Aviary: An Open-Source Multidisciplinary Design, Analysis, and Optimization Tool for Modeling Aircraft with Analytic Gradients

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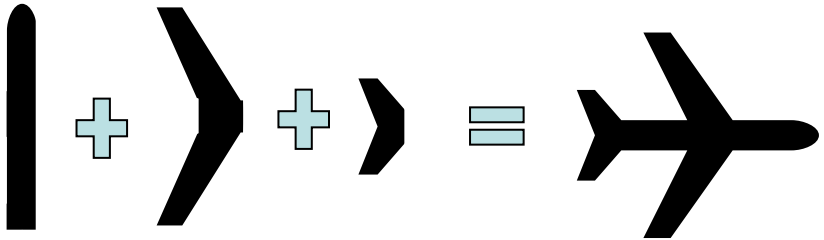
Today's Roadmap

This presentation covers:

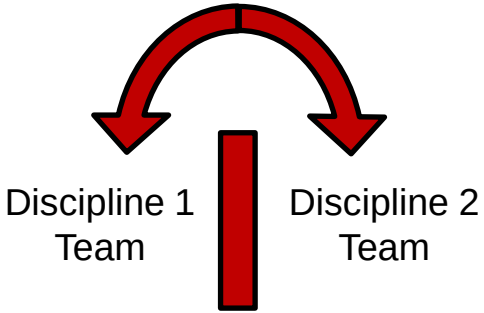
- Historic and future aircraft modeling needs
- The Aviary tool meets these needs
- How Aviary works
  - The structure of Aviary
  - The calculation methods in Aviary
  - The verification of Aviary
  - The user's interaction with Aviary

Historic Aircraft Modeling and the Need for a New Tool

Traditional Design Method

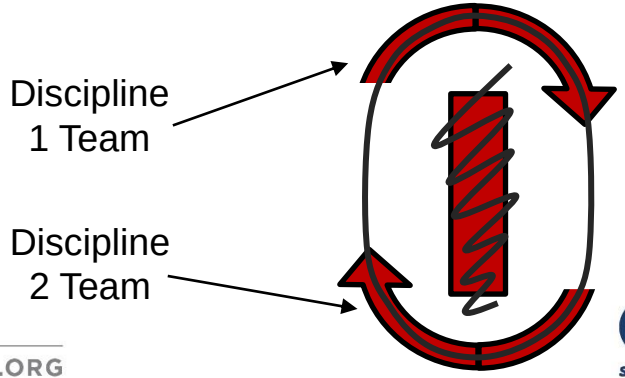


Data thrown “over-the-wall”
Manual iteration required



New Advanced Digital Design Method

Data coupled together
No manual iteration required



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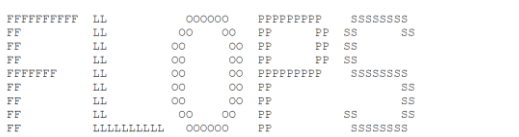
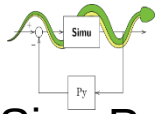
Aviary Builds on Legacy Tools and Meets this Need



General Aviation Synthesis Program

openMDAO

dymos



(SimuPy)

