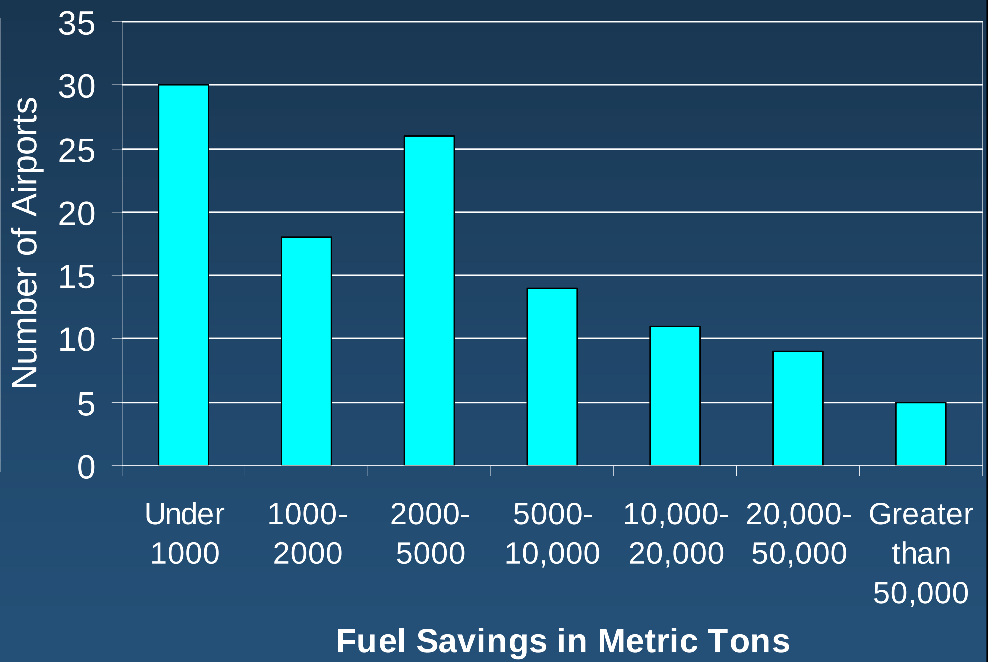
Airport Selection for Potential Delay Reduction

- Bureau of Transportation Statistics provides Out – Off – On – In (OOOI) times for certain air carrier flights
- Where OOOI information was not available, the baseline inventory assumed standard International Civil Aviation Organization (ICAO) taxi times of 26 minutes
- Only 113 airports in the original selection had OOOI information and were evaluated so that the benefit would be based on actual delay rather than default values

Potential Benefits from Delay Reduction (113 airports)

Fewer operations and less fuel used means a larger % change





However, in large airports with high delay and operations, small changes in percentages can equal large fuel changes in tons

Potential Benefits from Delay Reduction (113 airports)

Pollutant	Mass (metric tons) of Reduction	Percentage of Reduction
Carbon Monoxide (CO)	26702	21%
Non-Methane Hydrocarbons (NHMC)	3809	15%
Volatile Organic Compounds (VOC)	4088	15%
Nitrogen Oxides (NO_X)	4007	6%
Sulfur Oxides (SO_X)	1341	16%
Particulate Matter < 2.5 µm ($PM_{2.5}$)	113	13%

On the ground, aircraft tend to use a low power setting which influences CO emissions more than other pollutants

Fuel Burn Mitigation Initiatives

- Identified 24 initiatives in these broad categories:
  - New and Extended Runways
  - Schedule De-Peaking
  - Integrated Weather Technology
  - Improved Traffic Flow Collaboration
  - Filling Gaps in Arrival and Departure Streams
  - New Arrival and Departure Routes
  - New Approach Procedures
  - Reduced Separation Standards
  - Improved Surface Efficiency

Initiative Selection

- Six initiatives are part of the Congressional report
  - Airspace Flow Program (Boston Logan International Airport demonstrated for this paper)
  - Continuous Descent Arrivals
  - Schedule De-peaking
  - RNAV/RNP Arrivals and Departures Procedures
  - New and Extended Runways
  - Airspace Redesign

Conclusions

- Aircraft contribute a small percentage (less than 1%) of emissions to local air quality at current aviation activity levels
- Aviation could become a more significant proportion of emissions in the future
- Reducing ground delays can lead to potential reduction of 10-25% in LTO fuel burn and emissions
- Mitigation of ground / terminal area delays has a positive change on local air quality
  - aviation initiatives alone are unlikely to resolve poor air quality

Questions?

