

# **Analysis to Support the Development of an Aircraft CO<sub>2</sub> Standard**

## Project 14

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Advisory Board Meeting  
October 13-15, 2015  
Seattle, WA

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**ASCENT**  
AVIATION SUSTAINABILITY CENTER

# Mitigating Aviation's Contribution to CO<sub>2</sub> Emissions



- Increasing concern over aviation's contribution to climate change
  - Commercial aircraft contribution to domestic GHG emissions is approximately 2%<sup>1</sup>
  - Aviation demand expected to increase over the upcoming decades
  - Contribution to climate change is expected to increase in the future<sup>2</sup>
- Ambitious goals set for U.S. (e.g. carbon neutral growth by 2020 with respect to a 2005 baseline)
- Several solutions available to mitigate aviation's environmental impacts
  - Aircraft Technologies
  - Operational Improvements
  - Alternative Fuels
  - Policies
- Aircraft CO<sub>2</sub> standard being developed by the International Civil Aviation Organization (ICAO)/ Committee on Aviation Environmental Protection (CAEP)<sup>3</sup>

1 US GHG Inventory, US EPA

2 Clearing the Air: The Myth and Reality of Aviation and Climate Change

3 International Civil Aviation Organization [www.icao.int](http://www.icao.int)

# Objective of the CO<sub>2</sub> Standard



- Incentivize the reduction of CO<sub>2</sub> emissions beyond what can be achieved with normal market forces
- Standard should only incentivize introduction of fuel burn reduction technologies
- Standard should not discriminate based on how the aircraft is operated

# Research Motivation and Overview



- Project originally conceived in May of 2009 as PARTNER Project 30 to provide the FAA with sound technical, data driven analysis to support informed decisions regarding the development of a new aircraft CO<sub>2</sub> standard
- A two phased approach has been undertaken:
  - Phase 1: Support and drive the development of the certification framework, composed of a metric system and measurement conditions (May 2009 through June of 2012)
  - Phase 2: Support the assessment of cost effectiveness and cost benefit of possible stringency options (i.e., future potential regulatory levels) that could form the basis of the final standard adopted by CAEP (June 2012 through February 2016 final decision)
- This project takes part in the FAA-AEE-300 Emissions Roadmap under **Aviation Emissions Modeling** and **Certification and Regulations** (i.e. Standards)

# Objectives of ASCENT Project 14



- Continue to support of CAEP CO<sub>2</sub> standard setting process through the expected decision at the CAEP/10 meeting in Feb 2016
- Inform U.S. policy makers with analytical information for the CO<sub>2</sub> standard setting process
- Provide a preliminary analysis of the CO<sub>2</sub> cost-benefit analysis ahead of the CAEP cost-effectiveness assessment to ensure that U.S. policy makers are well informed of the expected outcomes and potential issues
- Address any emerging issues associated with various stakeholders in the process either in a quantitative or qualitative manner

# Outcomes and Practical Applications



- Outcomes
  - CAEP consensus on a functional CO2 Standard for new aircraft types only and potentially in-production aircraft types
  - Systematic analysis process utilizing the FAA environmental tool suite
  
- Practical applications
  - Technical and data driven input into CAEP process
  - Cost benefit analysis to inform U.S. policy makers and FAA team
  - Future fleet evolution studies for CAEP and NextGen