AVIARY

Combine legacy tools

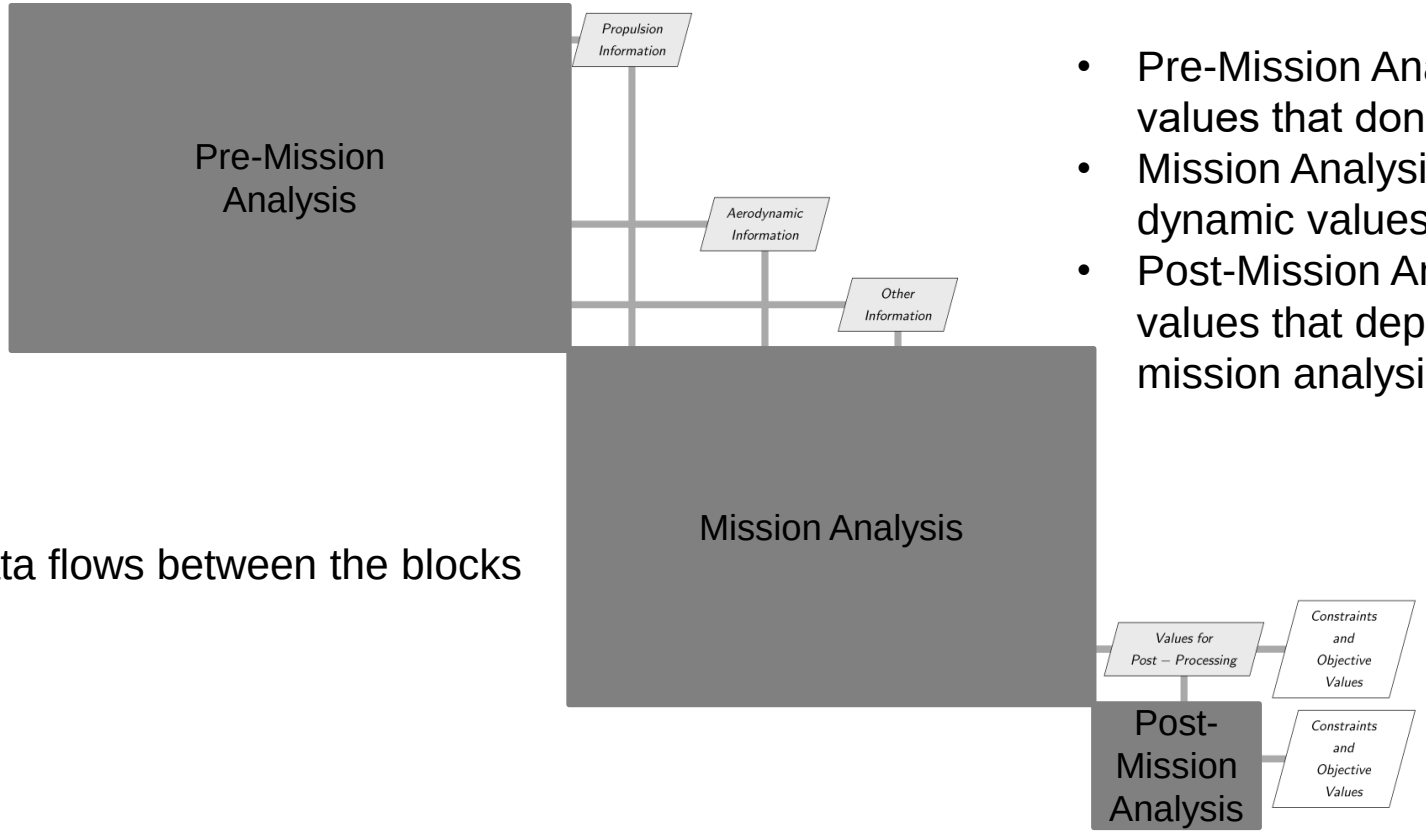
Modular for modification and substitution

Coupled Optimizations

Analyze advanced concepts

Open-source software

The Structure of Aviary



- Pre-Mission Analysis calculates values that don't change in time
- Mission Analysis calculates dynamic values
- Post-Mission Analysis calculates values that depend on the mission analysis

