Partnership for AiR Transportation Noise and Emission Reduction

An FAA/NASA/TC-sponsored Center of Excellence

Environmental Design Space

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Breaking Barriers: Airing Out a Sound Aviation Environment
March 4-7, 2007

EDS Development Team

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The Environmental Design Space project is managed by Joseph DiPardo

Outline

- Genesis of EDS
- FAA tool suite and EDS functionality
- Potential Stakeholder requirements
- Meeting Stakeholder expectations
- Initial EDS capability demonstrator
- Next steps
- Summary

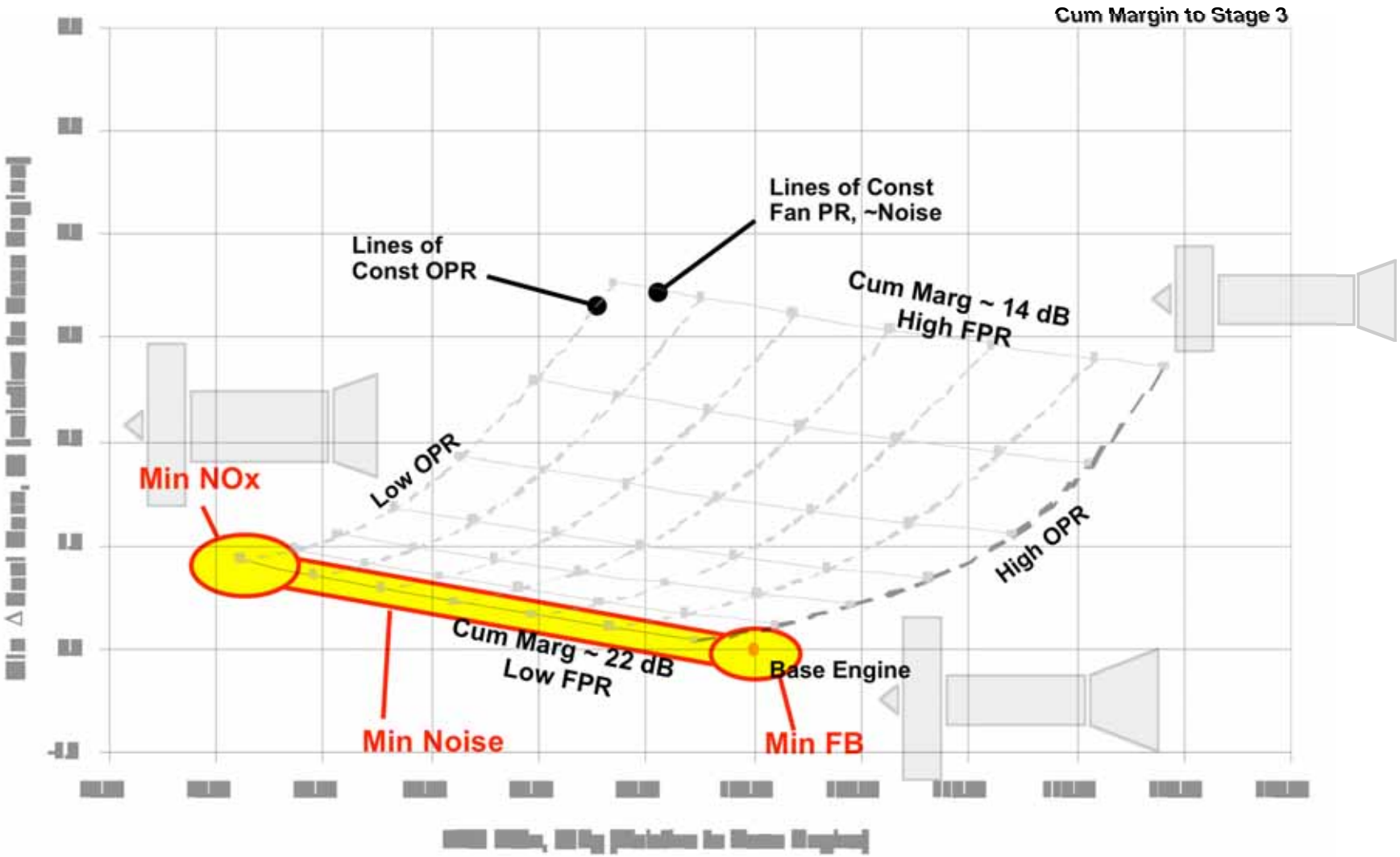
Genesis of EDS*

- Study initiated by Air Transport Association (Airlines) and Aerospace Industries Association (Manufacturers)
  - To support environmental regulatory discussions
  - Provide guidance for certification standards process
- Define an "Environmental Design Space" that:
  - quantifies Engine/Airplane design trade-offs in a manner that is technically feasible

    … in terms of Performance, Noise, Emissions ….
- Defines an Environmental Engine / Airplane System based on current and future technology sets
- Questions:
  - What does an "Environmental Design Space (EDS)" look like for current and future aircraft/engine systems?
  - What are the tradeoffs in terms of performance, noise, and emissions for technically feasible aircraft/engine systems?