# Approach

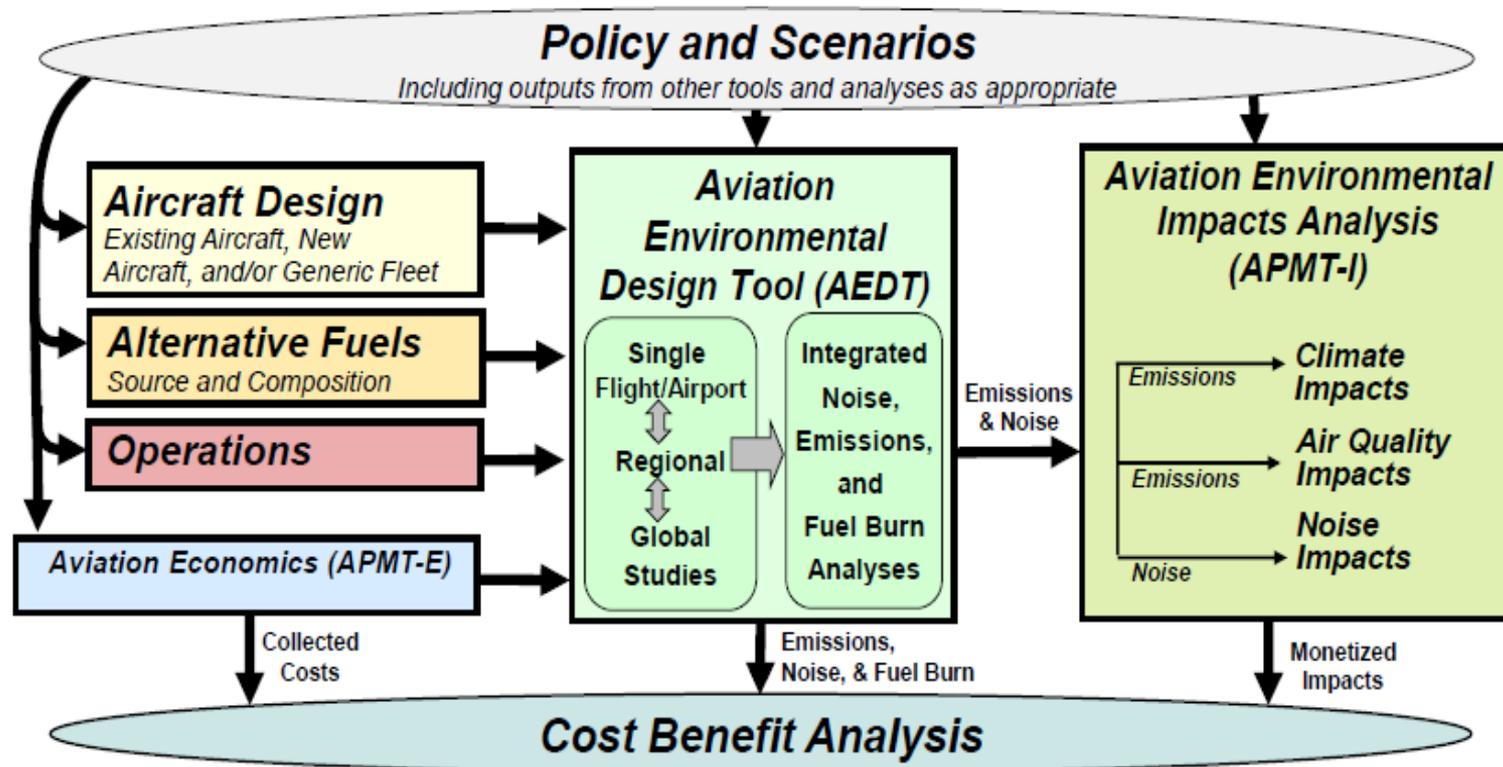


- Conduct extensive cost benefit analysis using the full FAA Tool Suite, in order to inform the U.S. position for the development of an aircraft CO<sub>2</sub> standard which will result in technology responses with the greatest environmental benefits while being technically feasible and economically viable
- Provide quantitative and methodological support of CO<sub>2</sub> Standard Main Analysis modelling process
- Conduct sensitivity analyses in order to inform decision makers of potential outcomes under different scenarios and assumptions using the FAA Tool Suite, quantitative and qualitative research methods
- Actively engaging stakeholders using a data driven collaborative approach

- A14 supported U.S. policy makers leading up to the July 2015 Steering Group Meeting in Montreal, Canada
- A14 is completing an extensive cost benefit analysis in order to inform the U.S. position for the development of an aircraft CO<sub>2</sub> standard
- A14 to inform U.S. policy makers leading up to Feb 2016 CAEP CO<sub>2</sub> standard decision
  - Provide materials to support MDG/FESG and WG3 meetings during October 2015

# Recent Accomplishments and Contributions #1: Cost Benefit Analysis

- ASCENT Project 14 team is conducting extensive cost benefit analysis using the full FAA Tool Suite in order to inform the U.S. position for the development of an aircraft CO<sub>2</sub> standard which will result in technology responses with the greatest environmental benefits while being technically feasible and economically viable

