FAST-Tech System Level Assessment

Project 97

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FAA

Ascent Fall Meeting
October 16, 2025
Washington, D.C.

This research was funded by the U.S. Federal Aviation Administration Office of Environment and Energy through ASCENT, the FAA Center of Excellence for Alternative Jet Fuels and the Environment, Project 97 through FAA Award Number 13-C-AJFE-GIT-155 under the supervision of Mr. Joshua Glottmann. Any opinions, findings, conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the FAA.

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Cost Share Partner: Georgia Institute of Technology

Objective:

To support the FAA through independently modeling and assessing the technologies that are being developed under FAST-Tech at the system and fleet levels.

Project Benefits:

This project will quantify the expected U.S. fleet wide reductions in aviation fuel burn/fuel costs and harmful engine exhaust products. These reductions are enabled by including FAST-Tech technologies onboard notional future aircraft in a fleet assessment.

Research Approach:

- Perform modeling of individual FAST-Tech technologies
- Incorporate these models into vehicle level performance analyses
- Include a demand forecast, fleet replacement matrix, and set of technology introduction scenarios
- Evaluate the fuel burn/fuel costs and harmful engine exhaust products reductions in the US fleet across various scenarios to estimate impacts of the FAST-Tech program

Major Accomplishments (to date):

- Capablities have been added to Georgia Tech modeling environment to enable modeling of FAST-Tech technologies
- Establishment of working relationships with nearly all FAST-Tech contractors
- Technology modeling efforts are underway

Future Work / Schedule:

- Continue FAST-Tech technology modeling efforts
- Make updates to the fleet environment and progress to the point where test runs for the fleet study can be conducted

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Presentation Overview

- FAST Program Overview
- ASCENT 97 Program Overview
- Methodology and Challenges
- Project Timeline and Next Steps

FAST Overview

FAST awarded grants in the following areas [1]:

- 22 Projects were funded in areas related to the SAF infrastructure needs including the production, transportation, blending, and storage. With the goal of increasing SAF production, enhancing SAF supply chains, and increasing SAF accessibility

- 14 Projects were funded in areas relating to the development, demonstration, and application of Aviation technologies with the goal of reducing aviation fuel burn/fuel costs and harmful engine exhaust products.

- FAST grant awardees include established and startup fuel producers; fuel logistics and supply chain companies; engine, aircraft, and component manufacturers; state and local governments; airport authorities; and universities. These awardees will carry out FAST projects in 23 states across the country.

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Focus of A97

- FAST grant awardees include established and startup fuel producers; fuel logistics and supply chain companies; engine, aircraft, and component manufacturers; state and local governments; airport authorities; and universities. These awardees will carry out FAST projects in 23 states across the country.

Under Ascent Project 97, Georgia Tech will project the benefits at the fleet level that could be realized by the FAST Technology Grants in the areas of Fuel Burn/Fuel Cost and NOx Reductions

FAST-Tech Funded Technologies

- FAST-Tech Awards were Announced by the FAA in August 2024 [2]
- Georgia Tech, through ASCENT 97, will be evaluating the following subset of FAST Technologies:
  – Georgia Tech has established a working relationship with most, but not all, of the listed contractors
  – It is still possible that the technologies Georgia Tech evaluates changes slightly

Contractor	FAA's Project Title	FAA Provided Descriptions
APiJET [2][3][4]	Optimizing Flight Routes using Real-Time Operating Constraints via Scalable Ground-Based Software	Enhancement of a ground-based software tool for use by airlines that recommends fuel optimized aircraft routings.
Green Taxi Inc [2][3][4]	Green Taxi Electric Taxi (eTaxi) System for Embraer E-175 Aircraft	Design, manufacture and certification of electric taxi (eTaxi) system on the Embraer E-175 aircraft, eventually expanding to other models.
Heart Aerospace [2][3][5]	Total Hybrid Electric Management and Integration System	Development of a hybrid electric management and integration system to automate dynamic adjustment of parallel hybrid propulsion sources onboard the aircraft.
Honeywell [2][3][4]	Sustainable Electrified Aircraft Power	Advancement of highly efficient, all electric turbogenerator auxiliary power unit to enable aircraft systems electrification and electrified propulsion.