- Data flows between the blocks

The Subsystems of Aviary

Pre-Mission Analysis

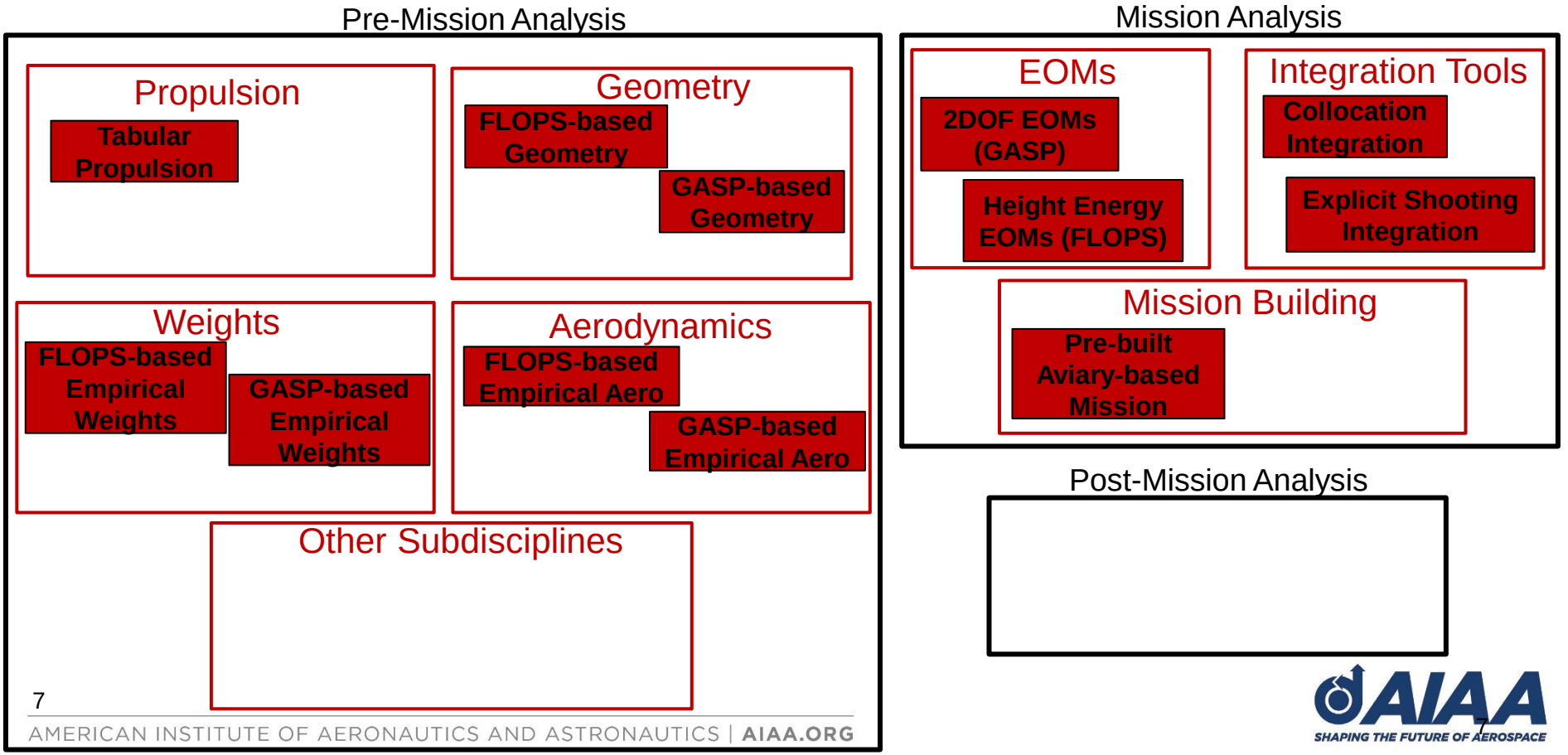
- Propulsion
- Geometry
