Session III: Technology & Operations: AVIATION ENVIRONMENTAL IMPACTS

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Aviation Environmental Challenges

Destination Green

NOISE | AIR QUALITY | WATER QUALITY | ENERGY | GLOBAL CLIMATE

- Aviation impacts community noise, air quality, water quality, energy usage, and climate change
- Environmental impacts from aviation emissions could pose a critical constraint on capacity growth

Aviation Environmental Impacts

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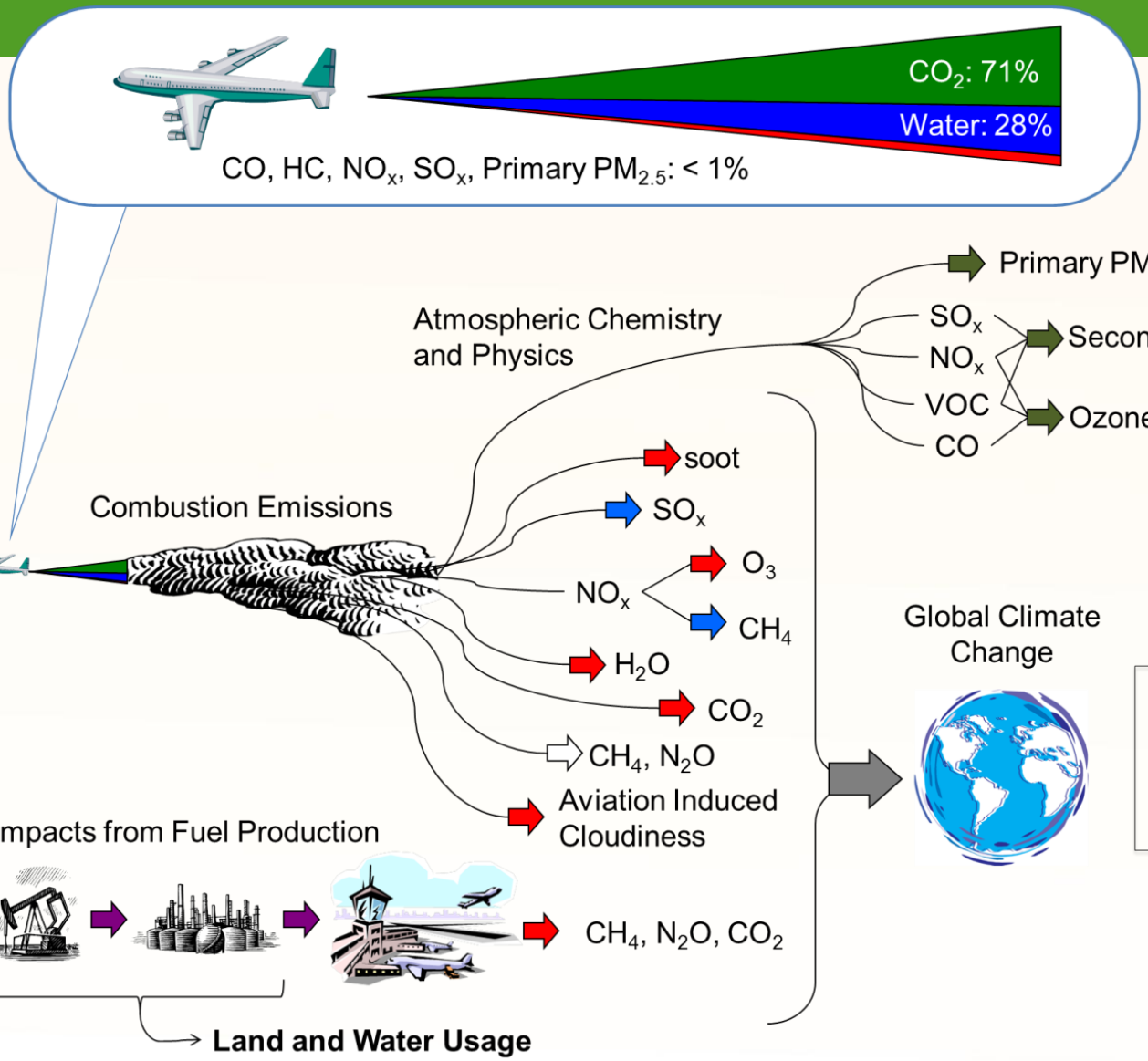