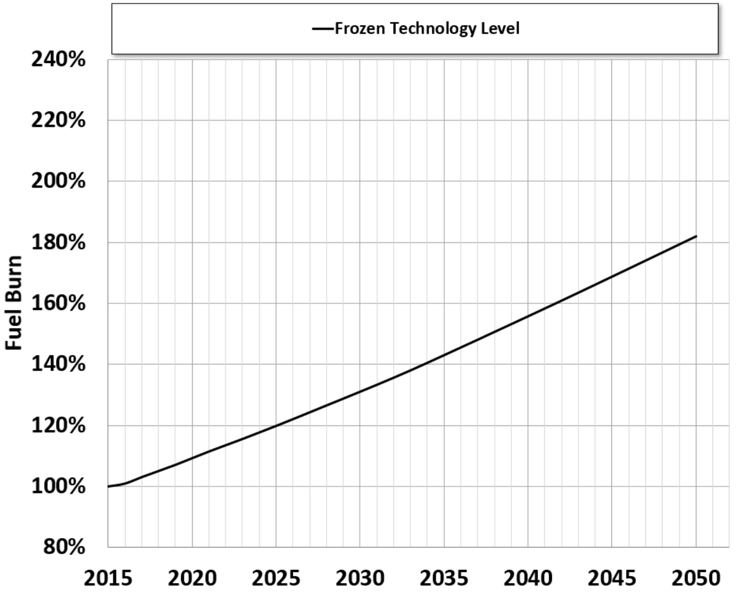
FAST-Tech Funded Technologies (Continued)

Contractor	FAA's Project Title	FAA Provided Descriptions
JetZero [2][3][6]	Blended Wing Body Lightweight Composite Structures	Development of key enabling technologies required to bring blended wing body technology to the market, primarily lightweight composite structures capable of supporting a non-cylindrical pressure vessel, and producible at rates required to meet market demand.
Otto Aerospace [2][3][7]	Wind-Tunnel Testing of a Transonic Aircraft with a Fully-Integrated Slotted, Natural Laminar-Flow Wing	Wind-tunnel testing of transonic, slotted, natural-laminar-flow integrated wing and aircraft design, with a particular emphasis on the wing geometry and how it integrates with the flight test vehicle.
University of Michigan [2][3][8]	Expanding Flight Operations-based Technologies: Fleet-wide and NAS-wide Arrival Flow Optimizer	Optimizing arrival air traffic routing in the extended terminal area through real-time route advisories implemented in the Nexteon SmartRoutes flight planning software service.
Wright Electric [2][3][9]	Ultra High Energy Battery	Development of a high temperature molten Lithium-Sulfur battery with roughly 3 times the capacity of commercial lithium-ion batteries, with an emphasis on reducing risks tied to airworthiness and high-volume production
ZeroAvia [2][3][10]	Project Hydrogen Aircraft Engine Zero Emission Leap	Design, build, integration and test of a suite of hydrogen fuel cell powered propulsion system technologies, including inverter, motor, and integrated systems.

Importance of Aviation Technology Programs – Fuel Burn

- Without technological improvement aviation fuel burn will worsen over time
  - Fuel consumed by U.S. commercial carriers in 2024 was ~19 billion gallons at the cost of ~48 billion dollars [11]
  - **Existing aircraft combined with increases in demand results in increases in fuel burn/fuel costs**

Fuel burn predictions from Georgia Tech's CLEEN I/II fleet analysis [15]



The CLEEN I/II analysis assumed a 2015 base year. Fleet assumptions will be updated for the CLEEN III Study [15]

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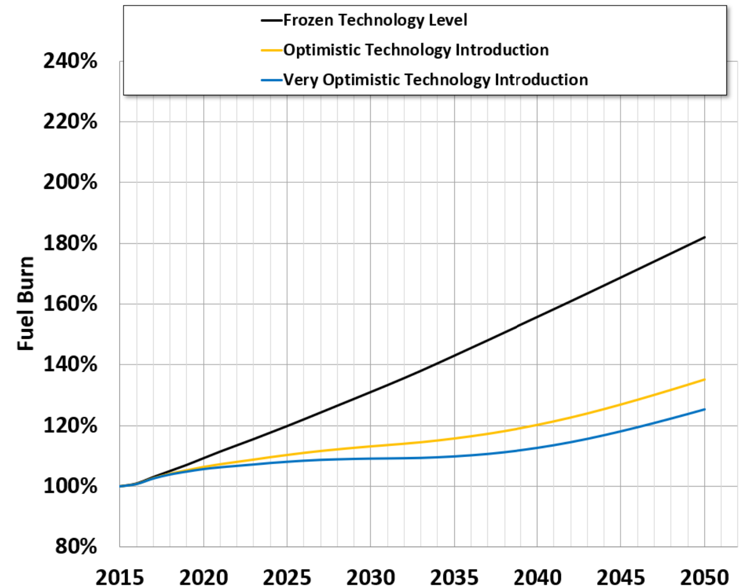