- Weights
- Aerodynamics
- Other Subdisciplines

Mission Analysis

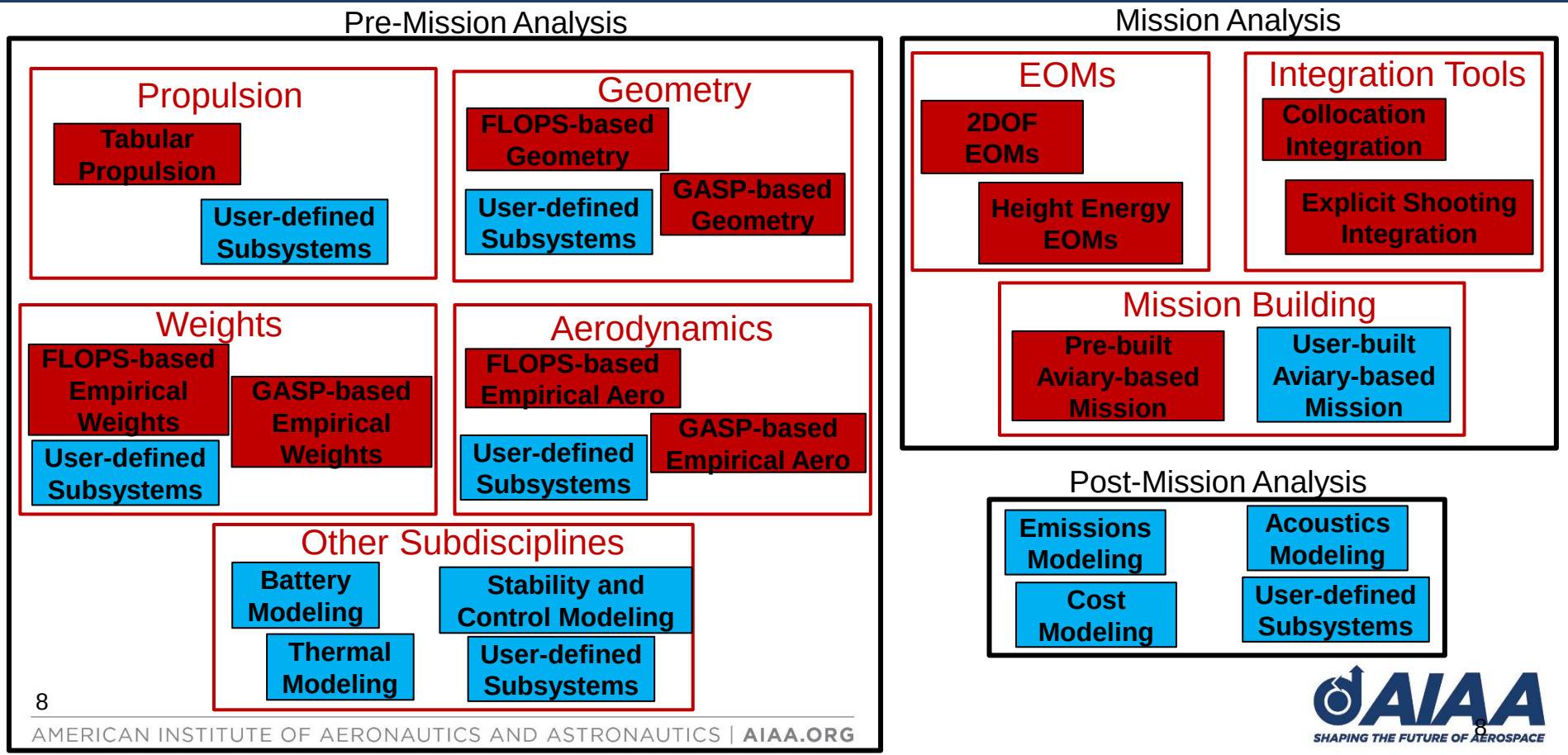
- EOMs
- Integration Tools
- Mission Building

