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
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

**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