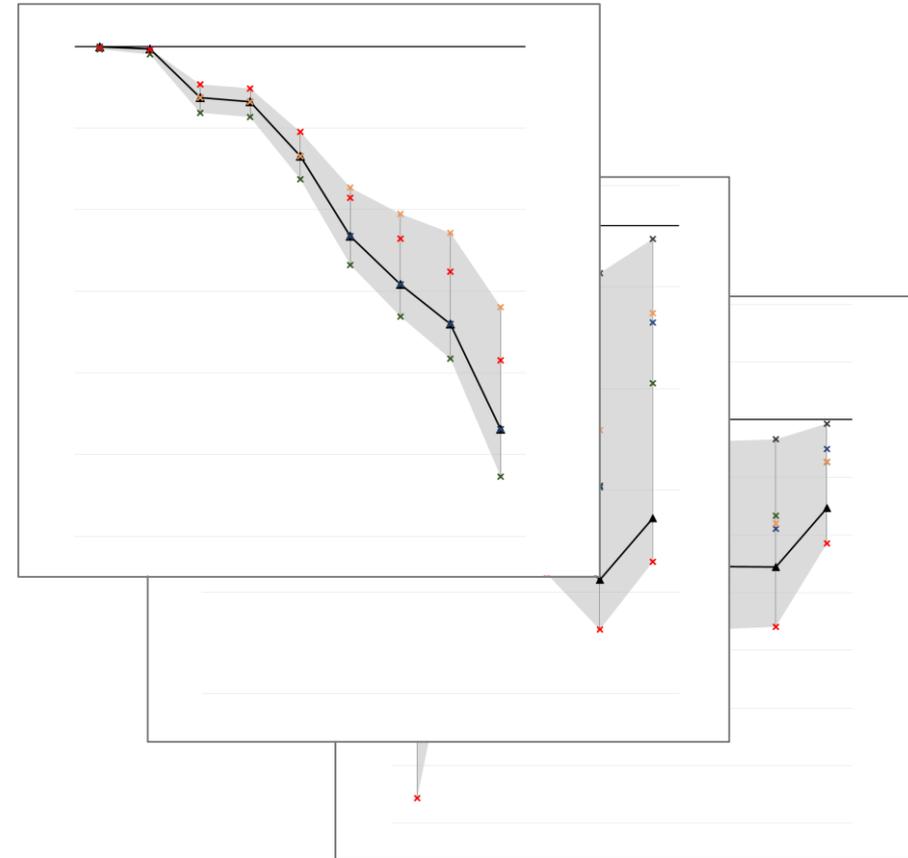




# Recent Accomplishments and Contributions #3: Sensitivity Analysis

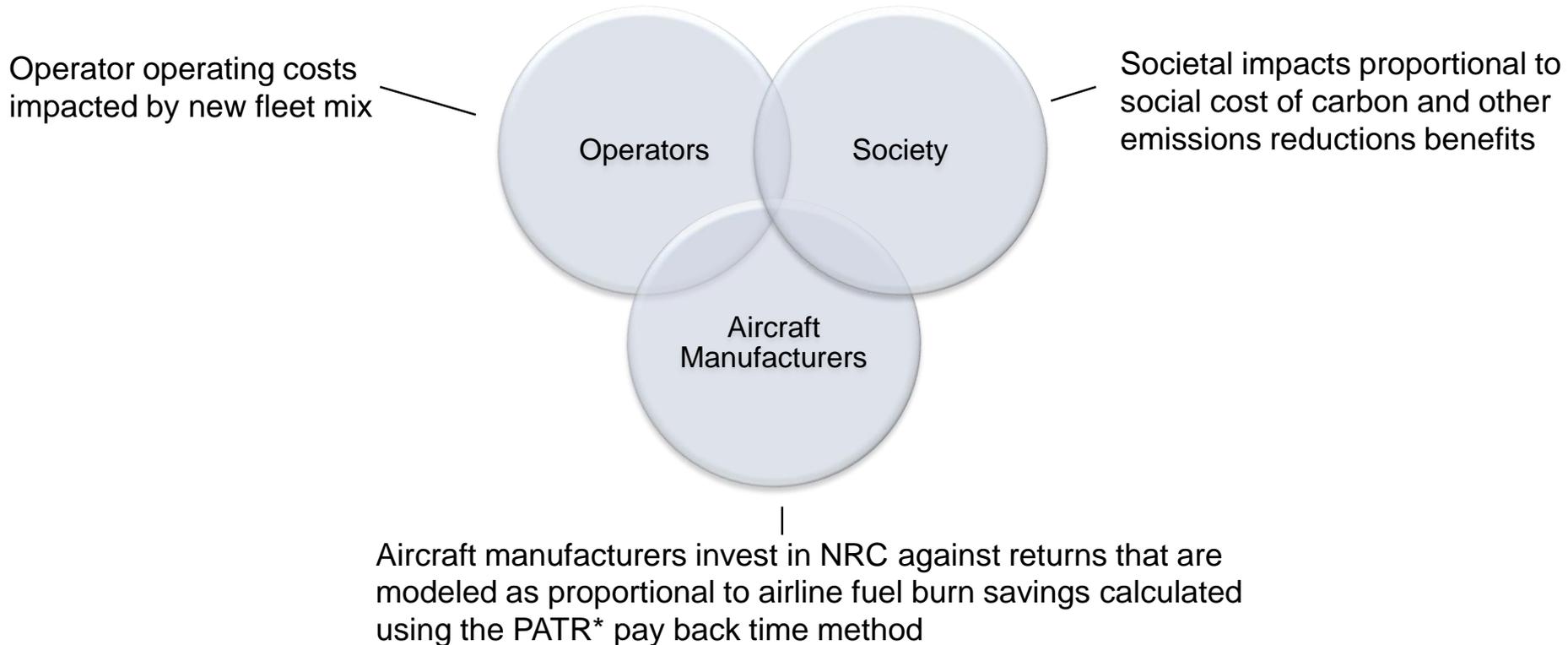
- ASCENT Project 14 team is conducting sensitivity analyses in order to inform decision makers of potential outcomes under different scenarios and assumptions using the FAA Tool Suite, quantitative and qualitative research methods