Impacts of Aircraft Noise

Physical

- Annoyance (e.g. speech and activity interference)
- Sleep disturbance
- Interference with school learning and academic achievement
- Potential health effects

Monetary

- Housing value loss
- Potential health costs

Source: Map – ESRI, Noise Contour – FAA & Wyle

Impacts of Emissions on Surface Air Quality

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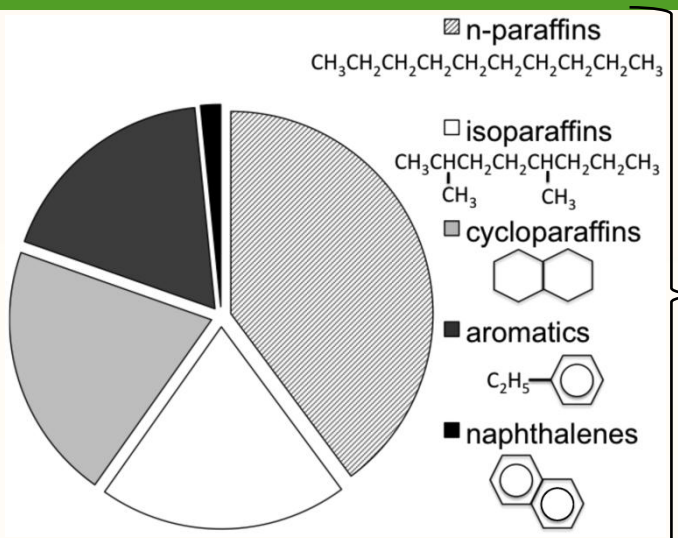
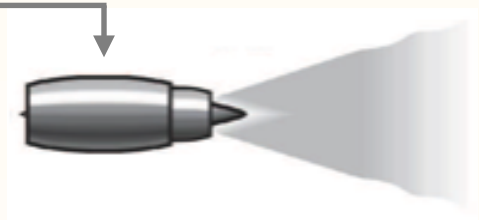


Weighted Mean Fuel Sulfur Content (PPM)		
	2006	2007
US East	446	321
US Gulf	858	800
US West	240	395
Nationwide	709	677