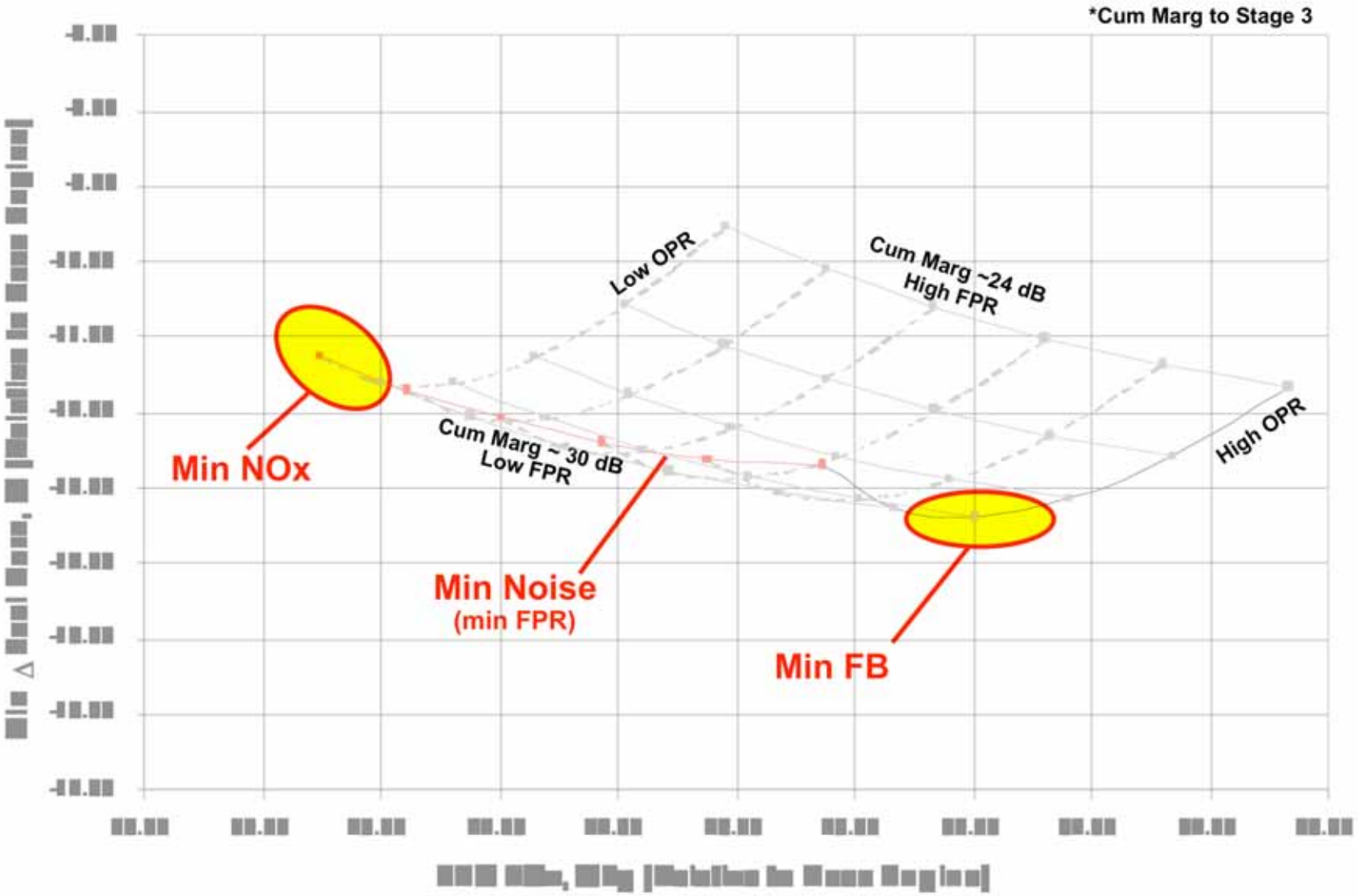
* Source: 2003: "*Environmental Tradeoffs in Commercial Aircraft Design: AIA EDS Feasibility Test and Lessons Learned*" Dave Halstead, GEAE

FB/NOx/Noise Carpet Plot - Certified Product



"Environmental Tradeoffs in Commercial Aircraft Design; AIA EDS Feasibility Test and Lessons Learned"
Dave Halstead, GE Aircraft Engines, January 12, 2004

FB/NOx/Noise Carpet Plot - 2010 Product



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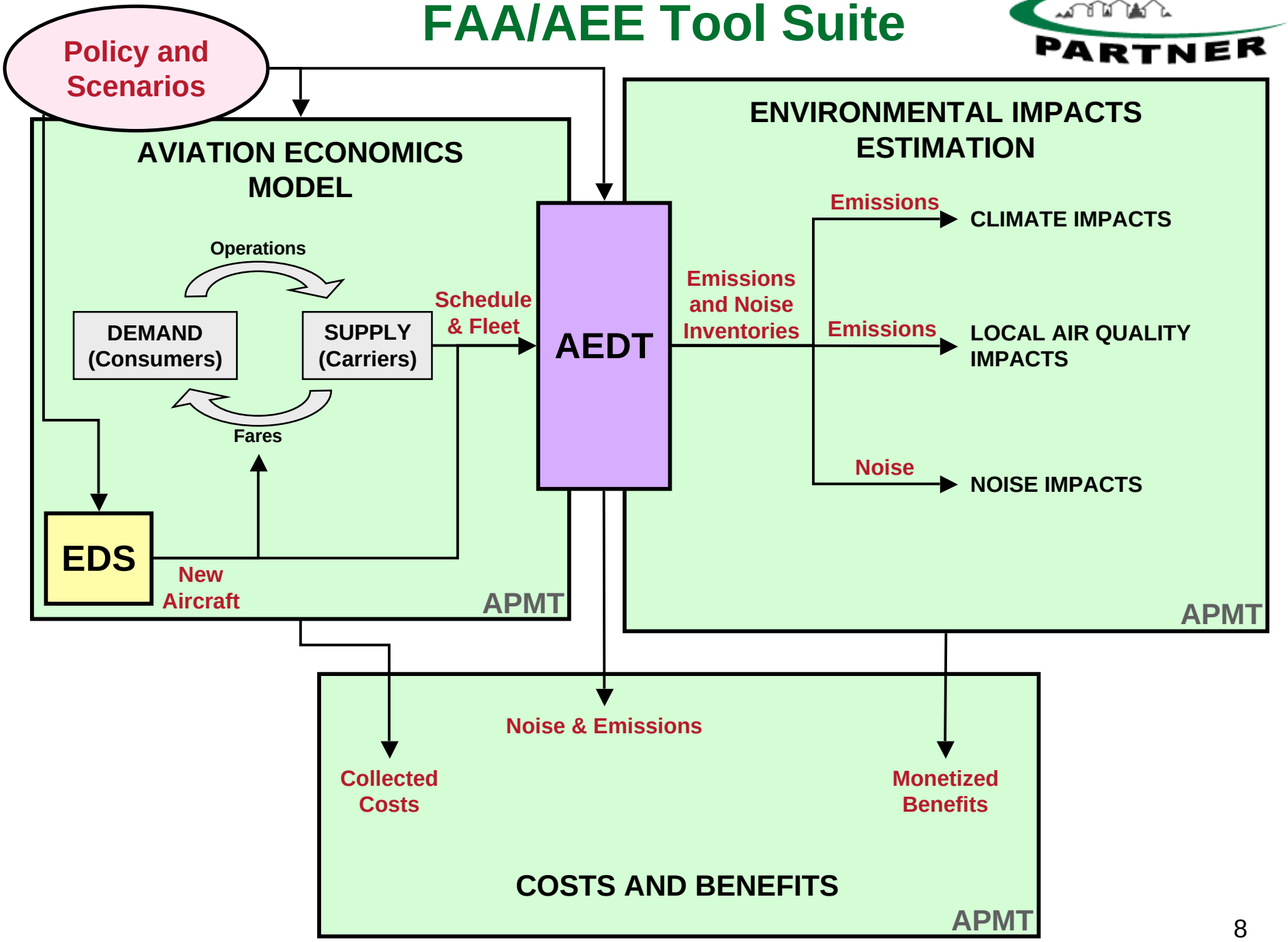
Summary and Lessons Learned*

