

FAA Aviation Emissions Research: Characterization, Impacts, Mitigation and Challenges

Presented To: ECATS 3rd Conference

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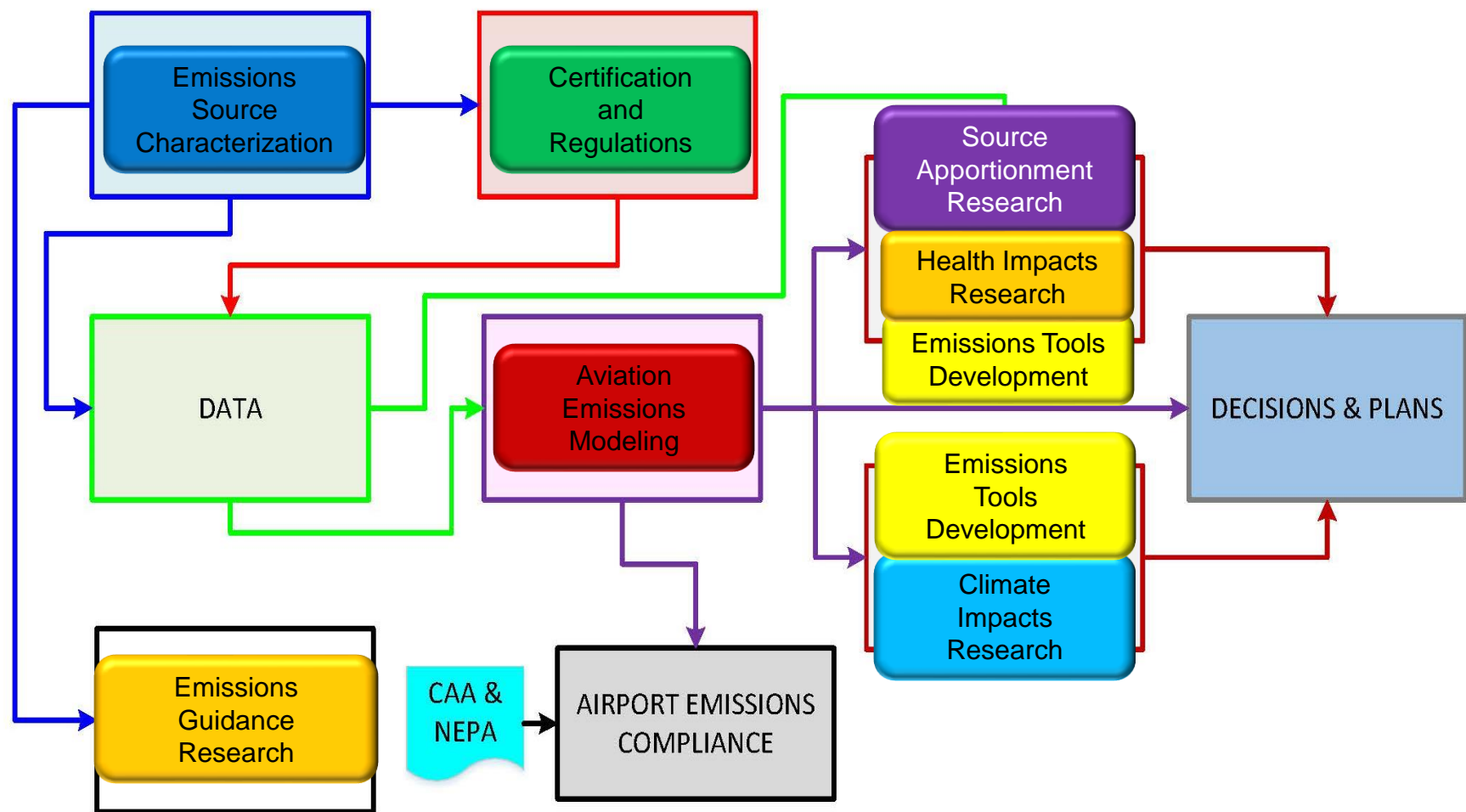
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- **Emissions Research Roadmap**
- **Emissions Measurements**
- **Air Quality Health Impacts**
- **Impact Analysis Tools**
- **Technology Maturation**
- **Outreach & Summary**



