Fuel composition and engine design determine emissions

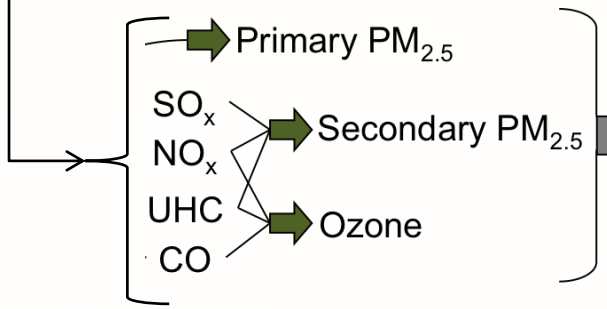
Fuel: $C_nH_m + S$

Air: $N_2 + O_2$



Tank-to-Wake Actual Combustion Emissions

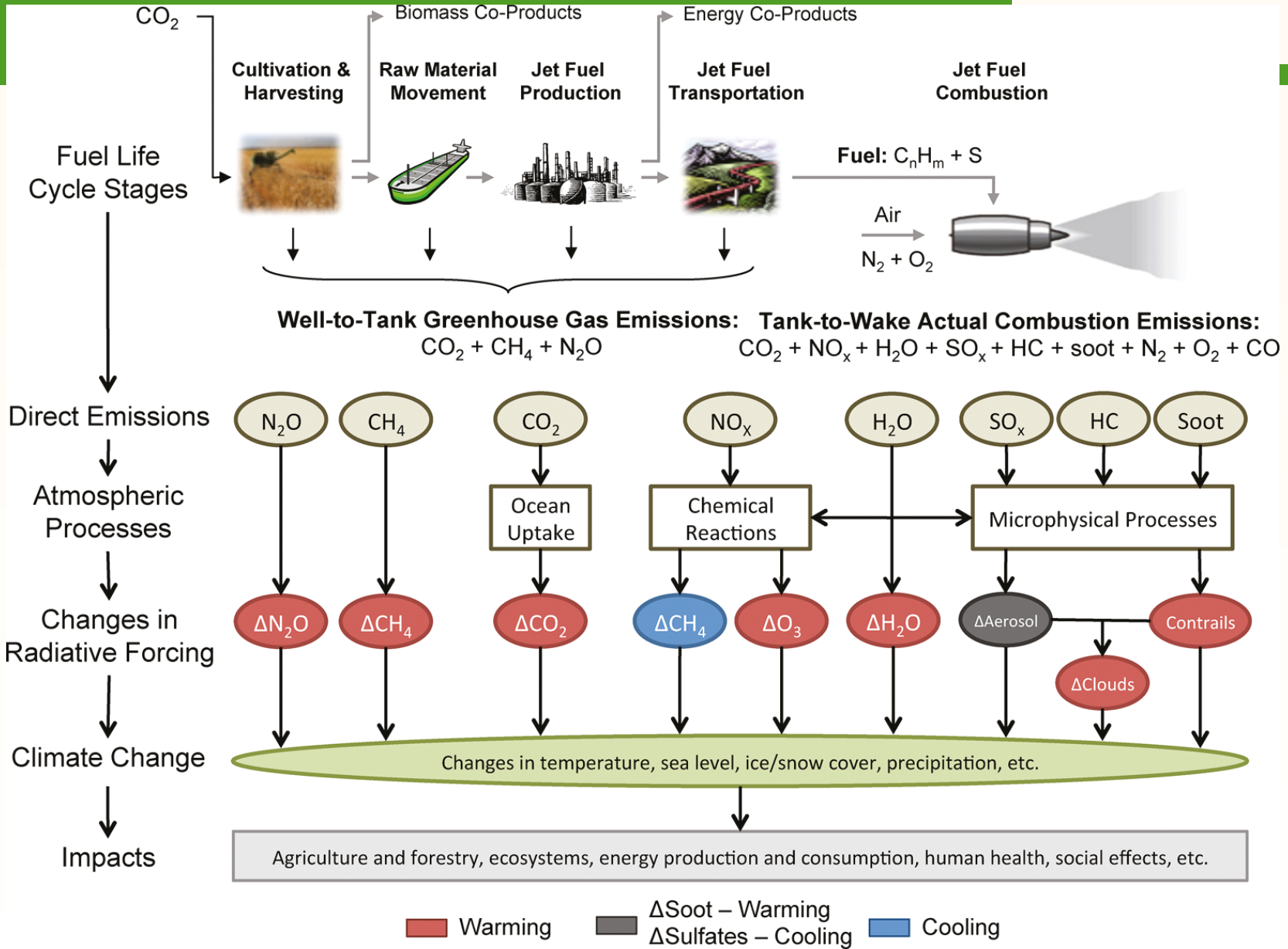
$CO_2 + H_2O + NO_X + SO_X + soot + CO + HC + N_2 + O_2$



