Emissions Research Portfolio Update

Office of Environment & Energy (AEE)

Presented to: REDAC E&E Subcommittee

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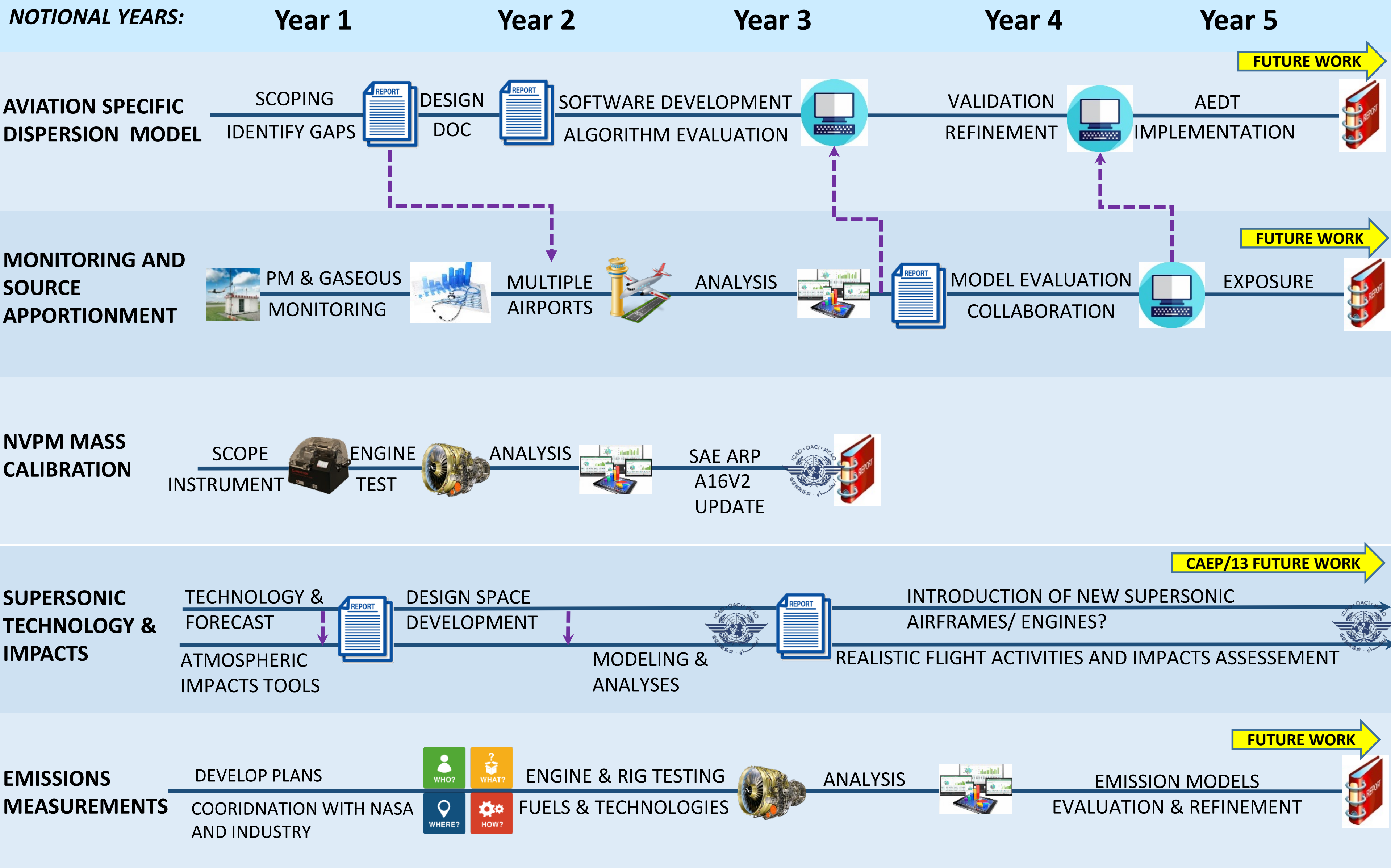
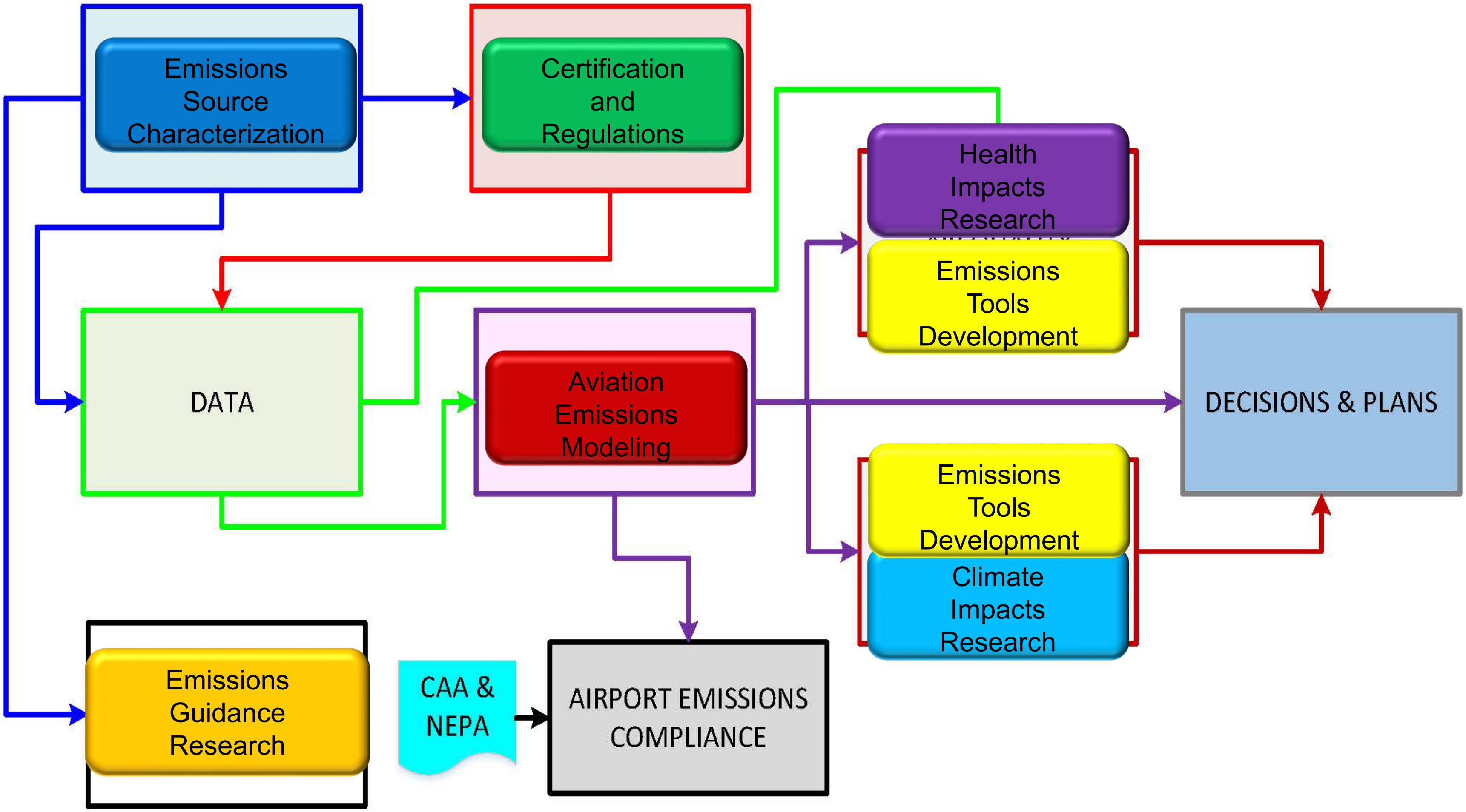
Outline