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  - Technological advancement is required to keep fuel burn/fuel costs at even close to current levels
  - At the scale of U.S. commercial carriers consume fuel, even a couple of percent improvement to aircraft's "Miles Per Gallon" equivalent results in cumulative **savings of billions of gallons of fuel and billions of dollars**

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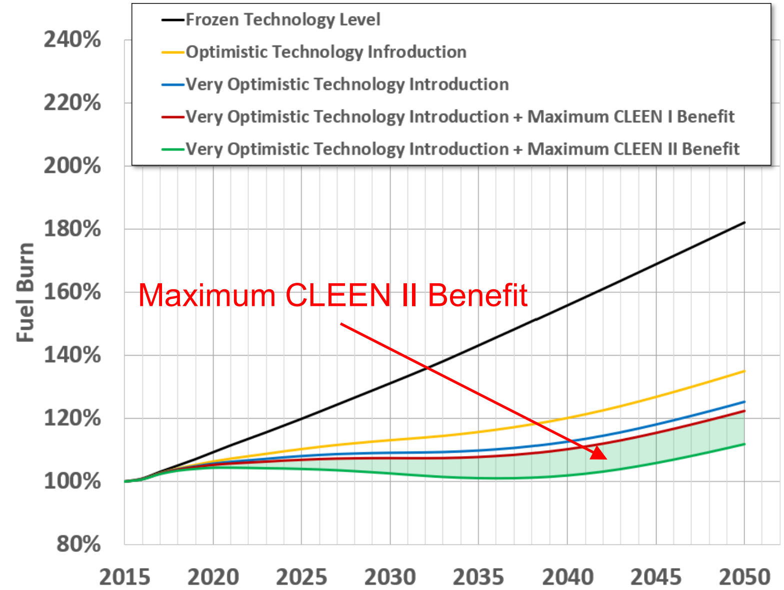

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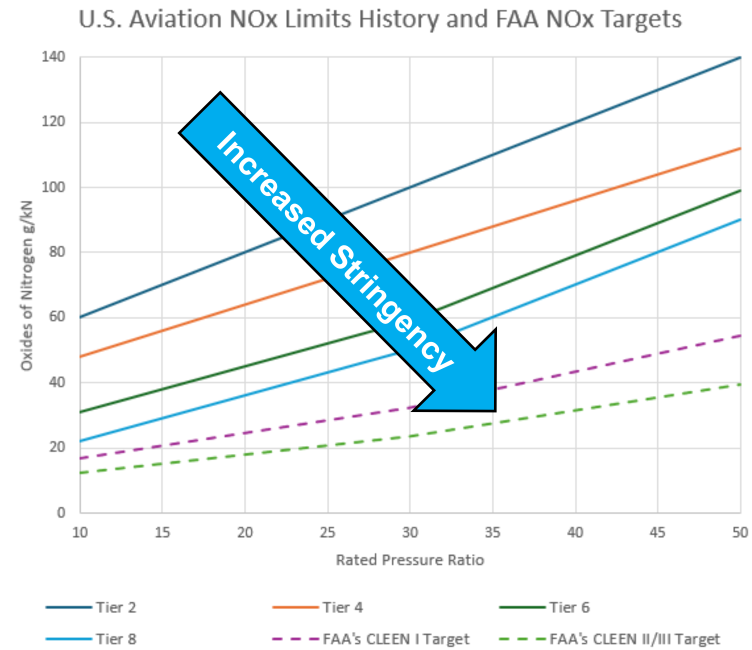
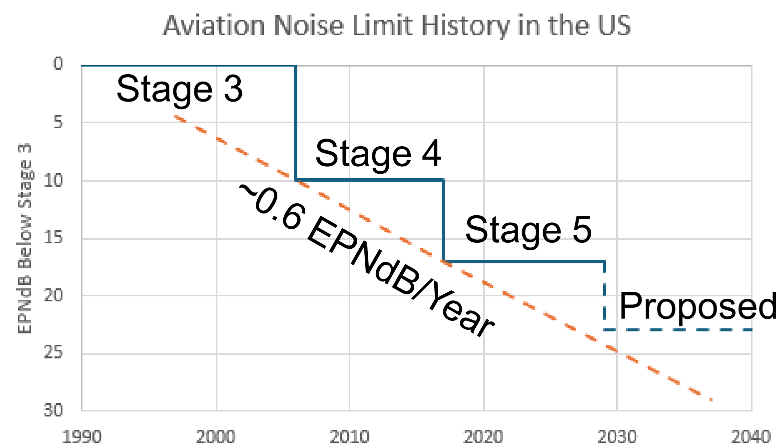
A major question ASCENT 97 seeks to answer is, "Will FAST-Tech funded technologies contribute to increasing the future aircraft fuel efficiency?"