Population Exposure and Health Impacts

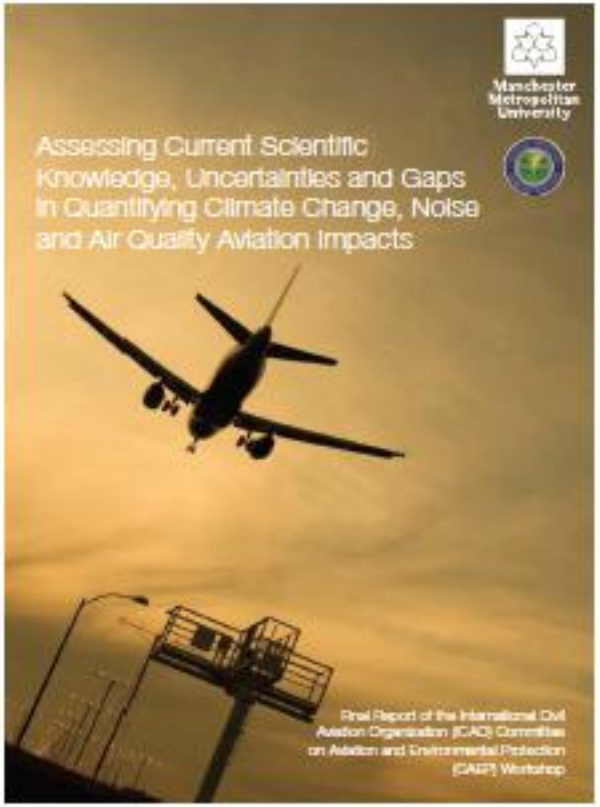
Atmospheric transformation, dispersion and removal determine pollutant concentration