- Emissions Research Overview
- Select ASCENT Research Highlights
  - A2
  - A48
  - A19
  - A39
- Summary

HIGHLIGHTS OF AVIATION EMISSIONS RESEACH PLAN



Emissions Research Roadmap



Emissions Research Overview

ASCENT Project	Description	Emissions Roadmap
2*	nvPM Emissions Engine Measurements	
10#	Forecast Technology and Influence of Commercial SST	
18*	Health Effects of Aviation Emissions	
19#	AQ Dispersion Model Development	
~~20~~	~~Fast-time APMT-I AQ Model Development (Adjoint)~~	
~~21~~	~~Updates to APMT-I Climate Model~~	
22*	Independent Evaluation of APMT-I Climate Model	
39#	Removing Naphthalene from Jet-A	
47#	Clean-Sheet Supersonic Engine Evaluation	
48#	Engine nvPM Emissions Standard Setting Support	
58*	Improving Policy Analysis Tools to Evaluate Aircraft Operations in the Stratosphere (NEW)	

Health Impacts Research | Emissions Tools Development | Emissions Source Characterization | Climate Impacts Research | Certification and Regulations | Aviation Emissions Modeling

Funded
* Funding Pending

A2: Engine Emissions Measurements

Work Plan In Process:

- Follow-on to assess the impact of SAFs on nvPM Emissions
- Improve nvPM mass instrument calibration criteria
- Conduct combustor rig tests at Honeywell
  - Addresses nvPM ambient condition corrections for certification
  - Data collection for ground-to-cruise nvPM correlation and cruise-climb NOx modeling
    - Evaluate cruise modeling methods (supports work for ASCENT Project 48)
    - Feeds in to ASCENT Projects 20 & 58 on NOx and nvPM Impacts on the atmosphere and air quality.
  - Use of 2 additional alternative fuels (TBD) in combustor rig tests
- Inform emissions modeling of blended fuels

A48: Engine nvPM Emissions Standard Development and Modeling Research

Work Plan In Process:

- Develop nvPM and NOx cruise-climb modeling using data from ASCENT Project 2
  - Addressing a major gap critical for Impacts Modeling
- Analysis of reported nvPM emissions data and margins with respect to CAEP/11 nvPM LTO mass and number standards
- ICAO Doc 9889 updates – Airport Air Quality Manual
  - More accurate representation aircraft emissions
  - Home of FOA4 methodology with
    - SCOPE11 methodology for nvPM emissions estimates
    - Explore volatile PM portion of methodology

