ASCENT Project 050

Over-Wing Nacelle Placement Evaluation

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Cost Share Partner: Georgia Institute of Technology

Objective:

- Use multidisciplinary design analysis and optimization (MDAO) methods to assess environmental impact of over-wing nacelle (OWN) placement
- Emphasis on high fidelity aerodynamics to capture drag penalty

Project Benefits:

- Enable accurate tradeoffs between noise benefits and fuel burn penalties
- Demonstrate computationally efficient methods for aircraft design studies

Research Approach:

- Computational efficiency is key challenge
- MDAO architecture aims at efficient information passing between disciplines: aerodynamics, propulsion, weights, noise
- Probability-based design methods aid efficiency
  - Design dimension reduction
  - Adaptive sampling
  - Multi-fidelity

Major Accomplishments (to date):

- Aircraft mission and propulsion cycle models
- CFD optimization of baseline nacelle
- Aero-propulsion coupling technique tested
- Active subspace reduces design space
- Multi-fidelity adaptive sampling tested

Future Work / Schedule:

- Test full multidisciplinary analysis (MDA) (summer 2021)
- Sequential stages of large-scale CFD-based optimization (fall/winter 2021)
- Final deliverable in Feb 2022

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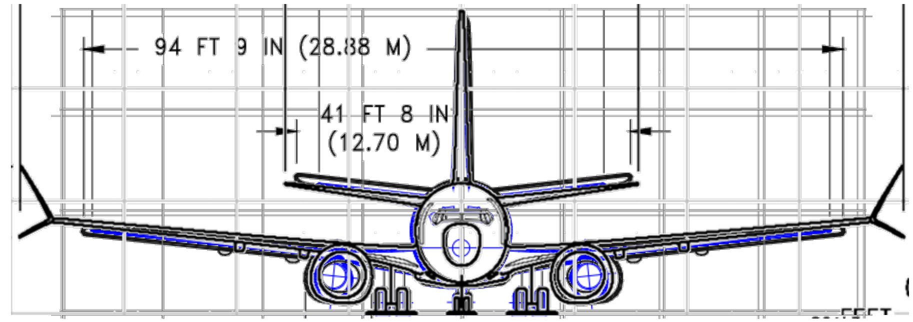
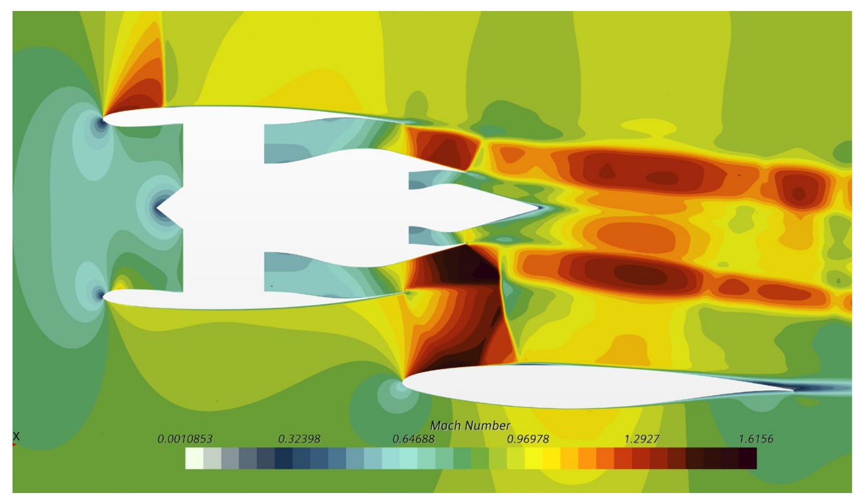
Aircraft/Engine Models Reflect FAA Priorities

- 150-pax aircraft mission model
  - Modified, notional A320Neo-like
- High (and very high) bypass ratio engine models
  - NPSS and WATE++ (NASA design tools)
  - Baseline geared turbofan engine model similar to the PW1127G design
  - Tools capable of modeling "next gen" higher BPR designs
- FAA focus on forward-mounted OWN
  - Noise shielding from wing
  - However, complicated aerodynamic interaction with wing



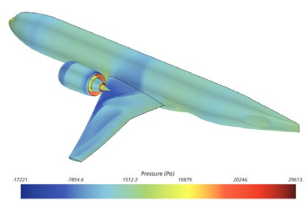
Limitations of under-wing space for typical 150-pax evolution.
Source: 737 Airport Planning Documents

