



Revolutionizing Aircraft Design and Technology Assessment through Digital Engineering



Dr. Jesse Quinlan

Strategic Technical Advisor, Advanced Air Vehicles Program (AAVP) Office

AIAA SciTech | F360: Digital Engineering for Next-Generation Aircraft Design and Development

January 6, 2024

NASA's Digital Transformation Strategic Framework

3 FUTURE STATE GOALS

4 TRANSFORMATION TARGETS

5 DIGITAL LEVERS

6 TECHNOLOGY FOUNDATIONS

7+ MISSION OUTCOMES

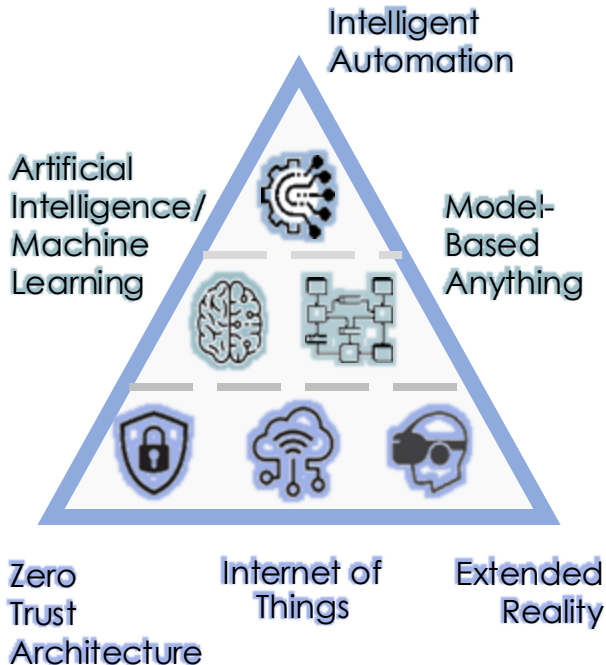
Transform the way we **Work**

Transform the experience of our **Workforce**

Transform the agility of our **Workplace**



- Establish Interoperable **Architectures**
- Transform Critical **Processes**
- Maximize the Impact of our **Data**
- Adopt Common **Tools**
- Strengthen Inclusive³ **Teaming**



NASA TM 20220018538

Digital Transformation at NASA is Agency-wide and capitalizing on strengths and opportunities across all levels of the Agency

NASA's Digital Engineering Need

Improve how the Agency Engineering Domain operates over the entire NASA lifecycle by effectively managing complexity, reducing cost and schedule, and improving product integrity via the integration of processes, digital tools, and techniques along with seamless flow of information throughout the engineering system development life-cycle (concept development, design, testing and validation, manufacturing and operations).

Opportunities for improvement with Digital Engineering at NASA abound, especially within NASA Aeronautics and the Advanced Air Vehicles portfolio

Sustainable Flight National Partnership Benefits

Small Core Gas Turbine for
5%-10% fuel burn benefit

Electrified Aircraft Propulsion
for ~5% fuel burn and
maintenance benefit

Sustainable Aviation Fuels for
reduced lifecycle carbon
emissions



Transonic Truss-Braced Wing for
5%-10% fuel burn benefit

High-Rate Composites for
4-6x manufacturing
rate increase

Integrated Trajectory Optimization for
1%-2% reduction in fuel required
and minimization of contrail
formation

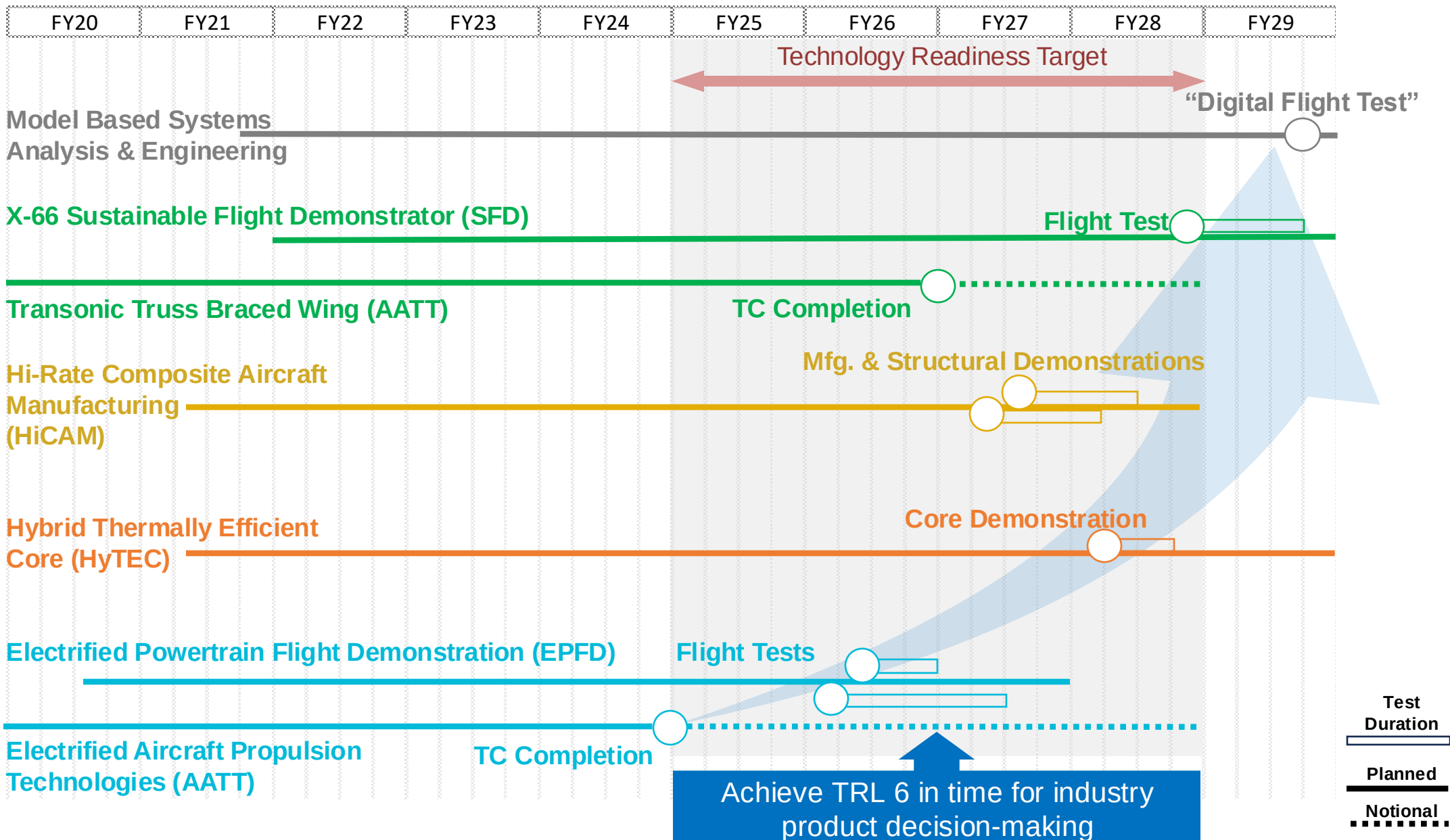
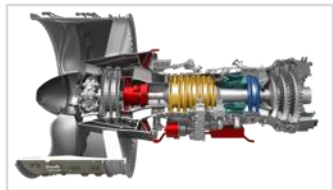
Next-generation transports using up to 30% less fuel, current and future fleets flying optimal trajectories, engines burning sustainable aviation fuels for net-zero lifecycle greenhouse gas emissions