A19: AQ Dispersion Model Development

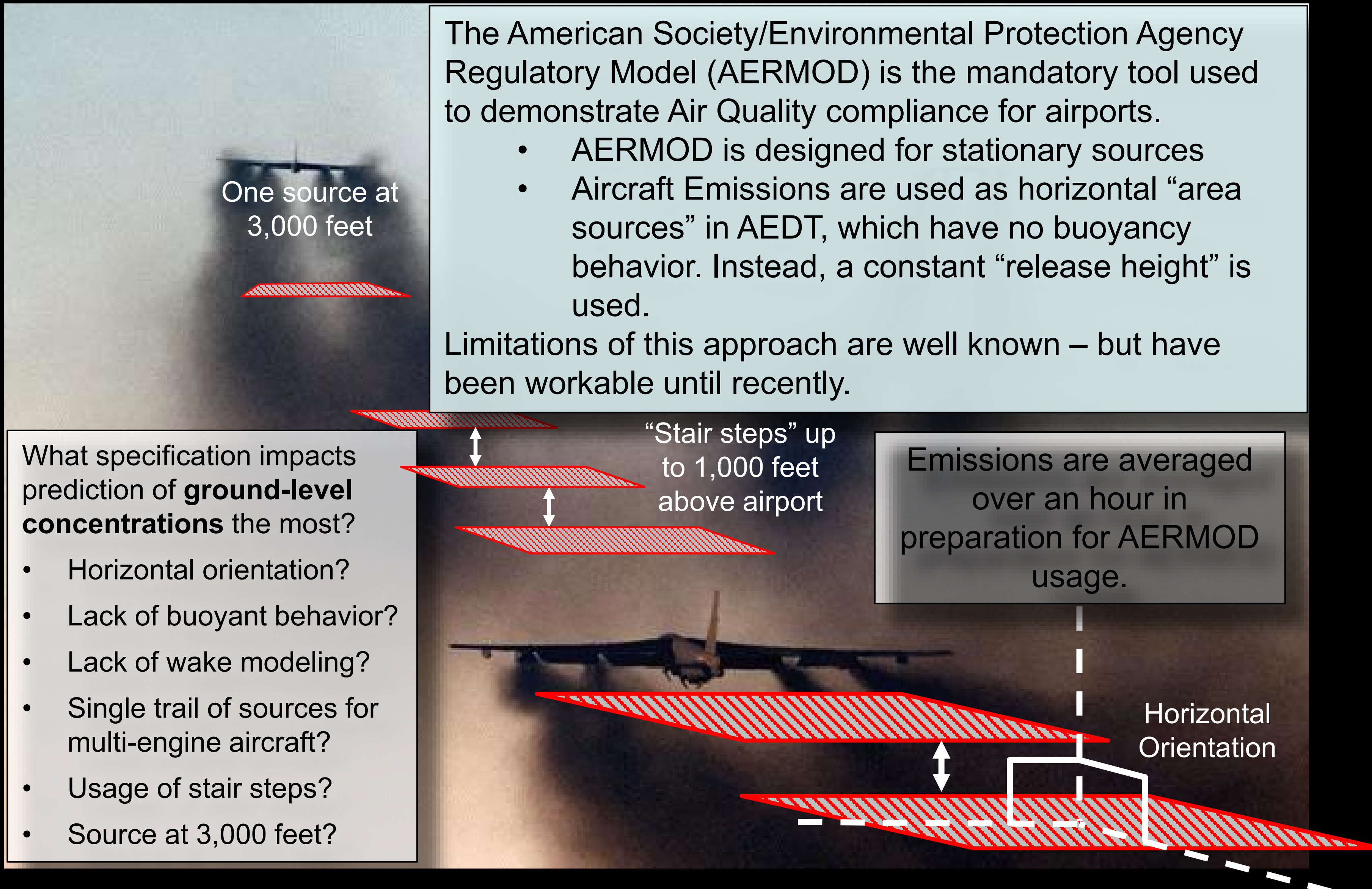
The American Society/Environmental Protection Agency Regulatory Model (AERMOD) is the mandatory tool used to demonstrate Air Quality compliance for airports.

- AERMOD is designed for stationary sources
- Aircraft Emissions are used as horizontal “area sources” in AEDT, which have no buoyancy behavior. Instead, a constant “release height” is used.

Limitations of this approach are well known – but have been workable until recently.

What specification impacts prediction of **ground-level concentrations** the most?

- Horizontal orientation?
- Lack of buoyant behavior?
- Lack of wake modeling?
- Single trail of sources for multi-engine aircraft?
- Usage of stair steps?
- Source at 3,000 feet?