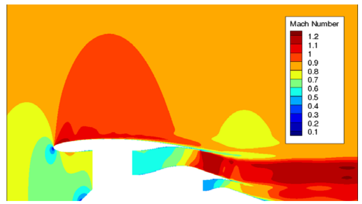


Mach number

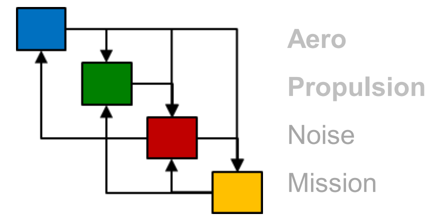
Recent Accomplishments

Setup of high performance computing for computational fluid dynamics (CFD)

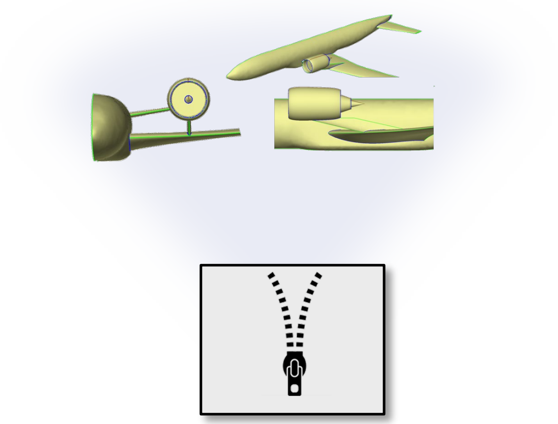




Architecting of multidisciplinary analysis



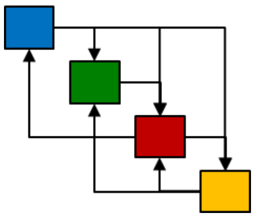
Mathematical techniques for computationally efficient optimization



Next steps: optimization on supercomputing clusters

Ex: Coupled Aero-Propulsion Challenges Addressed

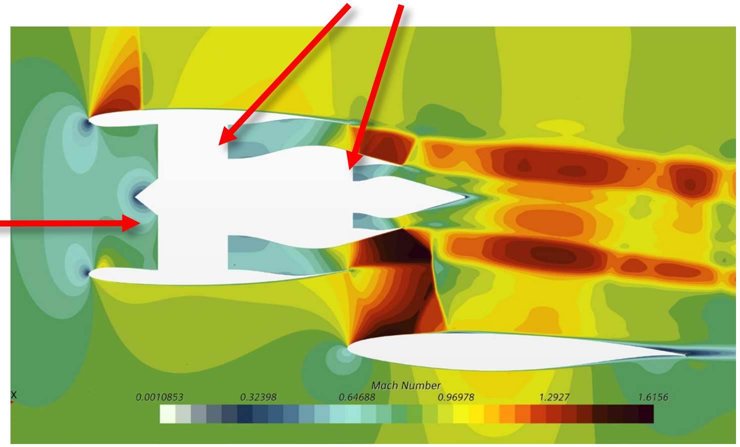
- Two-way coupling requires iterative solution with expensive CFD analysis



Aero
Propulsion
Noise
Mission

Engine cycle calculation between inlet and nozzle provides CFD boundary conditions

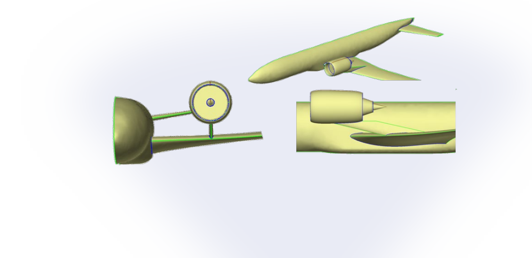
CFD provides inlet properties to engine cycle code

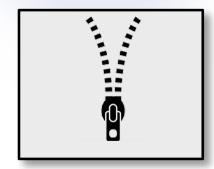


- Presence of wing influences exhaust plume
- Need iterative solution

Techniques Implemented for Optimization Efficiency

- Active subspace method "compresses" design space
  - Goal is computational tractability
  - Wing and nacelle shape variables
  - Most of the impact of 45 variables captured in ~5 transformed variables





- Multi-fidelity methods currently being tested
  - High fidelity CFD and lower order aerodynamics used together