Emissions Research Roadmap



EMISSIONS RESEARCH ROADMAP ELEMENTS – CURRENT AND FUTURE

LEGEND

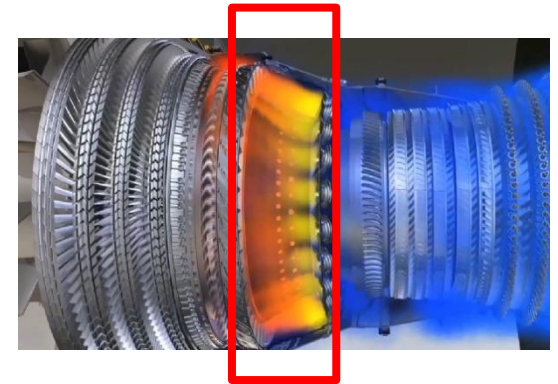
EMISSIONS MEASUREMENT	Emissions Characterization, Corrections Development, Fuel Composition Effects, Emissions from Advanced Technology, Rig Tests, Engine Tests, Collaboration with CLEEN, NASA, Industry and International Partners	  	
AVIATION SPECIFIC DISPERSION MODEL	An Aviation specific dispersion model for demonstrating compliance to regulations	   	
MONITORING AND SOURCE APPORTIONMENT	Comprehensive measurements in and around airports for source apportionment and validation updated or new compliance models.	   	
VOLATILE PM MODELING	New methodology to model volatile particulate matter in the vicinity of airports	  	
NVPM MASS CALIBRATION	Maturing the charged particle mass analyzer (CPMA) methodology for in-line and in situ calibration of nvPM mass instruments	 	
IMPACTS OF HIGH ALTITUDE EMISSIONS	Impacts of various sources of emissions in the upper atmosphere including supersonic transport, high altitude long endurance UAVs, rocket emissions	  	
SUPERSONICS	Technology, Forecasts and Emissions in collaboration with Noise/ CLEEN Divisions	  	
CONTRAIL PHYSICS & MITIGATION	Improved understanding of contrail formation and real-time predictability of the radiative forcing of contrails as affected by technology, fuels and operations. Mitigation of Contrails through technology, fuels and operations (Avoidance)	 	

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Emissions Measurements

- **Development of New International Engine Emissions Standards**
 - CAEP/10 non-volatile Particulate Matter (nvPM) Mass Concentration Standard (2016)
 - CAEP/11 Landing Take-Off nvPM mass and number standards (2019)
- **Current Research**
 - Standard Day (i.e. Ambient Conditions) Corrections
 - The role of Fuel Composition on nvPM Emissions
- **Inform Cruise nvPM and NOx Emissions Modeling**
- **Improve calibration methods of certification instruments**



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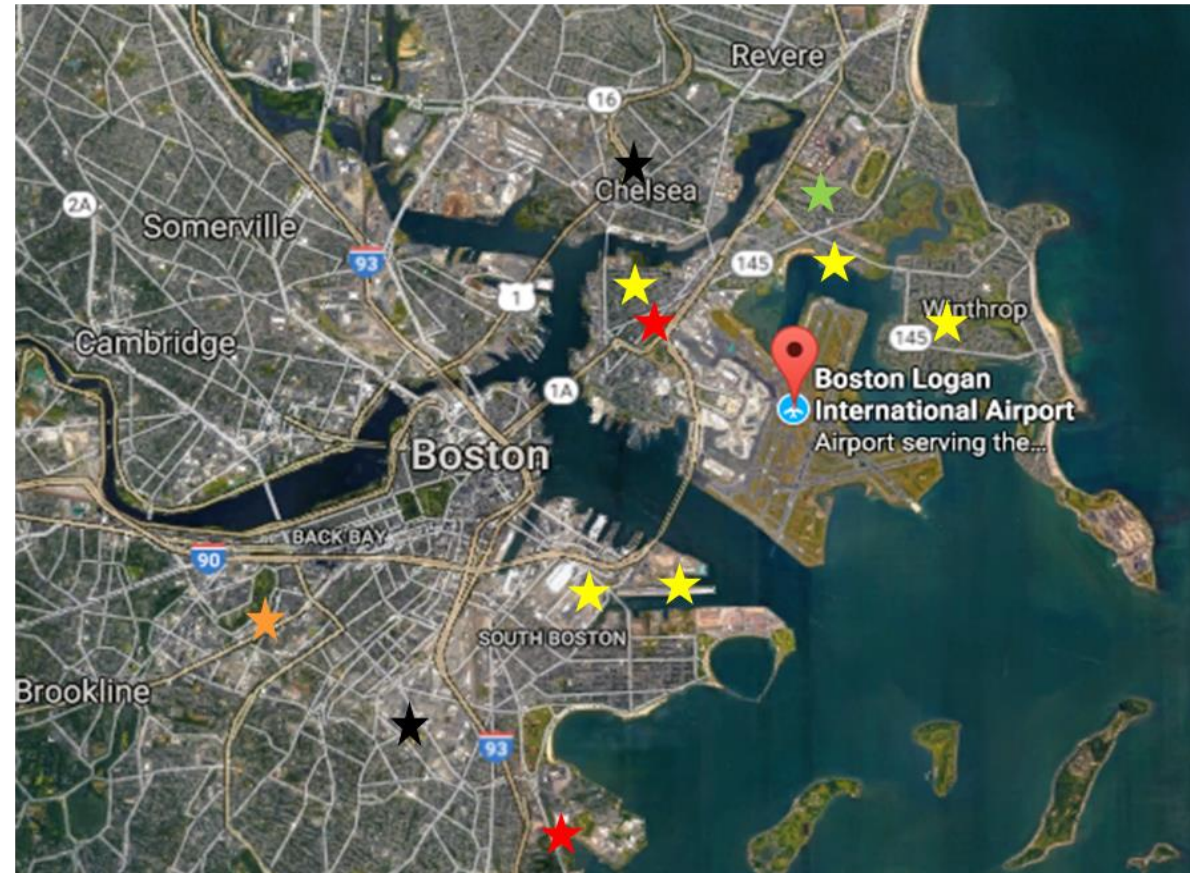
Air Quality Health Impacts: Monitoring and Source Apportionment