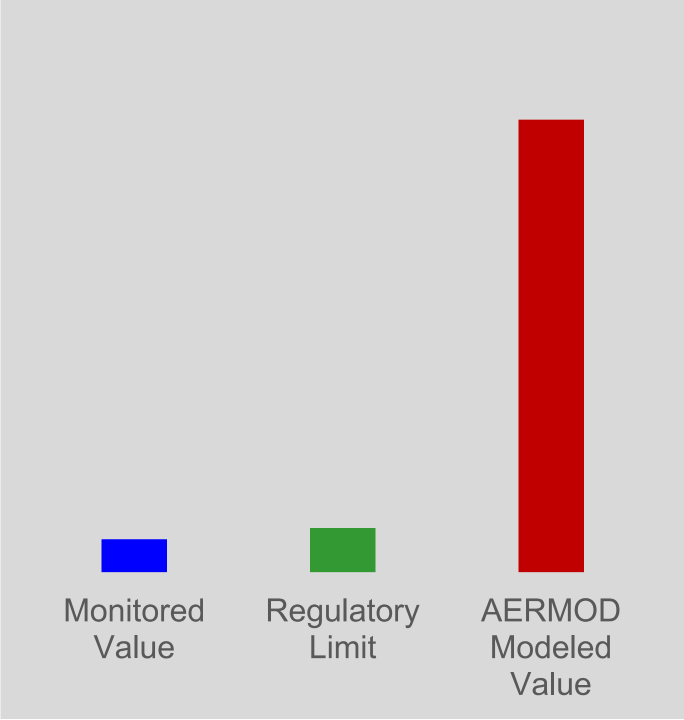


A19 Critical Need: Emissions Dispersion Model Development

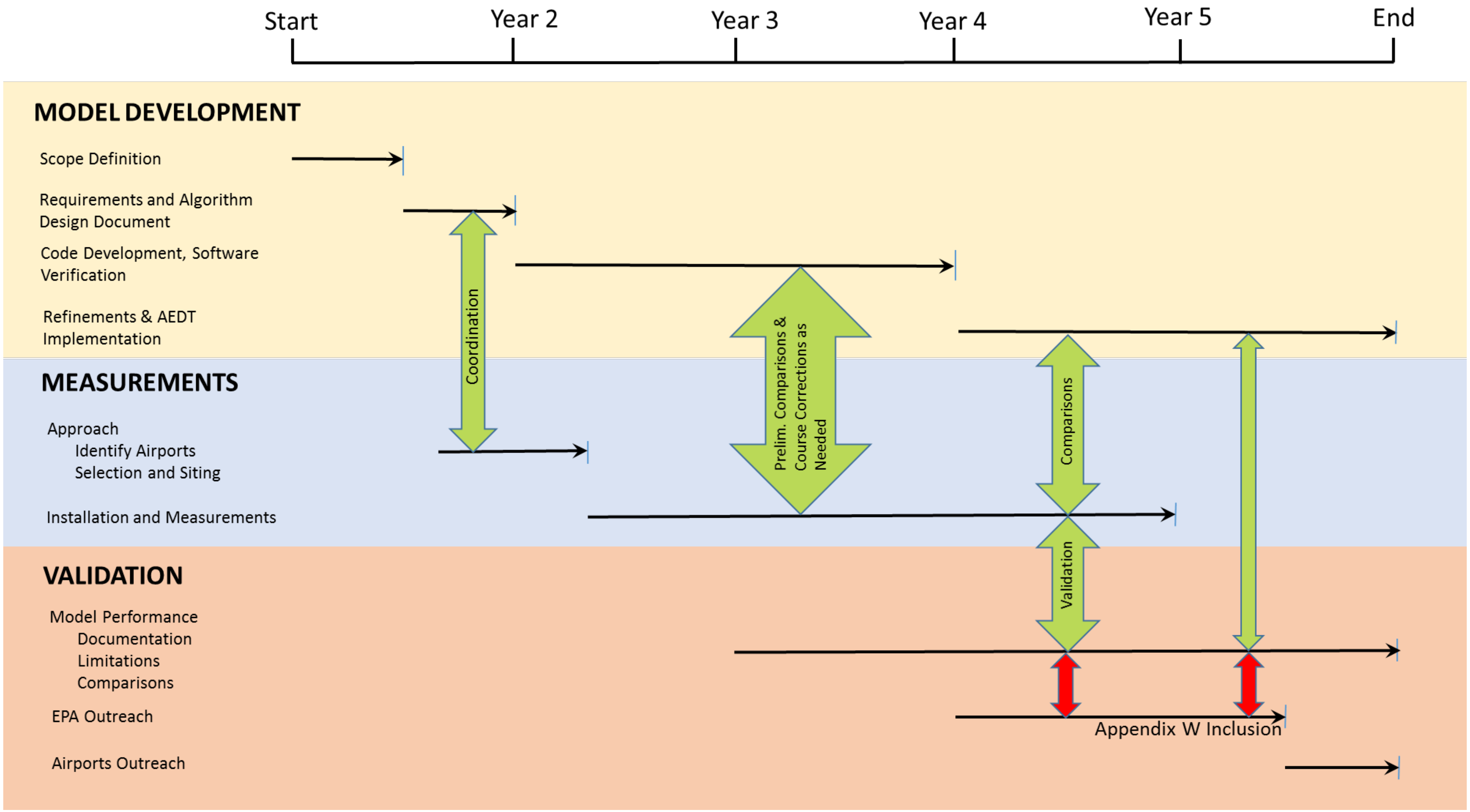
- **Challenge: EPA-mandated AERMOD model produces artificial violations of 1-hour NO_2 National Ambient Air Quality Standard**
  - Delays National Environmental Policy Act (NEPA) review
  - AERMOD does not represent aircraft emissions accurately