Climate
Impacts of Aircraft Emissions

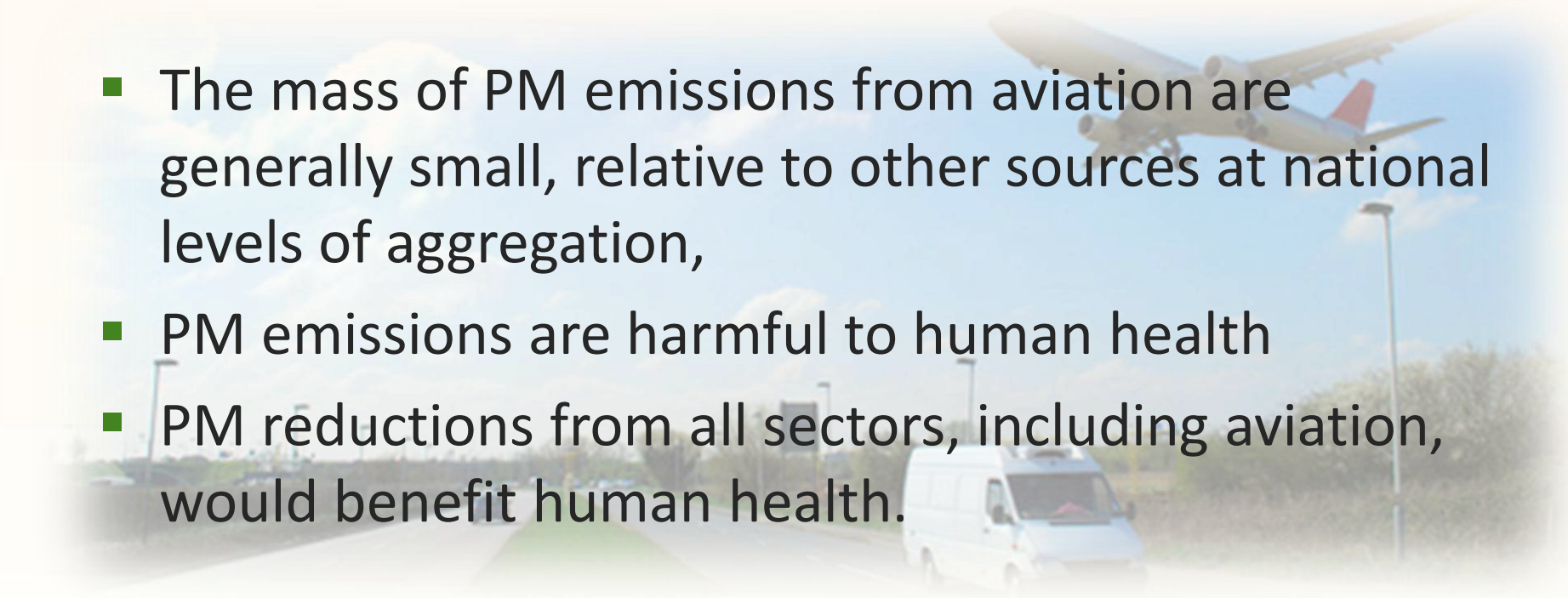


ICAO/CAEP
Impacts and Science Group

- CAEP/7 – proposal for impacts workshop
- Workshop, Montreal, Oct 2007
- Ad hoc group developed a strategy for taking forward recommendations of workshop
- CAEP/8 – ISG born
- CAEP/9 – first delivery of white papers air quality and climate impacts
- CAEP/10 – expand efforts to noise impacts



Consensus View of ISG on Particulate Matter emissions



- The mass of PM emissions from aviation are generally small, relative to other sources at national levels of aggregation,
- PM emissions are harmful to human health
- PM reductions from all sectors, including aviation, would benefit human health.

Consensus View of ISG on CO_2 emissions

- A reduction of global CO_2 emissions is required by approximately 2020 in order to keep global mean surface temperatures below a 2 degree increase (over pre-industrial levels)
- The radiative forcing of aviation CO_2 emissions is the best understood climate impact of aviation.
- Aviation CO_2 emissions are well quantified
- A reduction of aviation CO_2 emissions can contribute toward the '2° C goal'

Consensus View of ISG on non-CO_2 emissions

- Aviation has potentially significant non-CO_2 effects
- These non-CO_2 effects individually have both positive (warming) and negative (cooling) radiative forcing (RF) effects but the overall sum of RF effects including CO_2, is positive
- Non-CO_2 RF effects still have greater uncertainties over their magnitude than those of CO_2
- Given these uncertainties, it is unclear what action may be taken to address them at this time without risking unintended consequences and further research is needed to inform policy and regulatory action

Mitigating Impacts

U.S. Approach to Aviation Environmental Impacts Mitigation

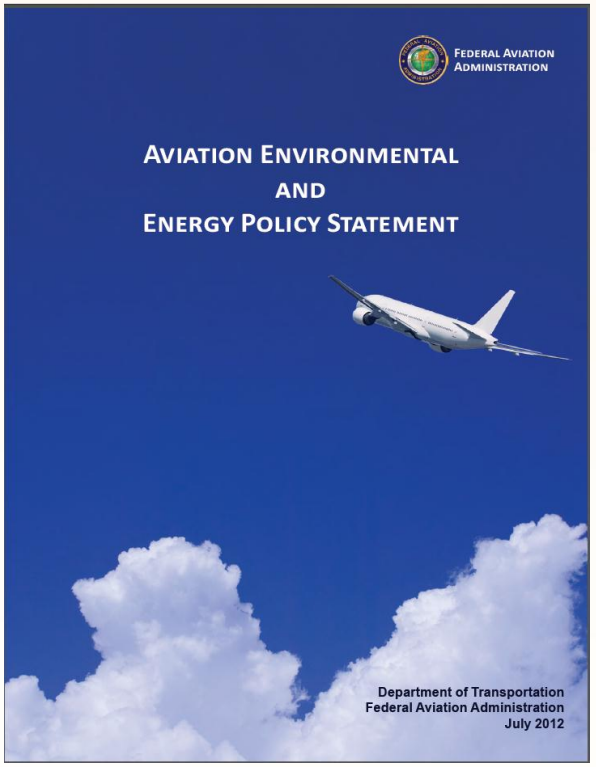
P1: Improved Scientific Knowledge and Integrated Modeling