Importance of Aviation Technology Programs – Certification

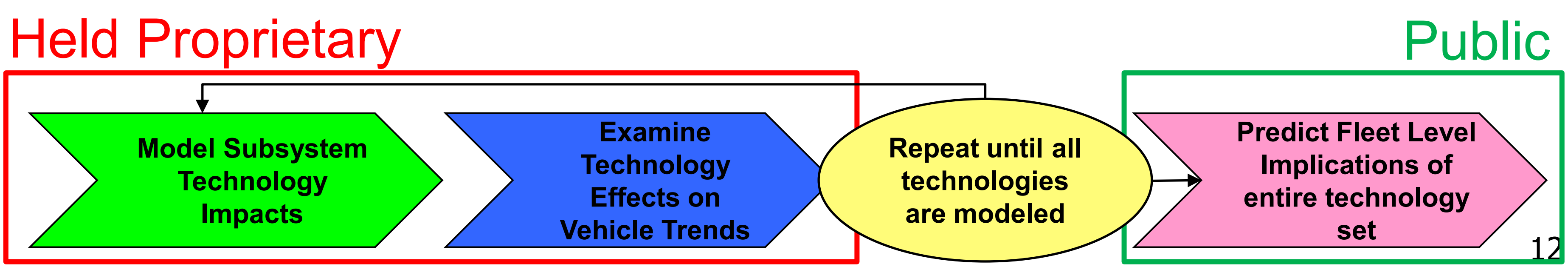
- Certification standards are becoming increasingly stringent over time, requiring technological improvement
- Oxides of Nitrogen (NOx)
  - Regulatory standards have become stricter over time [12]
  - The FAA has targeted even further reduction NOx reduction which will assist in meeting future regulations [1]
- Noise
  - Noise standards have followed a trend of expecting ~0.6 EPNdB reduction per year
  - New proposed standards for 2029 [13]
- Fuel efficiency metric adopted as new standard [14]