- Quantifying environmental impact is a complex, multi-disciplinary, systems-based problem
- **Significant environmental trades do occur**…
  - Best Noise solution is **not** best NOx solution is **not** best CO2 (ie, fuel burn) solution
- **An integrated approach is key to attaining balanced environmental regulatory strategy**
  - Noise vs. CO2 vs. NOx (and other emissions)
  - Local vs. national vs. global impact
  - Implications to costs and benefits to achieve a balanced solution

The FAA took the initiative to pursue the development of a tool set to address these needs

* Source: 2003: "*Environmental Tradeoffs in Commercial Aircraft Design: AIA EDS Feasibility Test and Lessons Learned*" Dave Halstead, GEAE

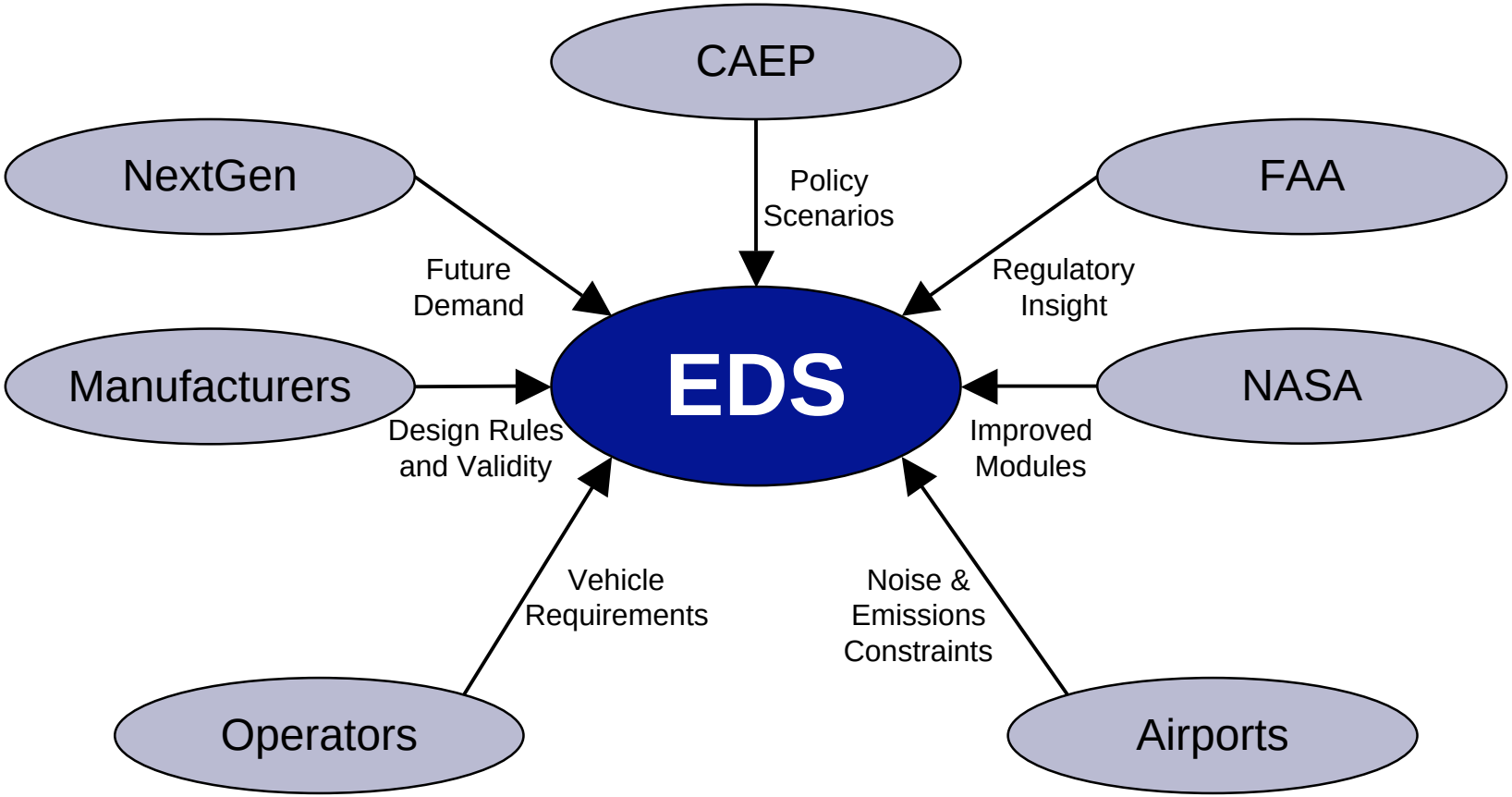
FAA/AEE Tool Suite



What must EDS be able to do?