- **Research Solution: Develop an aircraft-specific emissions dispersion model for compliance with EPA regulations.**

- **Expected Outcome – A more accurate model to demonstrate airport air quality compliance that is acceptable to EPA.**
  - Improved version of EPA's AERMOD
  - A new model reflecting the best science and algorithms



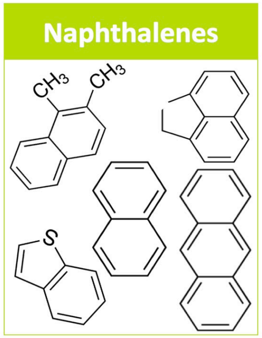
A19 Action Plan: 5-Year Dispersion Modeling Development Plan



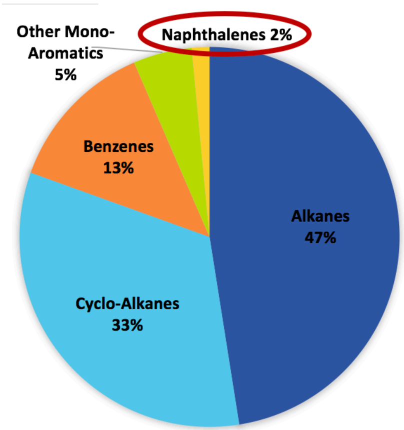
A19: MODEL DEVELOPMENT AND VALIDATION DATA GAP

- There are no comprehensive data sets yet to develop and validate models
- Knowledge of NO NO_2 splits based on very small number of monitor data (1 or 2)
- Systematic measurement of emissions species including NO, NO_2 and Particulate Matter along with Meteorological Data is needed
  - Multiple Airports in different climatic zones
  - Multiple monitors in a single airport
  - Co-located meteorological measurements
- Critical need for new infrastructure projects