Illustration of Sensitivity Analyses



# Recent Accomplishments and Contributions #4: Stakeholder Analysis

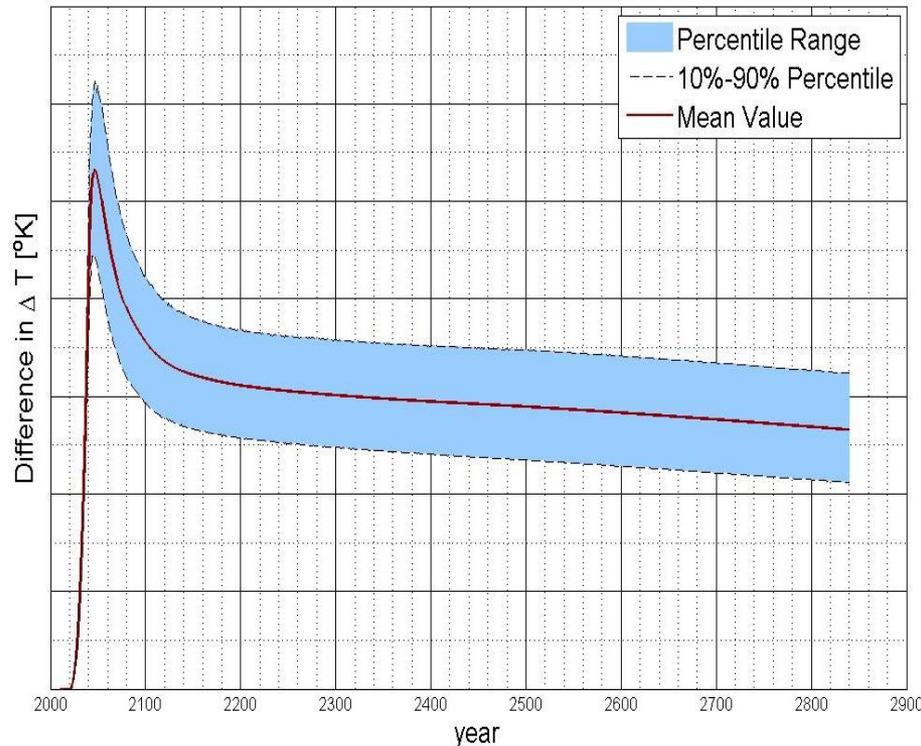
- ASCENT Project 14 team is actively engaging stakeholders using a data driven collaborative approach by quantifying the potential impact of the various CO<sub>2</sub> Standard options on forecast fleet evolution, airline and manufacturer economic metrics, and interdependencies using the FAA Tool Suite