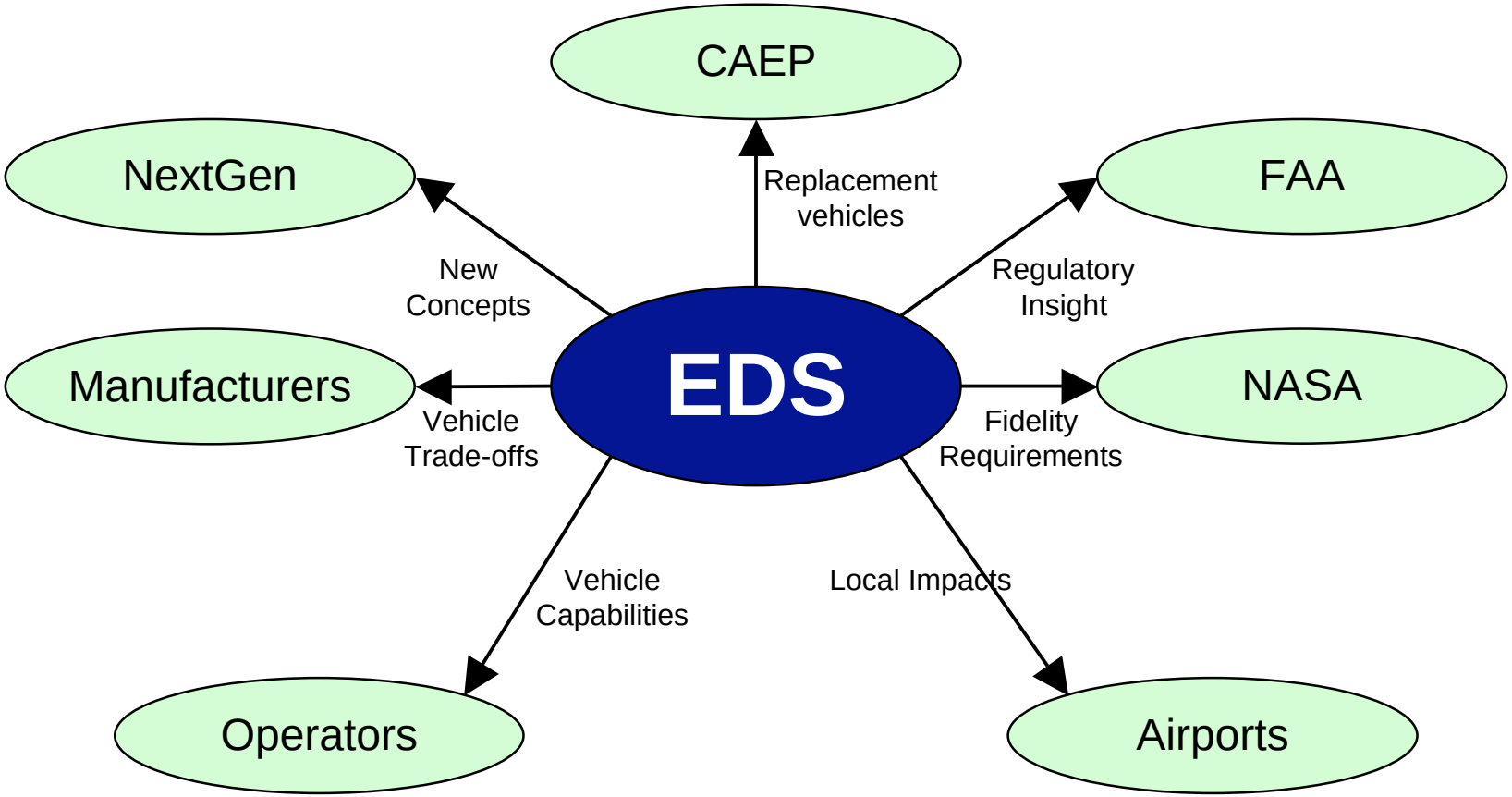
- Be capable of analyzing environmental and performance effects of:
  - New Technologies
  - New Aircraft both replacement and new system types
- Methods and assumptions must be **non-proprietary** and data generated must be accessible to the international community to **increase transparency**
- Enable the exploration of **trade-offs and interdependencies** amongst and between technology, economics and environmental impacts at the aircraft level
- Sufficient flexibility to be employed in a **parametric mode** to explore potential variations within an aircraft class
- Serve as a mechanism for collecting, incorporating and quantifying **long-term technology impact assessments**. This will be an inherently **expert-driven** process drawing on industry advice
- Inputs, outputs and execution times must be compatible with **AEDT and APMT needs**

EDS Potential Stakeholder Requirements



Each stakeholder places different requirements on EDS

EDS Potential Stakeholder Support



EDS can potentially support multiple users

How can we meet the expectations?

- Functionality of EDS must be accessible to both U.S. and international partners
- EDS results must be open to the community and based on **public domain information**
  - No proprietary data or assumptions
  - No empirical corrections of trends
- To ensure the results from EDS are satisfying the customer base at an acceptable level of accuracy a two prong approach was pursed:
  - Assessment of EDS capabilities
  - Industry collaboration

Assessment Plan Focus

- Assessment is critical for ensuring that the final EDS results are reasonable for the various stakeholders
- Achieving international confidence of EDS relies on a thorough documented assessment of the tools, architecture, assumptions
- To address *"How accurate is accurate?"*, we must:
  - Define what assessment metrics are appropriate for EDS
  - Determine uncertainties associated with EDS tools
  - Determine the appropriate level of fidelity
  - Identify process to engage broader community in assessment efforts
  - Identify appropriate process to communicate assessment outcomes to the broader community