A39 Research Question



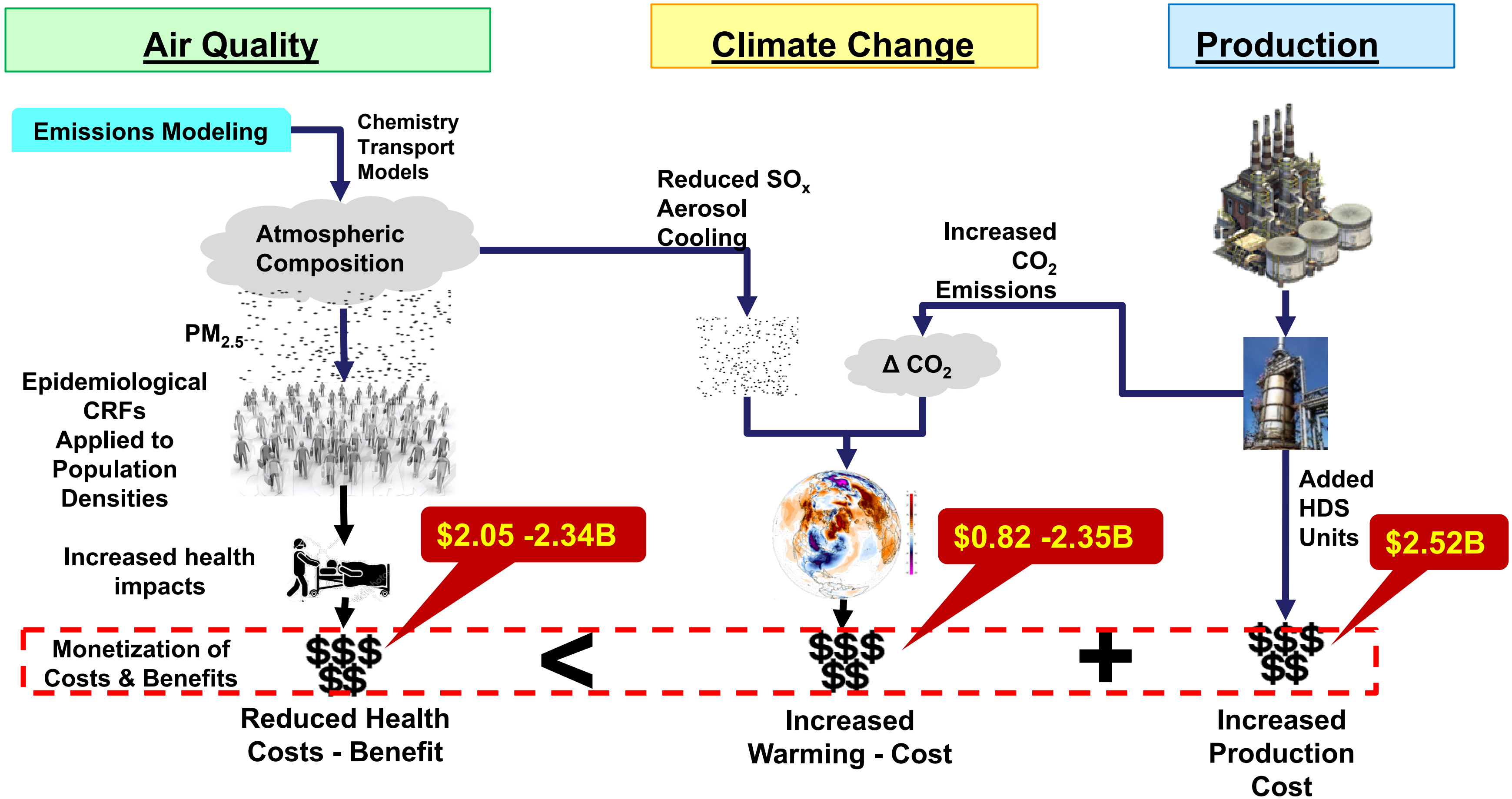
Jet fuel is composed of up to ~ 2% naphthalene, but **fuels absent naphthalene have ~ 15 – 40% lower nvPM emissions**, i.e., napthalenes have a disproportionate contribution to nvPM emissions



What are the costs and benefits to further refine jet fuel at the refinery to reduce or eliminate naphthalene and reduce nvPM emissions?