Post-Mission Analysis

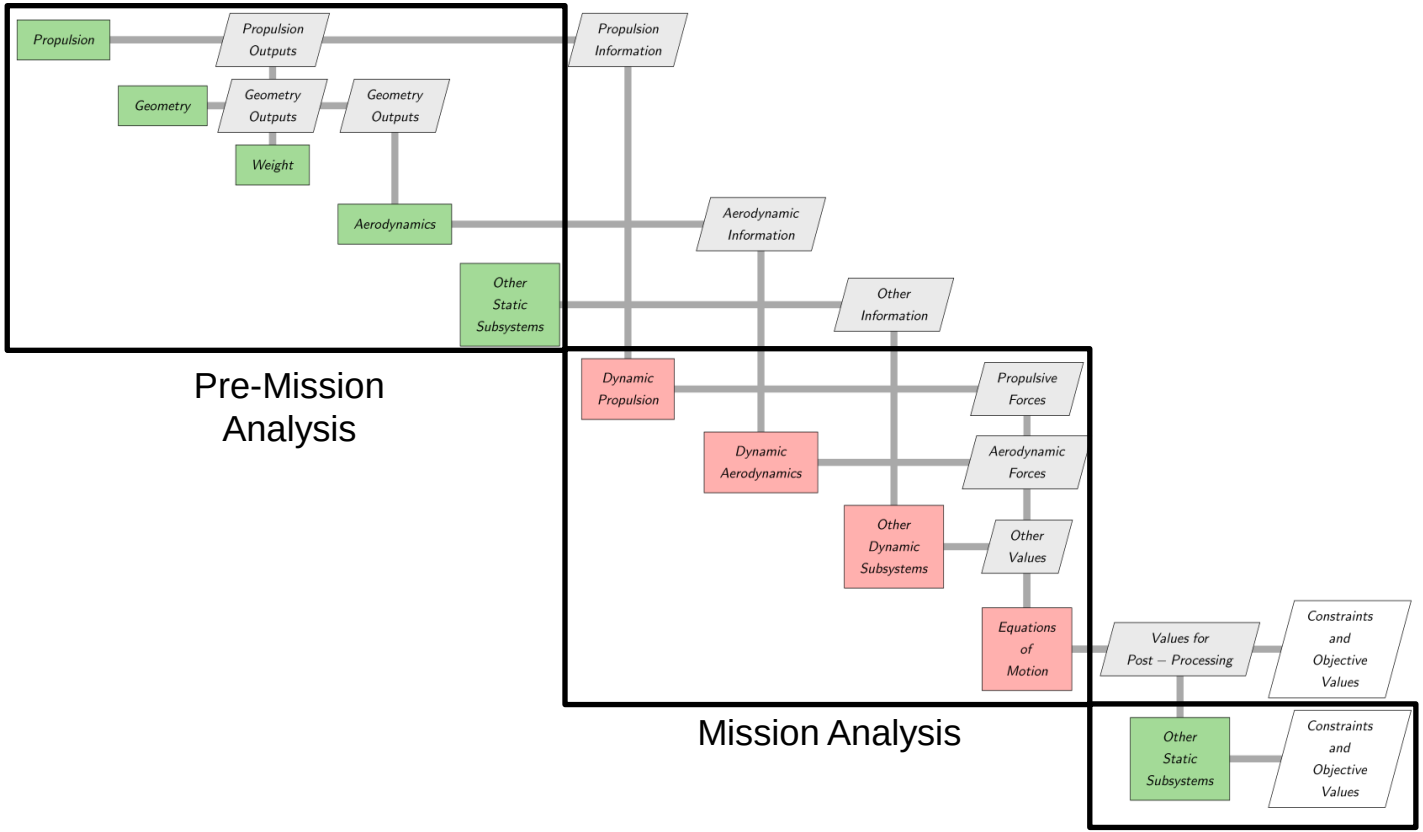
The Subsystems of Aviary



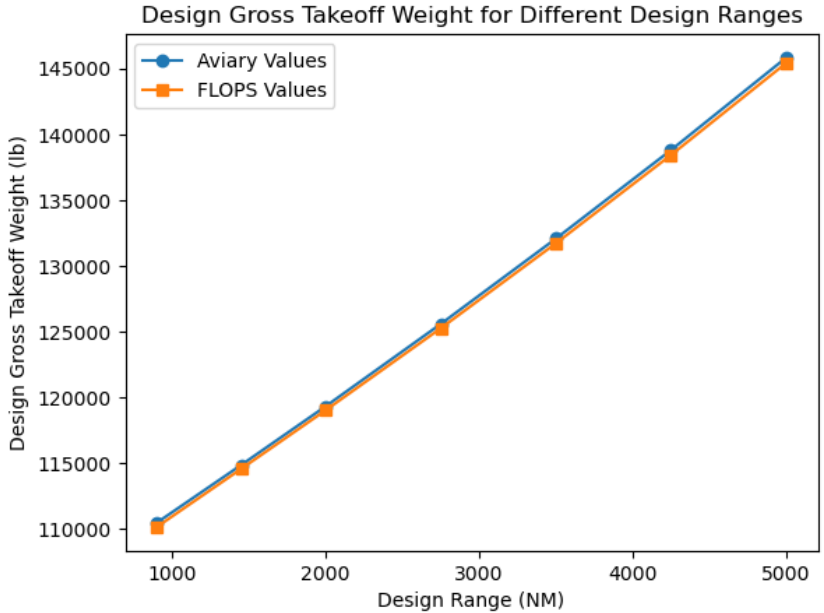
The Subsystems of Aviary



Revisit The Structure of Aviary



Verification of Aviary



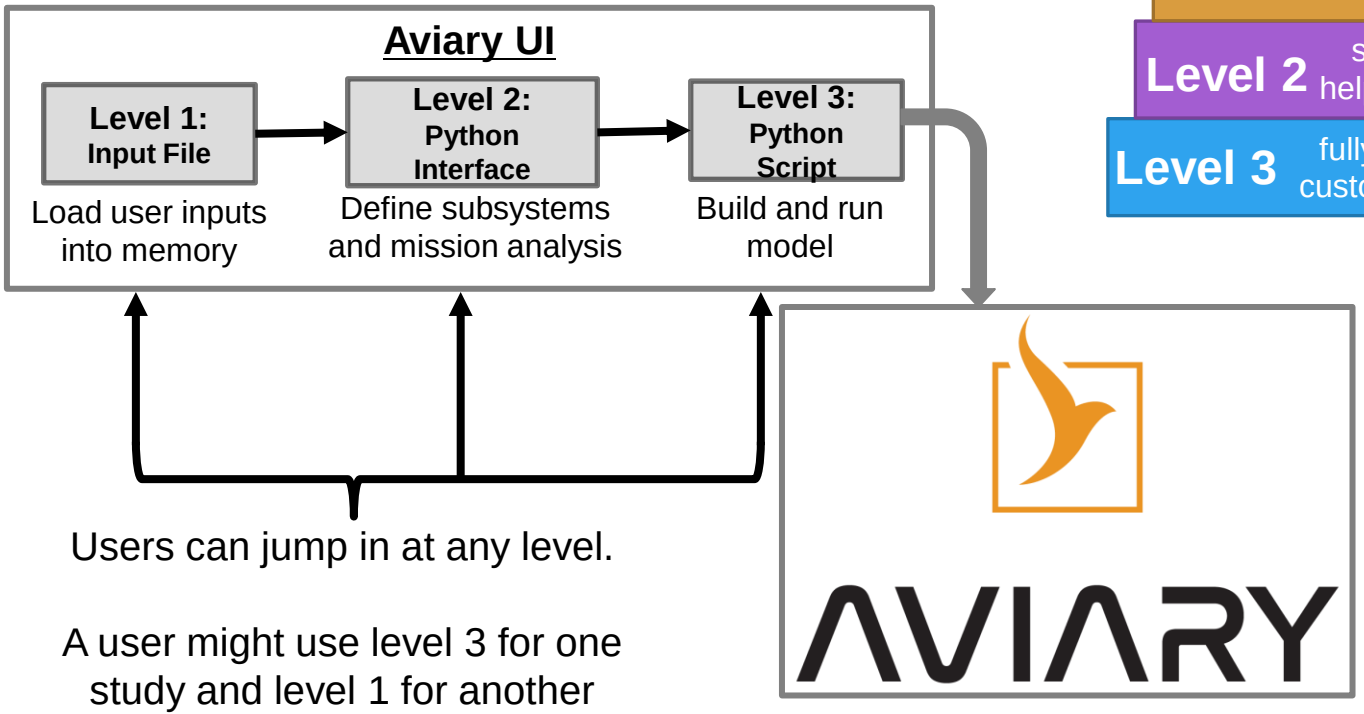
Aviary includes integration (benchmark) testing…

…and unit (component and subsystem level) testing.

Table 2 A summary of the subsystem unit test cases for each subsystem included in Aviary that are compared against legacy tools' results for verification.

Subsystem Tested	Unit Test Tolerance	Derivative Test Tolerance	Test Case Notes
GASP-based aerodynamics	1.5e-3	N/A	Derivatives only checked in the component unit tests (same for FLOPS aerodynamics).
FLOPS-based aerodynamics	5e-3	N/A	Some extrapolated points require looser tolerance due to difference in interpolation methods.
GASP-based geometry	5e-4	1e-9	Some values slightly altered to account for intentional changes in the code.
FLOPS-based geometry	1e-2	1e-6	Does not test canard features. Loose tolerance primarily due to roundoff error in FLOPS data.
GASP-based mass	5e-4	3e-9	Some values slightly altered to account for intentional changes in the code.
FLOPS-based mass	1e-4	1e-10	
Propulsion	1e-10	1e-10	This tests the scaled sea-level static thrust from pre-mission.

How the User Interacts with Aviary