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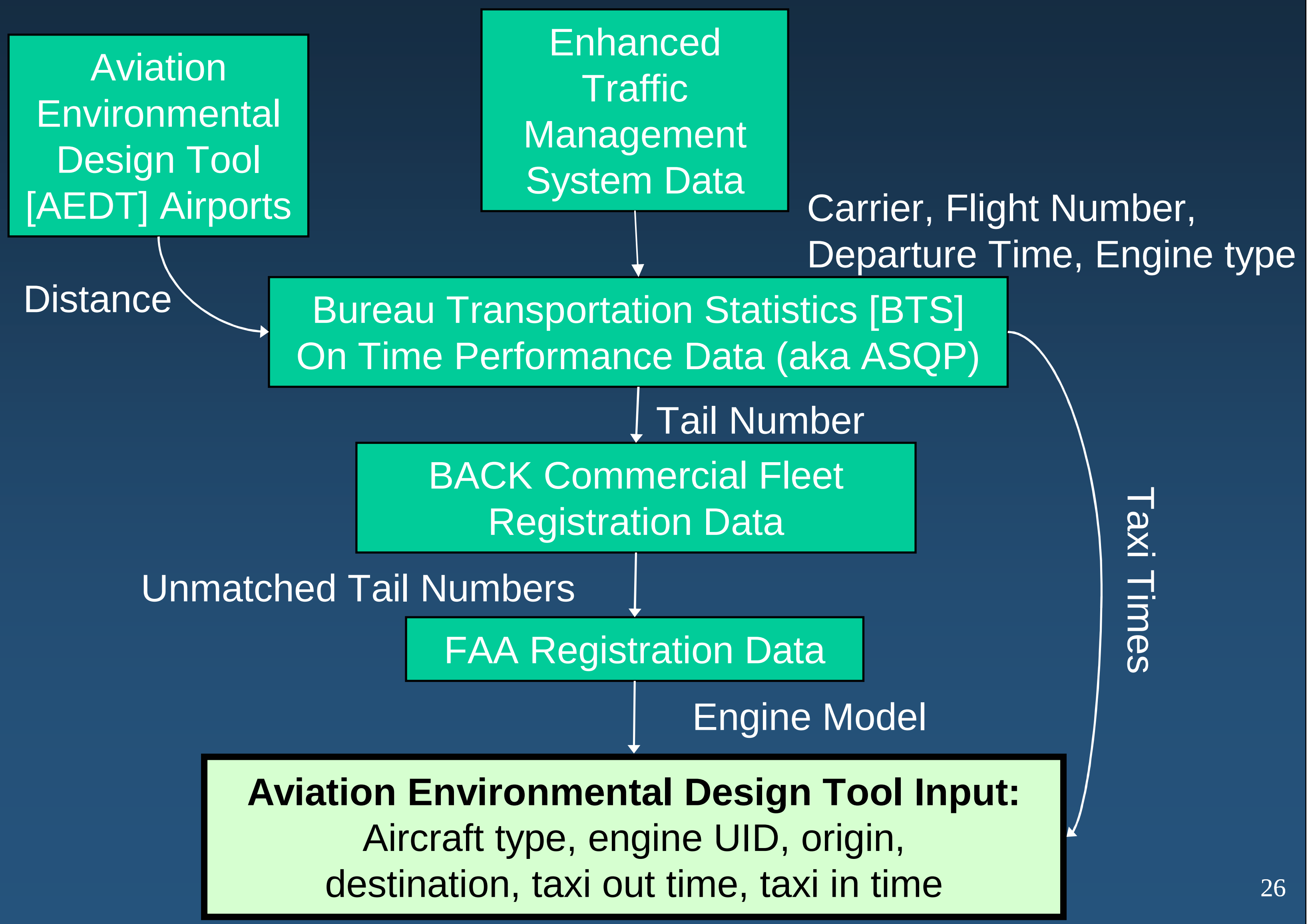