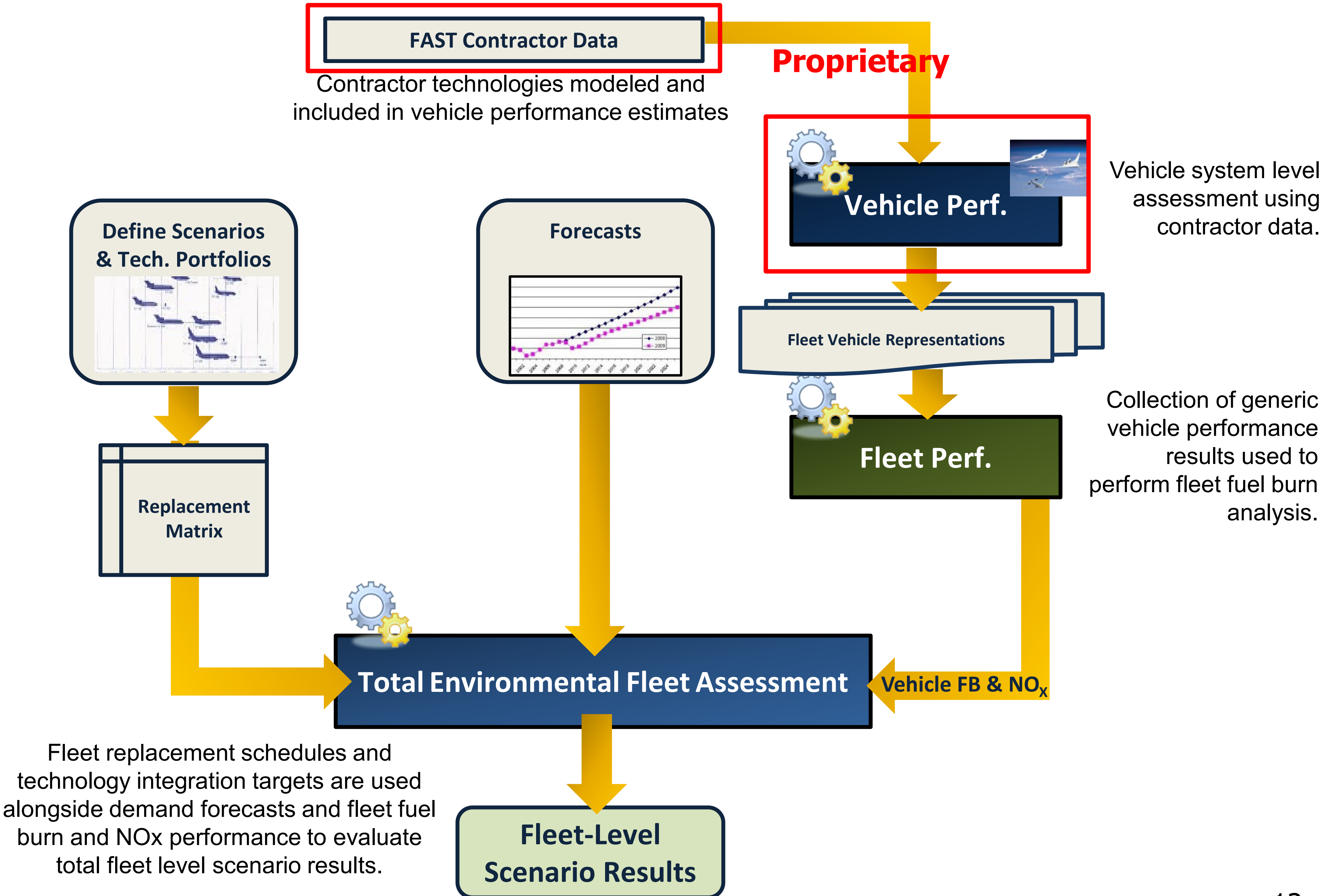


ASCENT Project 97 Overview

- Georgia Tech's objective in ASCENT Project 97 is to model and assess technologies under FAST-Tech program, to evaluate the if the technology set funded by FAST-Tech will improve target fleet level metrics
- Georgia Tech FAST-Tech efforts falls under two categories:
  - Technology Assessment
    - Technology modeling done with contractor input and data protected under NDAs
    - Technology modeling/validation process will be unique for each contractor
    - Aim is to predict vehicle level trends resulting from FAST-Tech technologies rather than creating a one-to-one representation of each technology
    - Prediction of the delta due to technology application is the result of this effort
  - Fleet Assessment
    - Establishment of baseline vehicle models, public technology set, base year fleet operations, and demand forecast model
    - Adapt fleet methodology for considerations of the FAST-Tech technology set
    - Predict fleet Fuel Burn/Cost and NOx reductions due to FAST-Tech technologies



FAST-Tech Fleet Benefit Assessment Problem Formulation



How Technologies are Organized: Technology Impact Matrix (TIM)

- TIM used to quantify combined technology impacts
- Separate TIM for each distinct EDS* vehicle model, captures comprehensive list of technologies
- Translates technology impact to EDS variable impact
- Stores baseline vehicle EDS vector
- Various type of impacts can be applied:
  - Scalar (Additive)
  - Scalar (Multiplicative)
  - Delta
  - Switch
  - Absolute
  - Noise