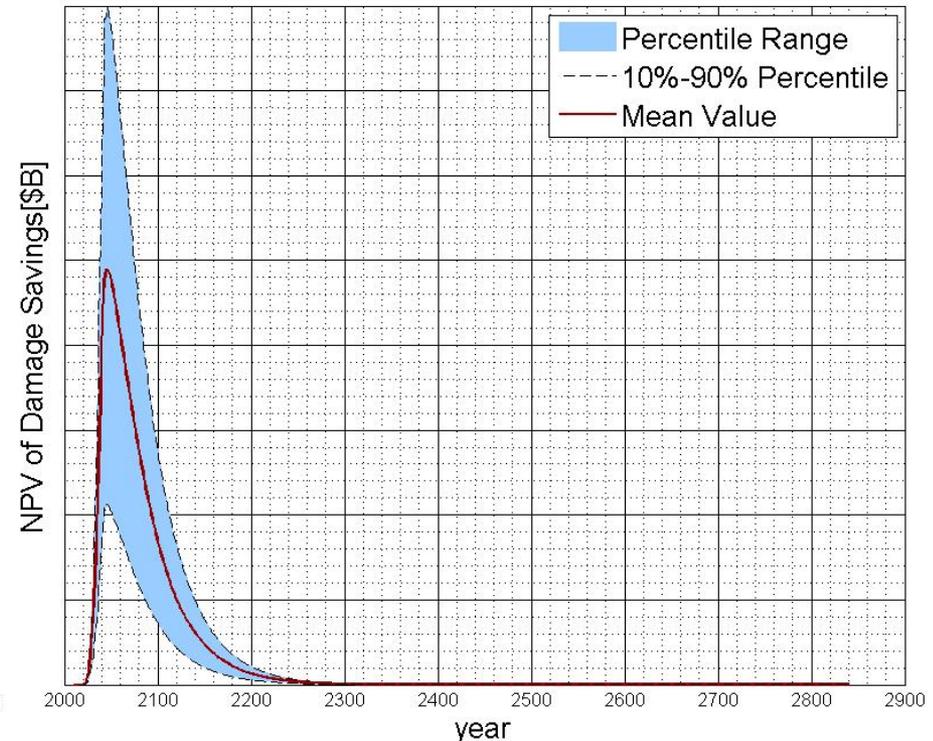
# Recent Accomplishments and Contributions #5

- Implemented latest version of APMT-I environmental model to analyze the social cost of CO<sub>2</sub> emissions
- Currently performing comparative analysis to determine the relative benefit of different Stringency Scenarios
- Climate impacts have long-lasting, uncertain costs and scale with fuel burn changes. Larger fuel burn reductions translate to greater climate impact cost savings