Engage industry through collaborative assessments to address these objectives

Industry Collaboration Focus

- Participate in collaborative assessment projects in which EDS-derived results will be compared to those obtained by industry collaborators who will use proprietary analysis tools
- Participation includes the following activities:
  - **Back-to-back** comparisons between proprietary tools and EDS for specific engine/airframe combinations
  - Determination of sources differences between the EDS capabilities and industry-proprietary methods
  - Identify EDS elements that need higher fidelity analysis capabilities
- Current interactions with industry:
  - General Electric
  - Pratt & Whitney
  - Boeing
- Key objectives:
  - Define appropriate design rules for different engine/airframe combinations
  - Validating trade-spaces and trends of NOx vs. Noise vs. CO2
- An **Industry Review Group** has been formed that will interact with EDS to vet trade spaces for applicability to CAEP and NextGen

Initial EDS Capability Demonstrators

- EDS supported two capability demonstrators in conjunction with the other FAA tools (AEDT, APMT), which included:
  - Fuel Price Increase
    - With and without EDS aircraft technology
  - NOx Emissions Certification Stringency
    - With and without EDS aircraft technology
- Prototype connectivity based on:
  - Aircraft and engine trade spaces with current technology levels
  - Same vehicles used for both scenarios as potential replacement vehicles