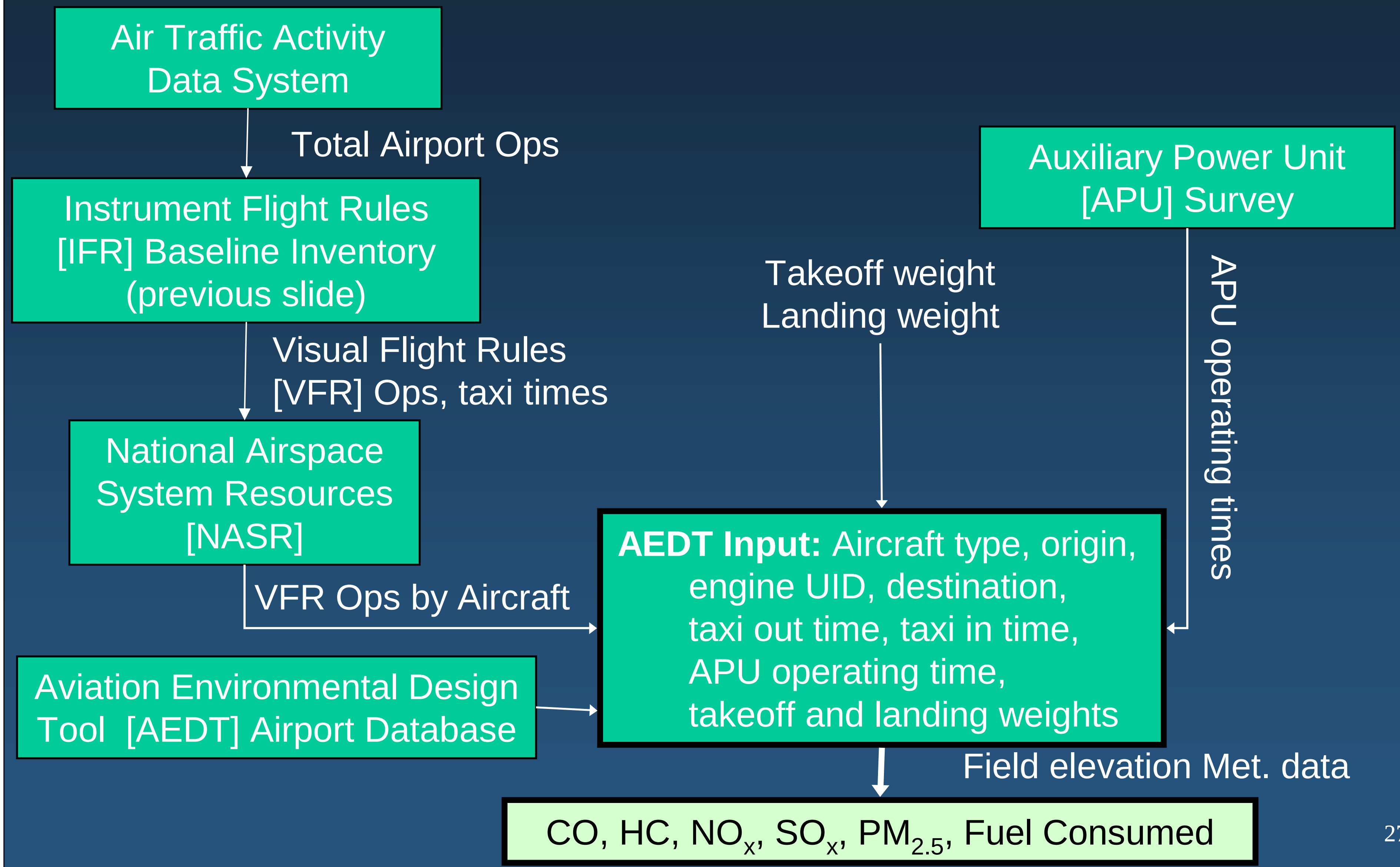
Backup slides