Site Selection

CURRENT SITES

- ★ Tufts long term PNC site
 - ★ Harvard long term Monitor site
 - ★ BU long term PNC site
 - ★ New monitor site (preliminary agreement)
 - ★ Potential monitoring site (seeking authorization)
- Sites chosen to be > 200 m from major roadways.
 - Near population areas
 - At varying distances from multiple runways based in part on projected wind direction and runway usage

PNC: Particle Number Concentration



- ASCENT Project 18: Boston University, Tufts University
 - Both fixed and mobile monitoring platforms
 - Ongoing



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Aviation Specific Dispersion Model Development

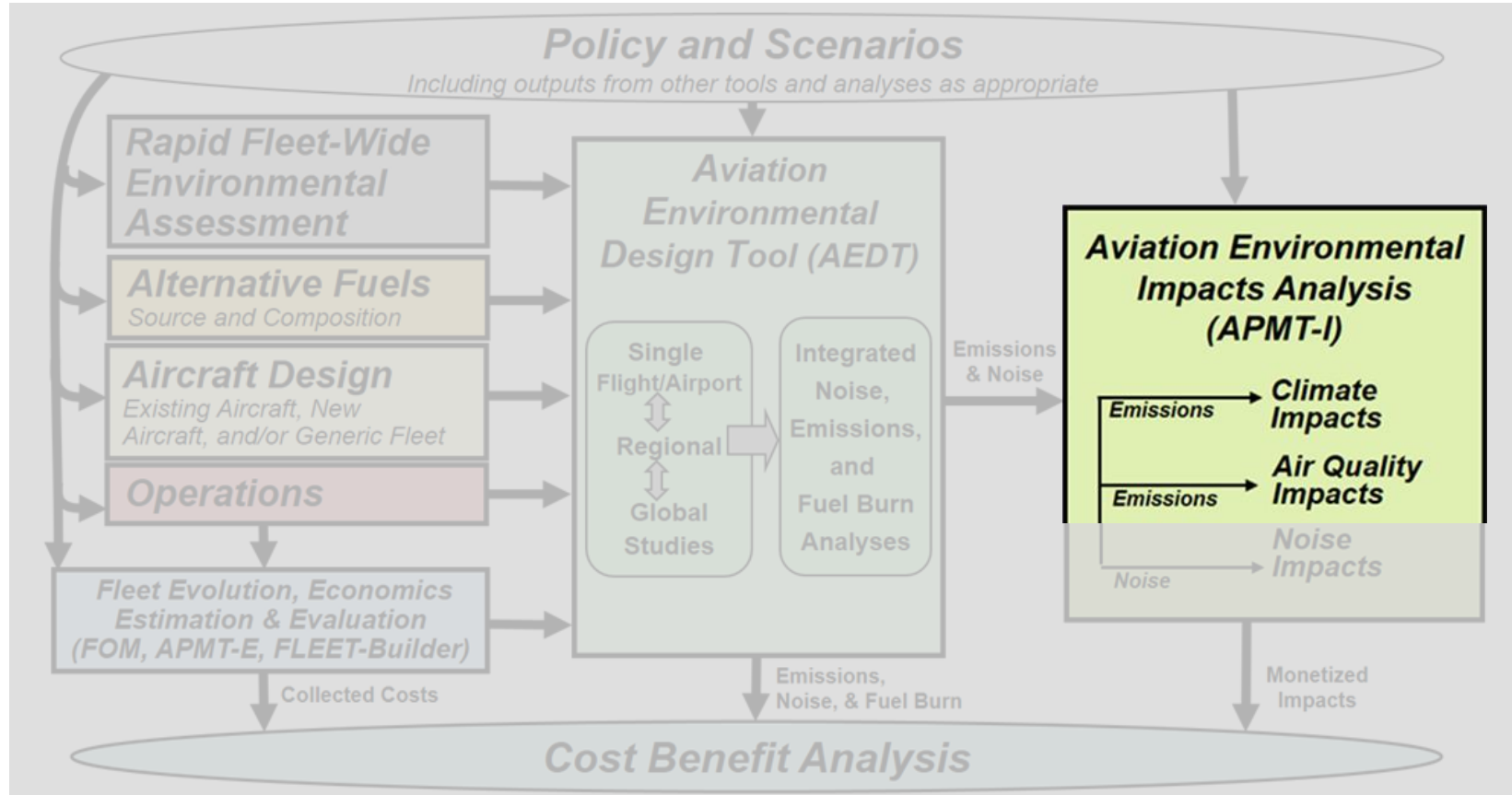
- **Challenge: Modeled Violation of National Ambient Air Quality Standard not Supported by Measurements**
- **Ongoing: Implementation of two different approaches for evaluation**
 - Gaussian Plume Model with chemically active Lagrangian Puff Component (ASCENT Project 19 University of North Carolina)
 - Lagrangian Particle Model (Janicke Consulting)
- **Evaluation Approach:**
 - Use existing model inputs and monitor data at LAX
 - Quantitatively compare the results with current AERMOD results
- **Expected Outcome: A more accurate approach to demonstrate airport air quality compliance**
 - Reflecting best science and algorithms