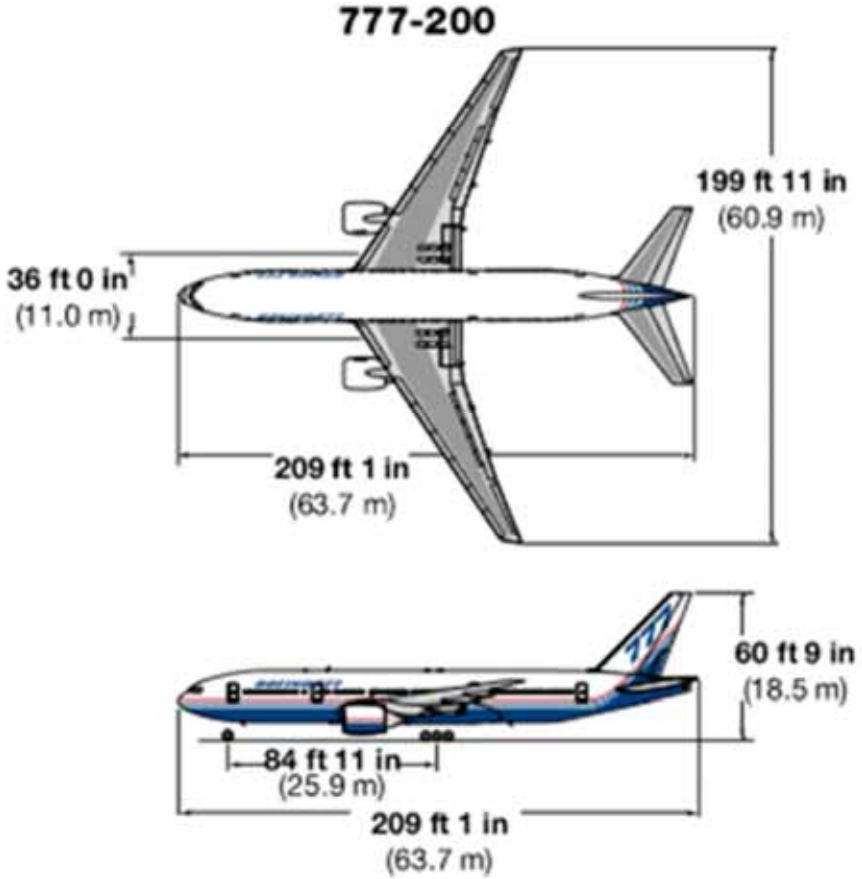
300 Passenger Class Reference Vehicle

- Airframe: Boeing 777-200ER
- Engine: GE 90-94B

http://www.snecma.com

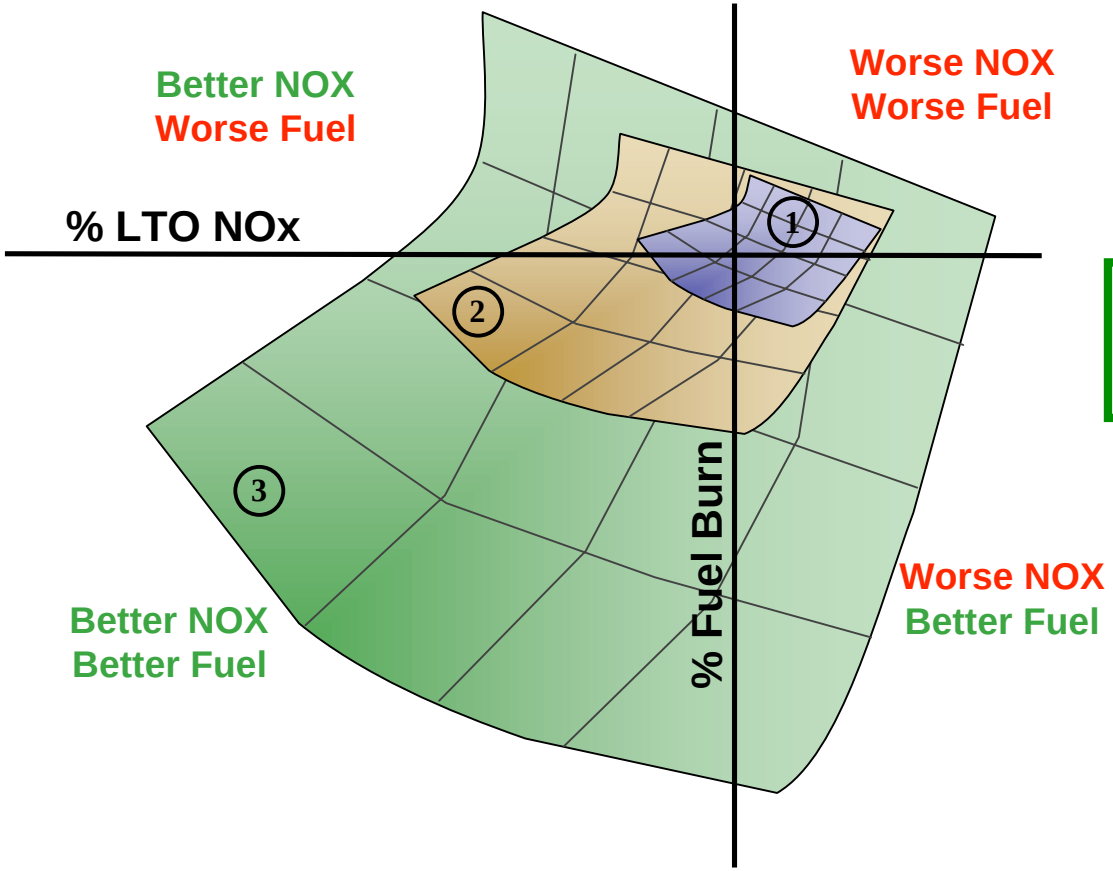
http://www.geae.com/

http://www.boeing.com/



http://www.boeing.com/

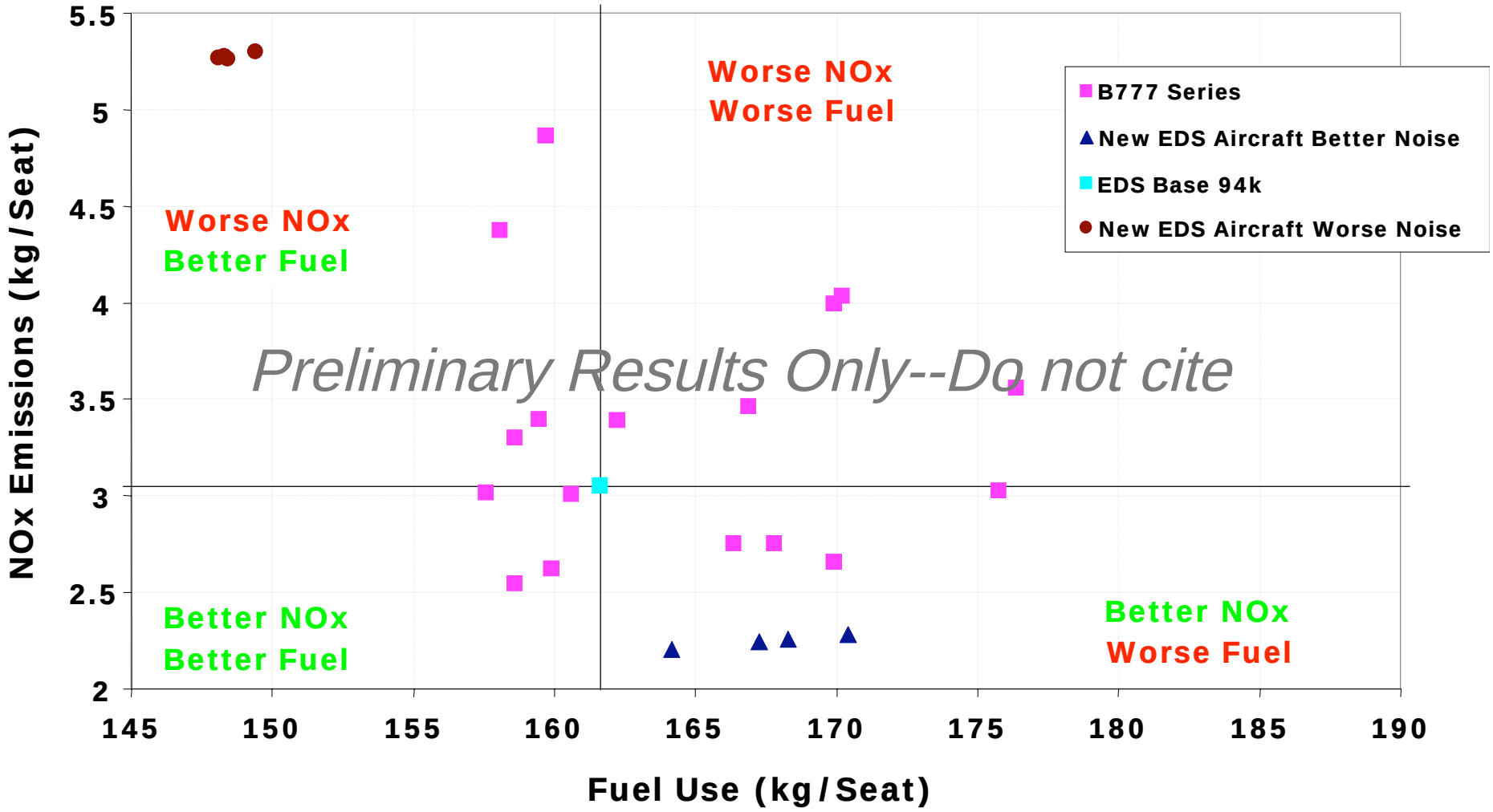
EDS Trade Spaces



Three different trade spaces for a given airframe/engine architecture type within a vehicle class may be investigated:

1. Trade space about current technology
2. Trade space about incremental changes from current technology (e.g., winglets or new combustor)
3. Trade space for future technologies