A39 updates PARTNER COE Project 27 (2007-2011)

Sulfur Removal Cost-Benefit Analysis



PARTNER Sulfur Cost Benefit Analysis Final Report
http://partner.mit.edu/projects/environmental-cost-benefit-analysis-ultra-low-sulfur-jet-fuels

Federal Aviation Administration

A39 (2016 to present)

Naphthalene Removal Cost-Benefit Analysis

Naphthalene in jet fuel identified as disproportionate contributor to soot emissions

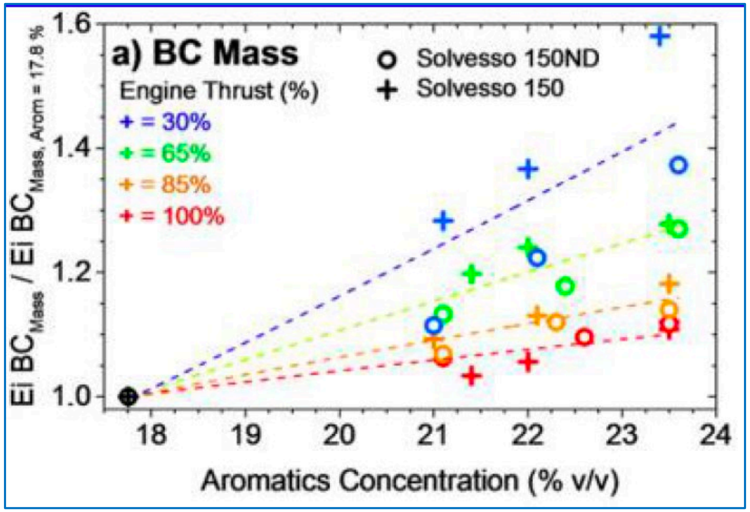
- Air Quality & Health Impact
- Climate Impact via Contrail Formation

Two means of fuel treatment considered

- Hydro-treatment (aromatics and sulfur)
- Extractive Distillation (aromatics alone)

Production costs (preliminary values)

- Societal economic cost: $0.06 to $0.09 per gal
- Market cost to refiner: $0.11 to $0.18 per gal



Key [1]

O :Jet A w/ Naphthalene-Depleted Aromatic Additive

+ :Jet A w/ Aromatic Additive

Monetized environmental impacts (preliminary values)

- Assumed 15% to 40% reduction in nvPM from change in fuel composition
- Air quality benefit (decreased impact): $0.00 to $0.04 per gal
- Climate cost (increased impact): $0.00 to $0.15 per gal (due to increased refining emissions, loss of sulfate aerosols, and assumption of no change in contrails)

A39 Considerations

- **Changes in fuel composition could reduce emissions**
  - Get reduced nvPM with reduced fuel aromatics – expect larger impact with reductions in naphthalenes and other more complicated aromatic compounds
  - Get reduced sulfates with reduced fuel sulfur content
- **Environmental impacts from reduced nvPM and sulfates**
  - Air quality benefit - less particulate matter pollution from aircraft operations
  - Climate impact is mixed – less radiative forcing from black carbon but increased radiative forcing from removal of sulfates and contrail impact is uncertain
- **Sulfur and Naphthalene Removal Cost-Benefit Analyses (CBA)**
  - Expect a net cost from reducing sulfur concentration in jet fuel to ULS levels
  - Might be a net cost with naphthalene removal using HDS and extractive distillation, but need to account for contrail impacts before being certain
- **Study Implications**
  - CBA studies are exploratory in nature - interested in knowing the relative merits of various means of reducing emissions from aircraft engines
  - Alternative jet fuels would provide air quality benefits relative to conventional fuel
  - Need to know more about contrail formation to get full story on climate impacts associated with changes in jet fuel composition

Summary

- **AEE has a comprehensive emissions research portfolio**
- **Research is underway to inform:**
  - Cruise-climb NOx and nvPM Modeling
  - nvPM Ambient Conditions Corrections Development
  - Improve nvPM mass instrument calibration
  - Improved Dispersion Modeling for Airport NAAQS/ NEPA Compliance
  - Cost benefit analysis re fuel components on emission reductions

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