Users can jump in at any level.

A user might use level 3 for one study and level 1 for another

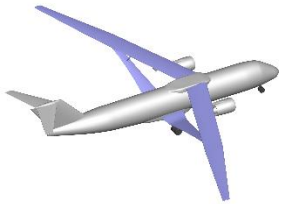
Level 1 text input file → No coding required

Level 2 script using helper functions → Swap subsystems, small setup tweaks

Level 3 fully scripted, custom analysis → Supreme model flexibility

Summary

This presentation covered:



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https://github.com/OpenMDAO/Aviary

Related Works

Papers Using Aviary:

- "Multidisciplinary Optimization of a Transonic Truss-Braced Wing Aircraft using Aviary" by Eliot Aretskin-Hariton et al. Published at AIAA SciTech 2024.
- "Noise Reduction Trajectory Analysis of a Supersonic Business Jet using Novel Optimization Tools" by Jeshurun Horton et al. Published at AIAA Aviation 2024.
- "Impacts of Hybrid-Electric Propulsion on a Transonic Truss-Braced Wing Aircraft" by Mark Leader et al. Published at AIAA Aviation 2024.
- "Studying the Usability of an Open-source Aircraft Design Tool" by John Jasa et al. Abstract submitted to AIAA SciTech 2025.
- "Optimization of a Multi-Mission Hybrid-Electric Propeller Regional Aircraft using Aviary" by Jason Kirk et al. Abstract submitted to AIAA SciTech 2025.

Additional examples and studies exist on the Aviary github repository.

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