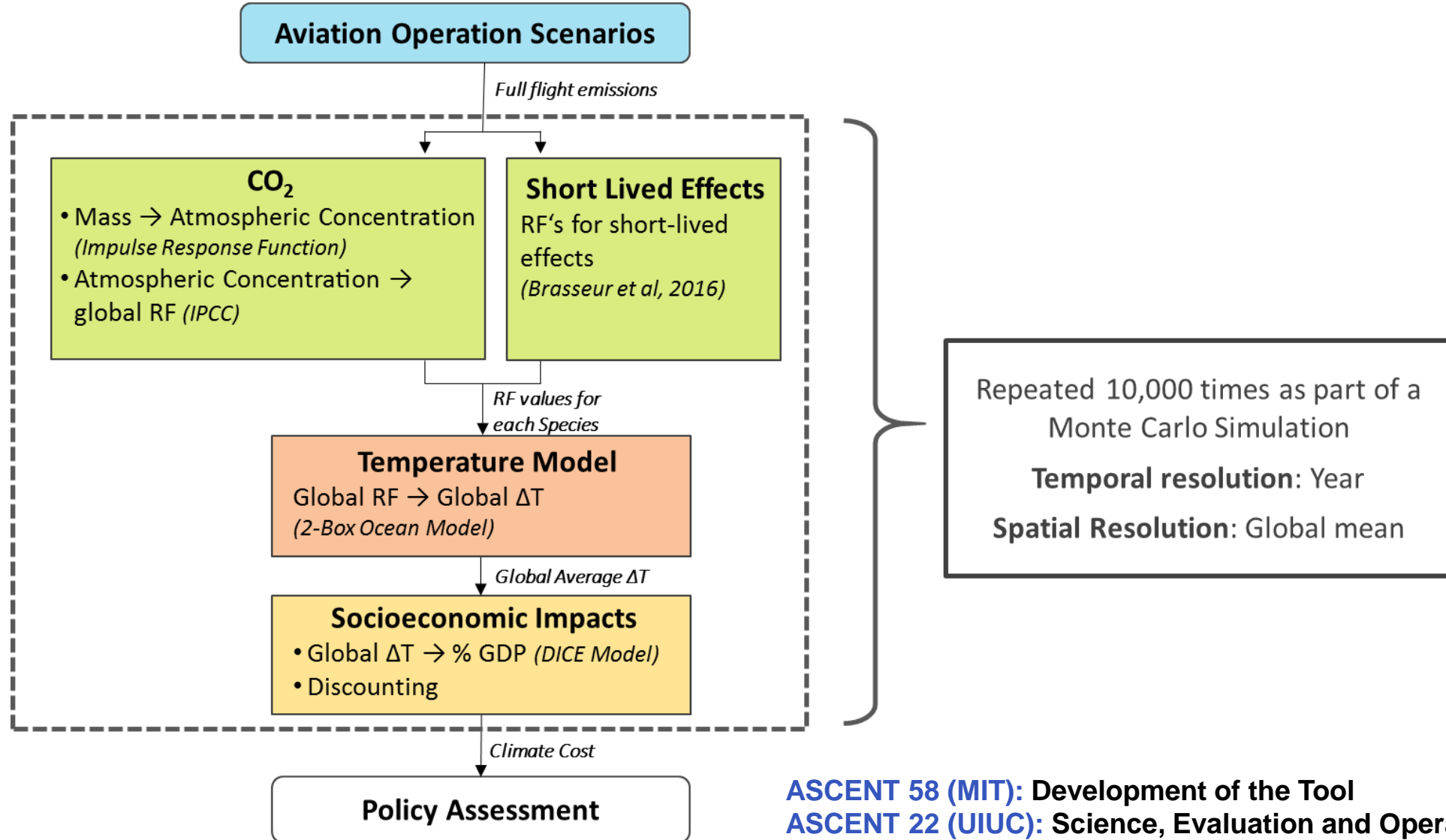


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The Aviation Environmental Tools Suite

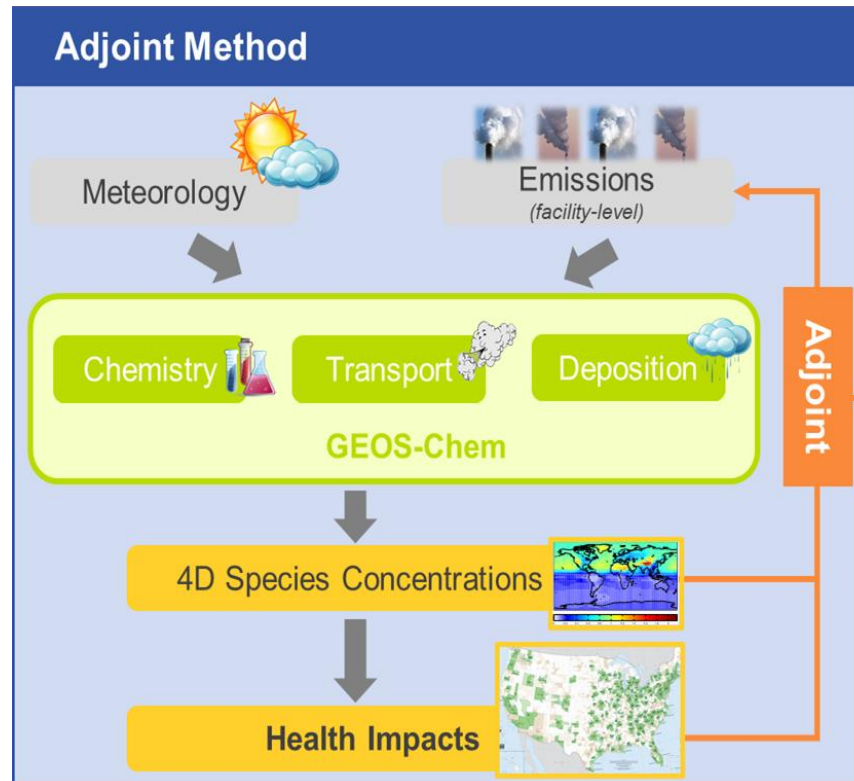




ASCENT 58 (MIT): Development of the Tool

ASCENT 22 (UIUC): Science, Evaluation and Operational Readiness





To quickly **assess a large number of aviation emission scenarios**, the sensitivities are applied to finely gridded aviation emissions using inner product multiplication:

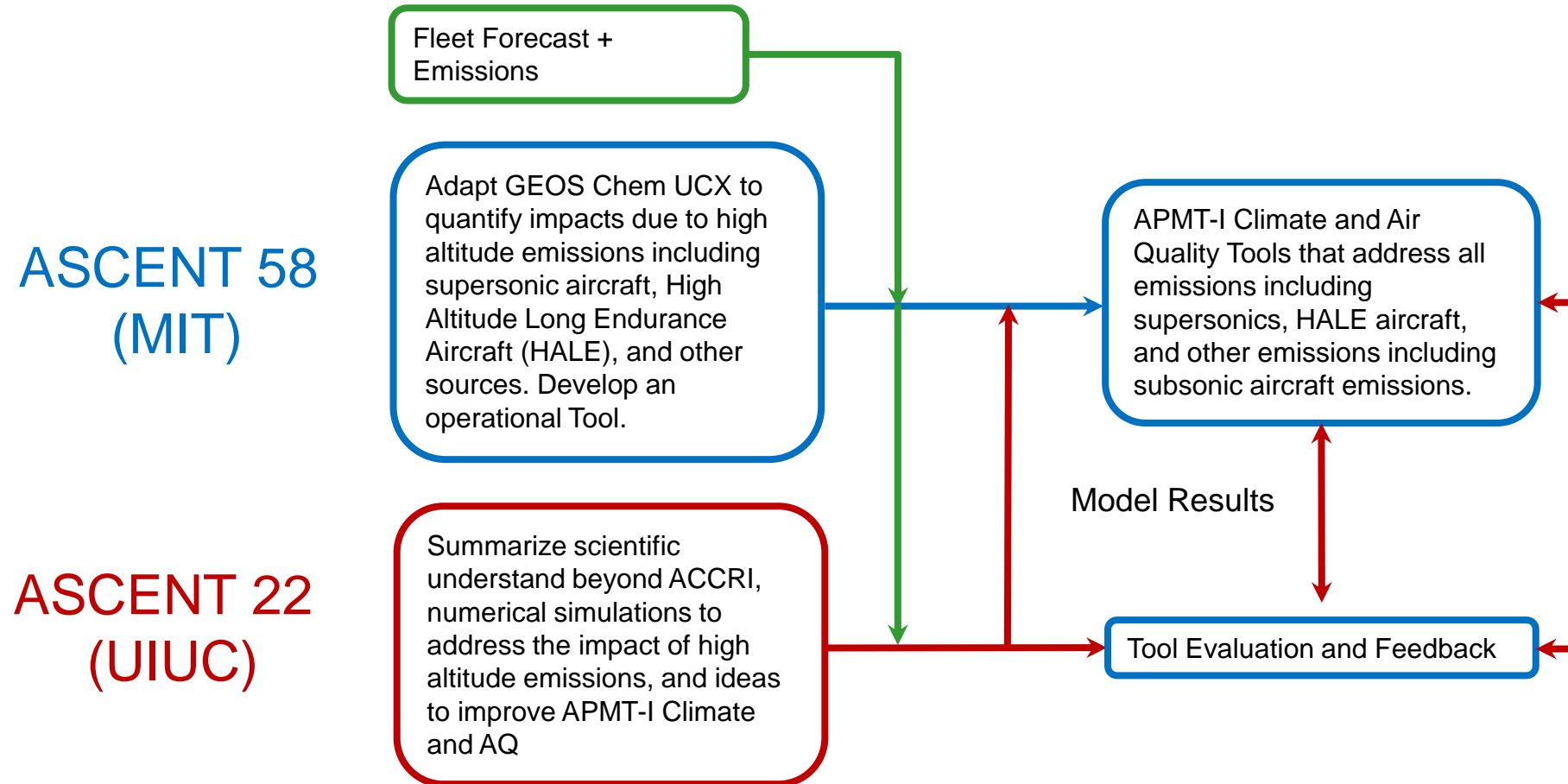
$$\frac{\partial J}{\partial E_w} : E_w = \text{Population exposure (PM}_{2.5}\text{/ozone) attributable to aviation emissions}$$