Example  $\Delta T$  Percentile Ranges

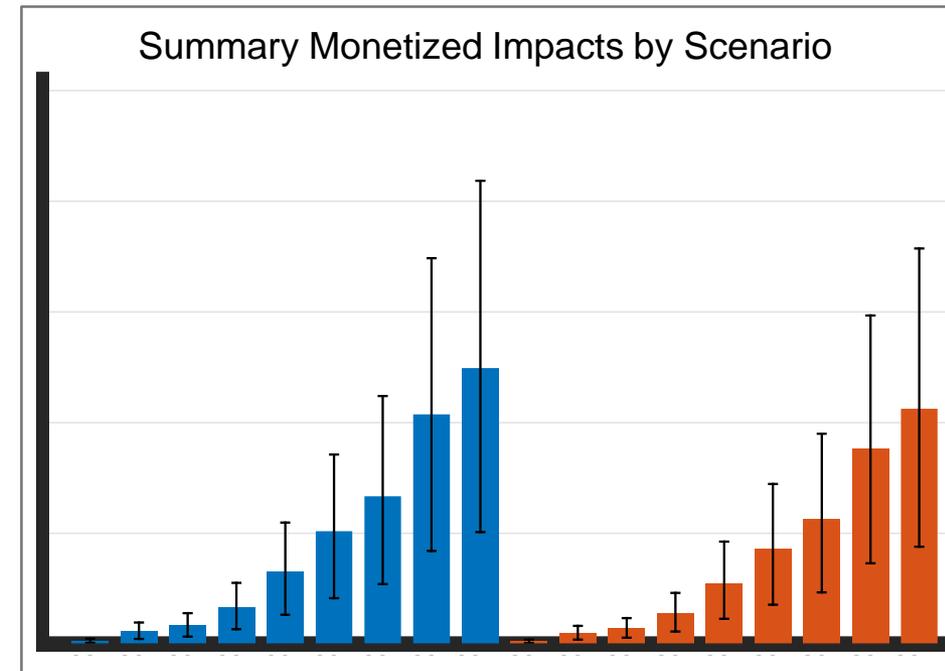
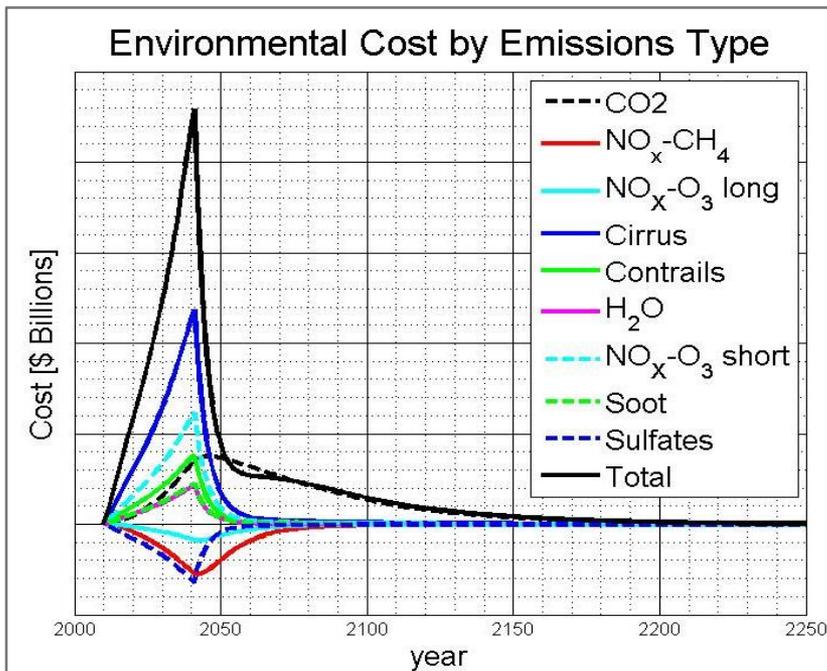


Example Cost Percentile Ranges



# Recent Accomplishments and Contributions #6

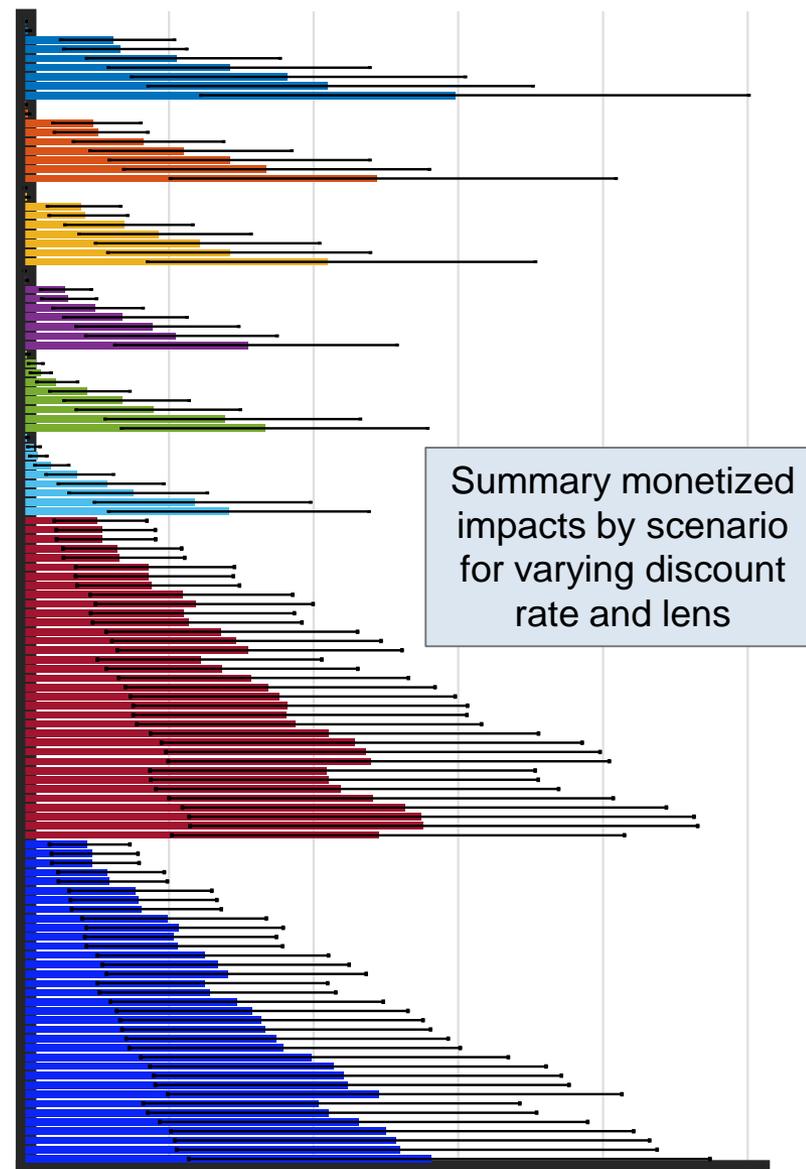
- APMT-Impacts analysis performed on both climate change and air quality models
  - Emissions costs broken down by emissions type to better understand impacts
    - Long term impacts are driven by CO2 emissions. In the short term, both warming and cooling effects are observed among the species
  - Comparative analysis performed to study the relative benefits of different stringency scenario options
    - Initial impacts analysis generally shows greater cost savings versus baseline for higher stringency scenarios