Fuel vs. NOx vs. Cumulative Noise Margin



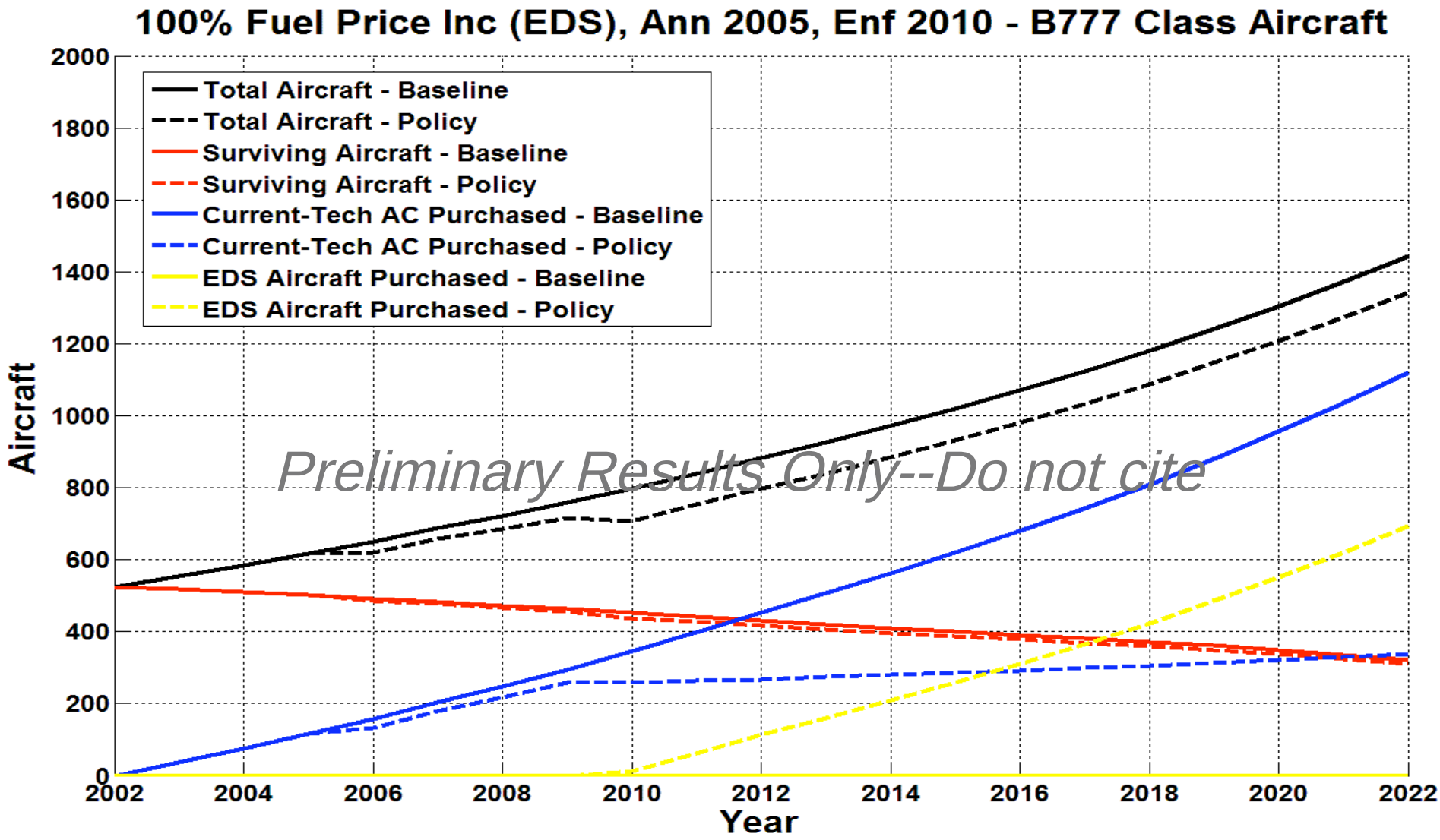
Results: Impacts of EDS Aircraft on Fleet Selection

- Results Relative to the Baseline

- Fuel Price Increase:
  - 100% increase ie from Baseline level of fuel cost of USD 0.5 per kg to USD 1.0 per kg
- NOx Certification Stringency:
  - 20% reduction from CAEP4 standard for new purchases