4D sensitivities (PM_{2.5}/ozone) 4D aviation emissions

ASCENT 58 (MIT): Development of the Tool



APMT-I Ongoing Research and Development



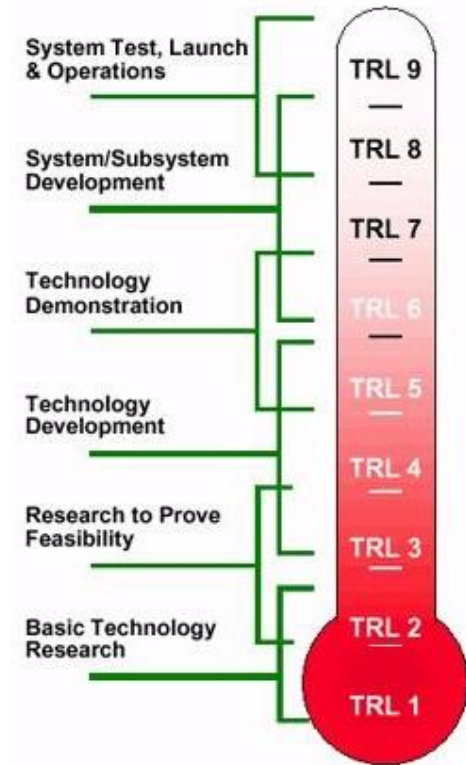
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CLEEN Program Overview



- FAA's principal environmental effort to accelerate development of new aircraft and engine technologies and advance the introduction of alternative jet fuels.
- Objective:
 - Mature previously conceived noise, emissions and fuel burn reduction technologies for civil airplanes from Technology Readiness Levels (TRL) of 3-5 to TRLs of 6-7 to enable industry to expedite introduction of these technologies into current and future aircraft and engines
 - Assess the benefits and advance the development and introduction of “drop-in” alternative jet fuels, including blends



CLEEN Program Overview

CLEEN Phase I (2010-2015)

- Industry partners: Boeing, General Electric, Honeywell, Pratt & Whitney, Rolls-Royce
- Federal Funding: \$125M (1:1 minimum cost share is required)



CLEEN Phase II (2015-2020)

- Industry partners: Aurora Flight Sciences, Boeing, Delta/MDS/America's Phenix, General Electric, Honeywell, Pratt & Whitney, Rohr/UTC Aerospace Systems, and Rolls-Royce
- Federal Funding: \$100M (1:1 minimum cost share is required)
- CLEEN II tech expected to be on a path for introduction into commercial aircraft by 2026

CLEEN Phase III (2020-2025) – To be awarded

CLEEN Fact Sheet

- https://www.faa.gov/news/fact_sheets/news_story.cfm?newsId=22534



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- The collage features several images related to aircraft engine technology:
- A 3D model of a commercial jet.
 - A cross-section of an engine core.
 - A 3D model of a turbine section.
 - A comparison of 'Uncoated' and 'Coated' turbine blades.
 - A 3D model of a turbine section with a red circle highlighting a specific area.
 - A close-up of 'Ceramic BOAS' (Bonded Oxide Adhesive System) on a turbine blade.
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Outreach: Aviation Emissions Characterization (AEC) Annual Meeting

Purpose:

- Communicate research findings and coordinate research among stakeholders (Domestic and International Government Agencies, Airports, Industry, Non-Governmental Organizations, etc.) interested in aviation emissions and their impacts.

Background and Activities:

- Started as National Particulate Matter Roadmap for Aviation
- 17th Annual Meeting held in 2020
- Primary forum: Annual Meeting
- Monthly Teleconferences with Coordinating Council
 - Share information on selected topics
 - Identify topics for in depth discussion for the Annual Meeting
- **18th Annual (virtual) Meeting Scheduled: May 25-27, 2021**



- **Comprehensive End to End Emissions Research Portfolio**
- **Research based on:**
 - Characterizing emissions of current and future engine technologies and fuels
 - Air Quality Health Impacts
 - Impacts Analysis Tools Development
 - Technology Maturation
- **Outreach through Annual AEC Roadmap Meeting**



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Online Materials



FAA Environment and Energy

- <http://www.faa.gov/go/environment>



Center of Excellence (COE) Program

- University research on alt jet fuels and environment
- <http://ascent.aero> and <http://partner.mit.edu/>



Continuous Lower Energy, Emissions and Noise (CLEEN)

- Reduce aircraft fuel burn, emissions and noise through technology & advance alternative jet fuels
- <http://www.faa.gov/go/cleen>



Commercial Aviation Alternative Fuels Initiative (CAAFI)

- Coalition that focuses the efforts of commercial aviation to engage the emerging alternative fuels industry
- <http://caafi.org>