Illustrative results. Not to be cited or quoted

# Recent Accomplishments and Contributions #7

- Sensitivity analysis performed on environmental impacts
  - Varied:
    - **climate responses to emissions**
      - Uncertainty in climate modeling is captured through impact lenses
    - **valuations of impacts**
      - Varying the discount rate alters how much value is put on impacts in the future
  - Stringency scenario rankings remain consistent for different input assumptions, but the magnitude of impact valuations show significant differences



- ASCENT Project 14 team is quantifying the potential impact of the various CO<sub>2</sub> Standard options on forecast fleet evolution, airline and manufacturer economic metrics, and interdependencies using the full FAA Tool Suite
- Actively engaging all stakeholders using a data driven collaborative approach
- Conducting extensive cost benefit analysis in order to inform the U.S. position for the development of an aircraft CO<sub>2</sub> standard which will result in technology responses with the greatest environmental benefits while being technically feasible and economically viable

**BACKUP**

- External
    - Extensive interaction with CAEP:
      - Numerous working and information papers for all of the CAEP/10 cycle meetings and workshops e.g.:
        - CAEP Reports
        - • COST-BENEFIT ANALYSIS... (CAEPx\_SGx\_IPxx\_Cost-Benefit Analysis of CAEP10 CO2 Stringency Options)
        - • CO2 main analysis: Cost... (CAEPSG.201x.WPx.en\_FESG-MDG)
        - • INVESTIGATION OF PRICE... (IP0x\_MDG-FESG-STG-0x)
        - • POST-PROCESS IMPLEMENTATION OF PRICE... (IP0x\_MDG-FESG-STG)
        - • CO2 MAIN ANALYSIS... (CAEPSG.201x.WP.x.3.en\_MDG-FESG)
        - • CO2MAIN ANALYSIS: FUEL PRICE... (IP0x\_MDG-FESG-STG-0x)
        - • CO2MAIN ANALYSIS: FUEL PRICE... (WP0x\_MDG-FESG-STG-0x)
        - • Technology review... (CAEPx\_WGx\_CO2\_WP0x)
        - • CO2 MAIN ANALYSIS: FRAMEWORK... (CAEPx\_WGx\_CO2-x\_IP0x)
        - • CO2 MAIN ANALYSIS: FRAMEWORK... (presentation)
      - Weekly, at times daily, teleconferences
      - Submissions and presentations to CO2TG subgroup teleconferences
    - Extensive interaction with Volpe
    - Extensive support of interaction with Stakeholders
      - Manufacturers, Operators, NGOs, EPA
- Within ASCENT
  - Collaboration with ASCENT Projects 20, 21, and 24A on environmental impact modeling to assess value of the standard
  - Collaboration with ASCENT Projects 11A and 11B on fleet modeling

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