Instrumental Flight Rules [IFR] Operational Baseline

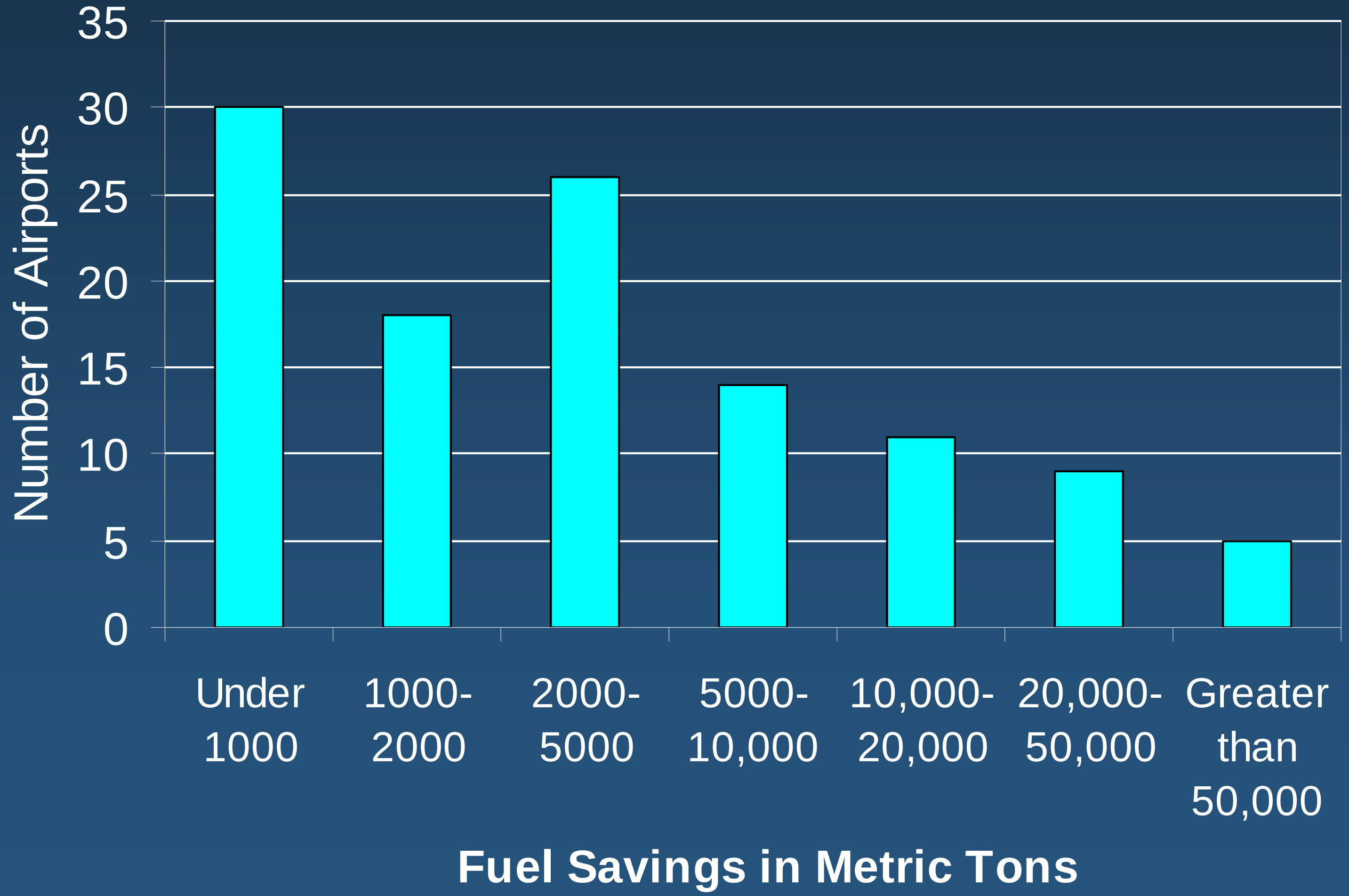


All Operations Baseline



Potential Benefits from Delay Reduction (113 airports)

- Large airports with high delay and operations, small changes in percentages can equal large fuel changes in tons



Airspace Flow Program Overview

- **Ground Delay Programs** delay flights destined for the affected airport based on the acceptance rate of the airport regardless of the en-route route

- **Airspace Flow Programs** only delay flights that would use the affected airspace
  - Provides more equitable delays at affected airports
  - Reduces taxi-out times at affected airports

Airspace Flow Program Sample Results

- Compared to the Ground Delay Program, the Airspace Flow Program would have reduced NO_x by almost 4% and fuel could have been saved by up to 10% over the course of five hours.

	Mass (Kg) of Reduction	Percentage of Reduction
Carbon Monoxide (CO)	204	14%
Non-Methane Hydrocarbons (NHMC)	34	8%
Volatile Organic Compounds (VOC)	36	8%
Nitrogen Oxides (NO_X)	35	4%
Sulfur Oxides (SO_X)	11	10%
Particulate Matter < 2.5 µ*m* (*$PM_{2.5}$*)	1	8%
Fuel	8021	10%