150 Passenger Vehicle Notional & Truncated

Technologies

EDS Variables

DoE Variable Name	#	Units	Tech Combo Rule	Tech Combo Rule	1995 Baseline	T1 Wing Structure Tech	T2 Aero Tech 1	T3 Aero Tech 2	T4 Aero Tech 3	T5 Engine Tech 1	T6 Engine Tech 2	T7 Engine Noise Tech	T8 Airframe Noise Tech	LSA EDS Vector
FCDO	1	NONE	Scalar	3	1		-0.1	-0.02						0.88
FCDI	2	NONE	Scalar	3	1		-0.05	-0.01						0.94
Duct15_dP	3	%	Delta	2	0.015					0.005				0.02
T4max	4	degR	Delta	2	3300						500			3800
JETTO	5	NONE	Noise	4	0							-3		-3
MGRAP	6	NONE	Noise	4	0								-0.6	-0.6
CCC	7	NONE	Switch	5	0				1					1
AR	8	LBM / IN^3	Absolute	1	9.741				10.5					10.5
GW	9	LBF	Absolute	1	174900	154900								154900
Ext_Ratio	10	NONE	Absolute	1	0.94						1.05			1.05

*EDS = Environmental Design Space, GT modeling & simulation environment

How Technologies are Organized: Technology Compatibility Matrix (TCM)

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- TCM checks for compatibility between technologies

- Four options for compatibility
  - Incompatible = -1
  - Compatible = 0
  - Enabler = 1
    (i.e., must be applied together)
  - Interaction = 2

- TCM informs changes to the tech packages / impacts are made accordingly

150 Passenger Vehicle
Notional & Truncated

	T#	T01	T02	T03	T04	T05	T06	T07	T08
T#	TECHNOLOGY NAME	Wing Structure Tech	Aero Tech 1	Aero Tech 2	Aero Tech 3	Engine Tech 1	Engine Tech 2	Engine Noise Tech	Airframe Noise Tech
T01	Wing Structure Tech								
T02	Aero Tech 1	0							
T03	Aero Tech 2	0	1						
T04	Aero Tech 3	0	-1	-1					
T05	Engine Tech 1	0	0	0	0				
T06	Engine Tech 2	0	0	0	0	0			
T07	Engine Noise Tech	0	0	0	0	2	0		
T08	Airframe Noise Tech	0	0	0	2	0	0	0	

Technologies

Technologies

Modeling Challenges Resulting from Technology Set

- The technology set necessitates several changes to the initial fleet assessment methodology that Georgia Tech developed for our work with ASCENT 37 [15]
  - Aircraft configurations other than Turbofan Tube and Wing w/ Jet A fuel must be modeled. Based on the funded technologies the following configurations must be included:
    - Blended Wing Bodies
    - Hybridized Turboprop
    - Hydrogen Fuel Cell power source
    - Battery based power source
  - Fuel Savings (and the other factors resulting from reduction in Fuel Consumed) can no longer be calculated by just the reduction in Gallons of Jet A consumed
    - A metric considering alternative fuels must be used
  - In prior Fleet Studies conducted by Georgia Tech, (such as CLEEN), it could be assumed that all new vehicle deliveries would be new Turbofan Tube and Wing w/ JetA aircraft that would be replacing older retiring Turbofan Tube and Wing w/ JetA aircraft, (or being order to serviced increased demand)
    - This assumption no longer holds

Project Timeline

2024

- Formation of Georgia Tech's FAST-Tech team
- Selection of fleet methodology
- FAA grant announcement
- Development of modeling capability based on public research

2025

- Development of modeling capability based on public research
- Establish contractor relations
- Hold contractor kickoff meetings held
- Development of FAST-Tech technology models

Current Effort

2026

- Development of FAST-Tech technology models
- Completion of multiple technology models
- Fleet assessment challenges addressed, and methodology updated
- Conduct preliminary test run of fleet study possible if enough technologies modeled

2027

- Complete remaining technologies models
- Address any shortcomings discovered in test fleet study test
- Simulate final fleet study

Georgia Tech is dependent on the completion of all contractor FAST Efforts to produce the data required for the fleet study and the timeline will be affected by any delays

Summary Remarks

- Georgia Tech is nearly done with the establishment of working relationships with all FAST-Tech contractors
- Majority of Georgia Tech's resources are currently devoted to the technology modeling efforts
  - Initial set of technology modeling efforts should be completed in the first half of 2026
  - As the technology modeling efforts are completed, resources can be redirected to perform the fleet study
- Objective for next year:
  - Progress remaining technology modeling efforts
  - Make updates to the fleet environment and progress to the point where test runs for the fleet study can be conducted

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Thank you !

Questions ?