P2: New Aircraft Technologies

P3: Sustainable Alternative Aviation Fuels

P4: Air Traffic Management Modernization and Operational Improvements

P5: Policies, Environmental Standards, and Market Based Measures



Environmental protection that allows sustained aviation growth

Reducing Aviation's Environmental Impacts

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Pillars → / *Environmental Goals* ↓	P1 Scientific Knowledge	P1 Integrated Modeling	P2 Aircraft Technologies	P3 Alt Jet Fuel	P4 ATM Mod & Ops Improvement	P5 Policy Measures
NOISE: Reduce significant noise impact	X	X	X		X	X
AIR QUALITY: Reduce significant air quality impact	X	X	X	X	X	X
ENERGY: Improve NAS energy efficiency	X	X	X	X	X	X
ENERGY: Develop sustainable alternative fuels	X	X		X		X
CLIMATE: Reduce GHG emissions and their impacts	X	X	X	X	X	X

Technology & Operations Role Mitigating Aviation Environmental Impacts

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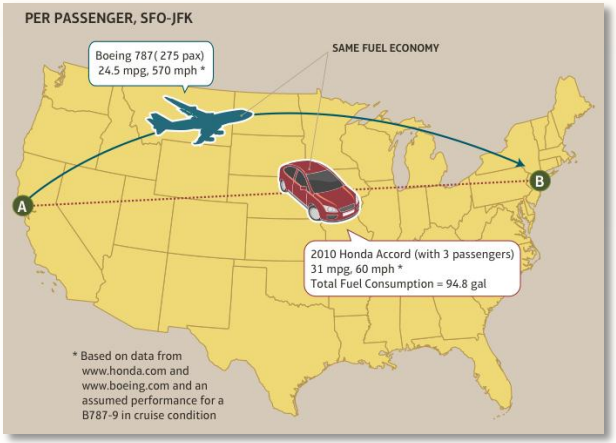
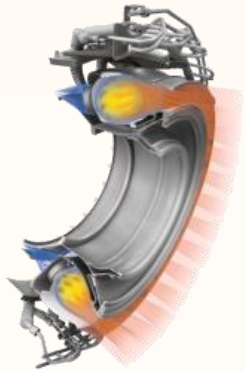
- Significant environmental gains: continuous reductions in absolute number of people exposed to objectionable noise, significant reductions in NO_x, other harmful emissions
- Over the past 30+ years, fuel burn improvements of approx. 70%+ achieved through aircraft technologies and operational improvements
- Significant reductions in fuel burn and CO_2 emissions continue - fully loaded B787 SFO-JFK yields similar fuel efficiency to a 2010 Honda Accord (with three passengers) at almost 10 x the speed



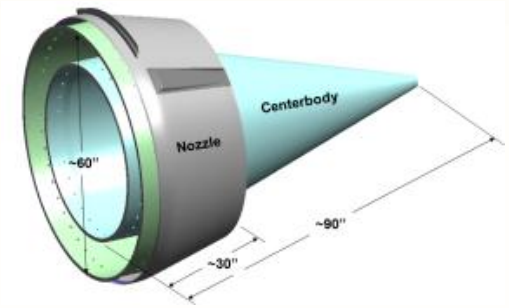
Technology Solution Example
CLEEN

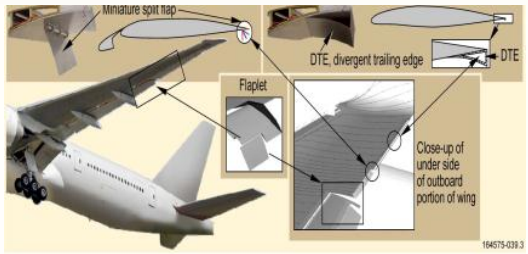
Continuous Lower Energy, Emissions and Noise

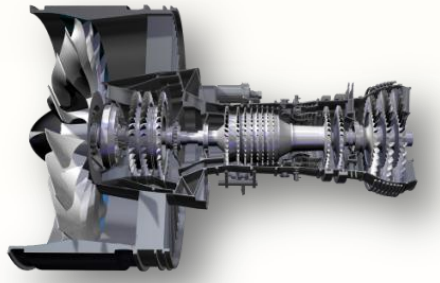
- 5 year effort to accelerate technology development and commercialization with 50 percent cost share
  - FAA budget: US$125 million
  - Industry budget: US$125 million+