- Illustrated for B777 seat class (300-400 seat) aircraft

Preliminary Results



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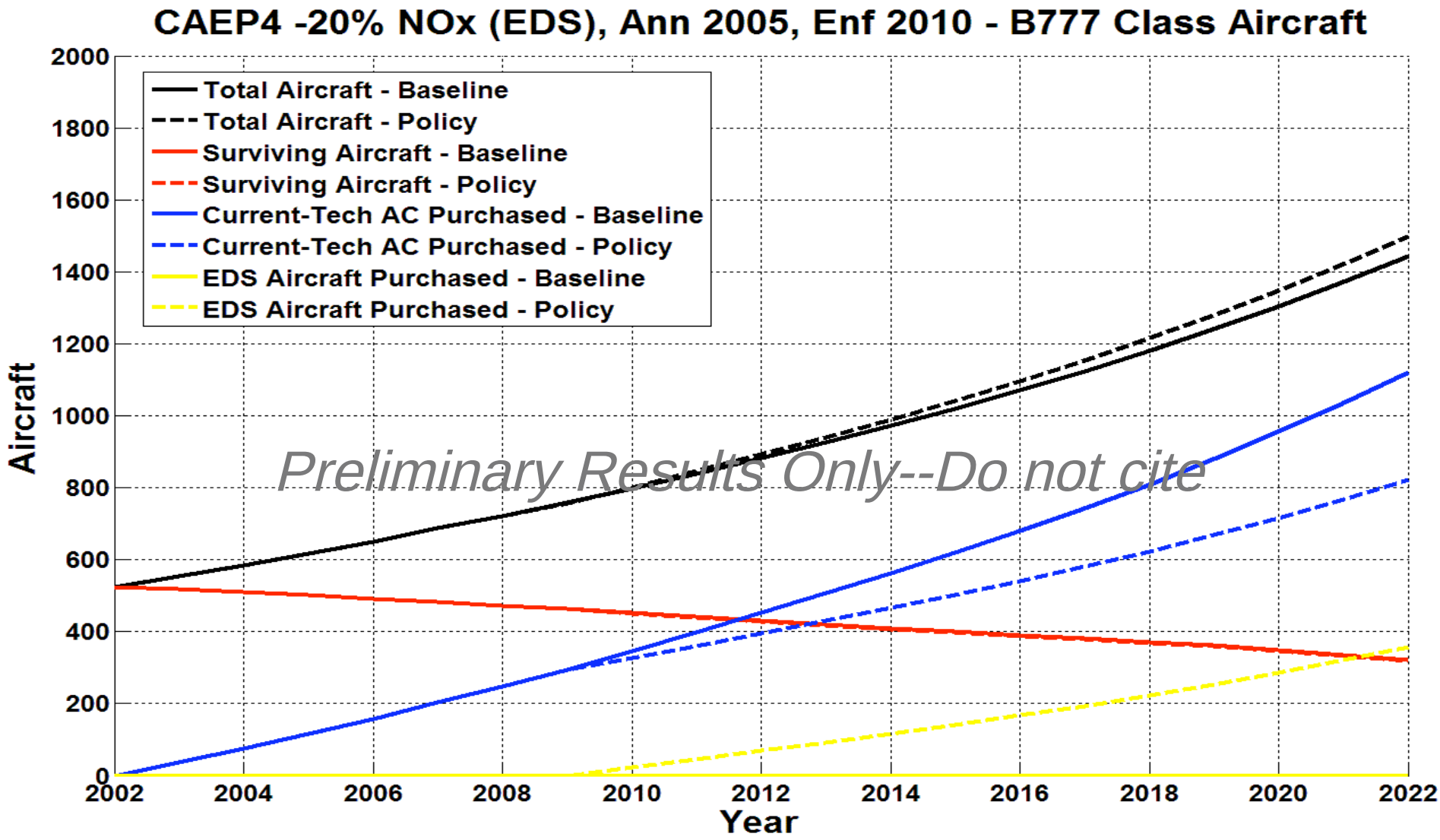
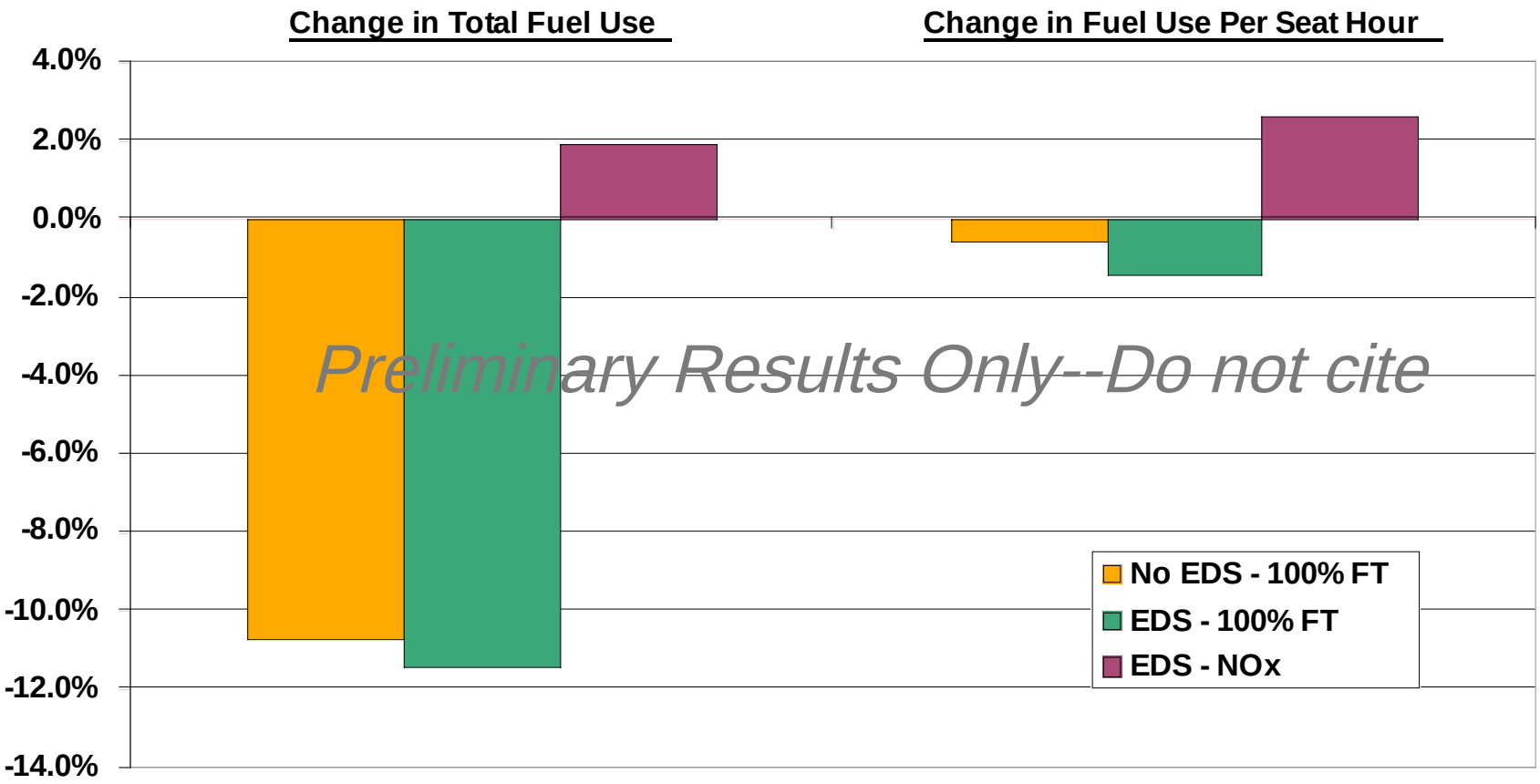


EDS: B777 Class Outputs

Change in Fuel Use from the Baseline for B777 Size Class Aircraft (300-400 seats)



Next Steps

- Increase engagement of international community
- Continue EDS development based on:
  - Assessment results
  - Industry collaboration
- Continue trade space generation to encompass additional seat classes to support the other FAA tools for CAEP policy sample problems
- Establish stronger linkage with NextGen

Summary

- FAA has made a commitment to use EDS
  - to inform decision-making for the CAEP meeting in 2010
  - to help establish trades among noise and emissions impacts in order to better quantify and manage the impacts associated with NextGen operations
- We are:
  - Not building aircraft
  - Not giving “the” answer
  - Are providing insight to the trade-offs that exist between NOx vs. Noise vs. CO2
  - Actively engaging industry and international partners through this development

EDS will allow for more effective assessment and communication of environmental effects, interrelationships, and economic consequences in support of CAEP and NextGen