- Mixed portfolio of technologies
  - *Engine*: GE, Honeywell, Pratt & Whitney, Rolls-Royce
  - *Aircraft*: Boeing
  - *Alternative Fuels*: Boeing, Honeywell, Pratt & Whitney, Rolls-Royce







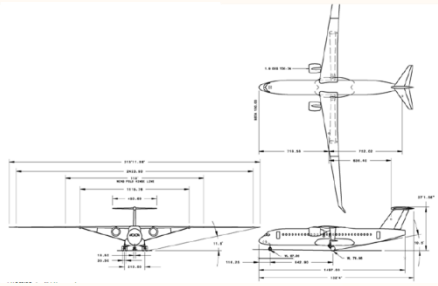
Boeing-FAA ecoDemonstrator

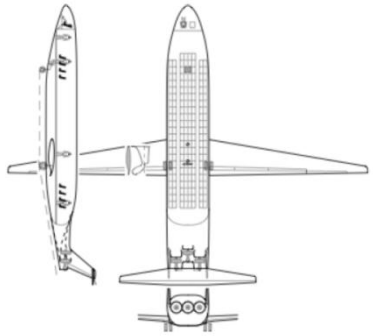
- Completed testing of 737 in Glasgow, Montana in August 2012
- CLEEN funded adaptive wing trailing edges
- Better aerodynamic performance, reduced fuel burn, emissions and noise

Photo: Boeing

Novel Technology Ideas

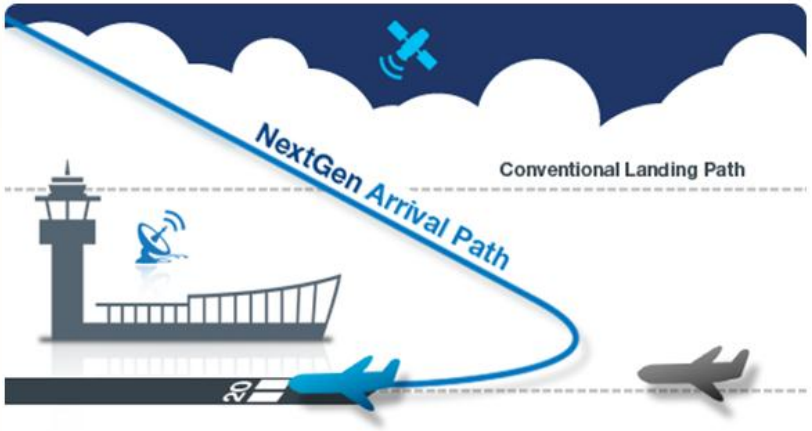
- Integrating engine, airframe and operations could lead to a step-change in environmental performance
- Some Examples:
  - Analysis of Mission Specification
  - NASA Environmentally Responsible Aviation and N+3 projects
  - Silent Aircraft Initiative
- Reduced cruise Mach number with unswept wings
- Change to configuration to allow larger bypass ratio engines
- Lifting fuselage
- Engines flush-mounted at aft fuselage with boundary layer ingestion





Synergies/Interdependencies Among Mitigation Options

- Via both technology and operational improvement results in less fuel needed for a given aviation demand level and
- Increases alternative fuel viability as less alternative fuel feedstock will have to be grown
- Operational procedures can mitigate both noise and emissions impacts



Closing Observations

- To mitigate impacts and set goals need to continuously assess challenges, trends, and interdependencies in a rigorous manner
- Pursue goals through a combination of air traffic innovation, fleet modernization & alternative fuels and use policy and market based measures as gap-fillers as necessary
- Continuously check tradeoffs to understand cost/benefit of various solutions sets and use best science available to inform decisions