Subsonic Airliner Technologies

Ensure U.S. industry is the first to establish the new “S Curve” for the next 50 years of airliners



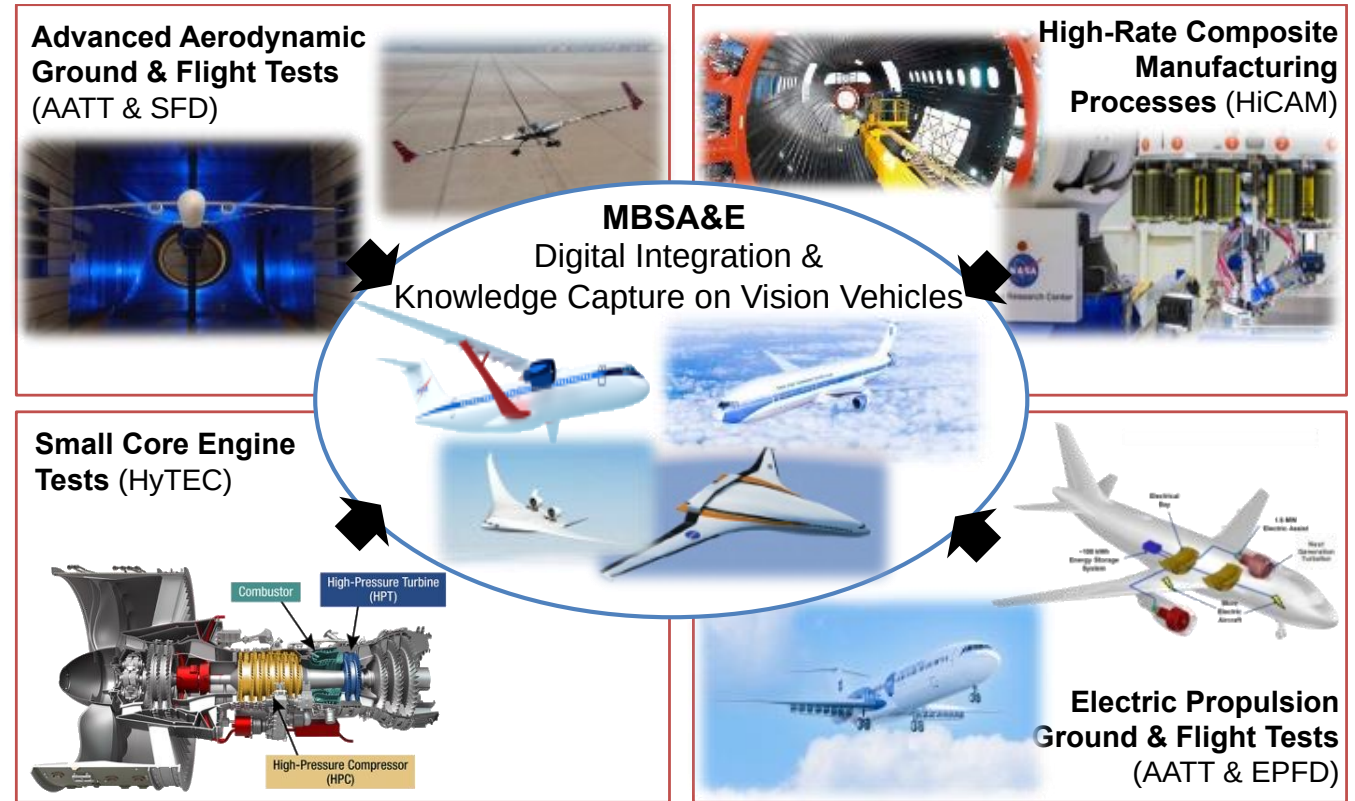
Ultra-Efficient Airlines: SFNP Integrated Technology Development



MBSA&E Vision for the Sustainable Flight National Partnership

Objectives:

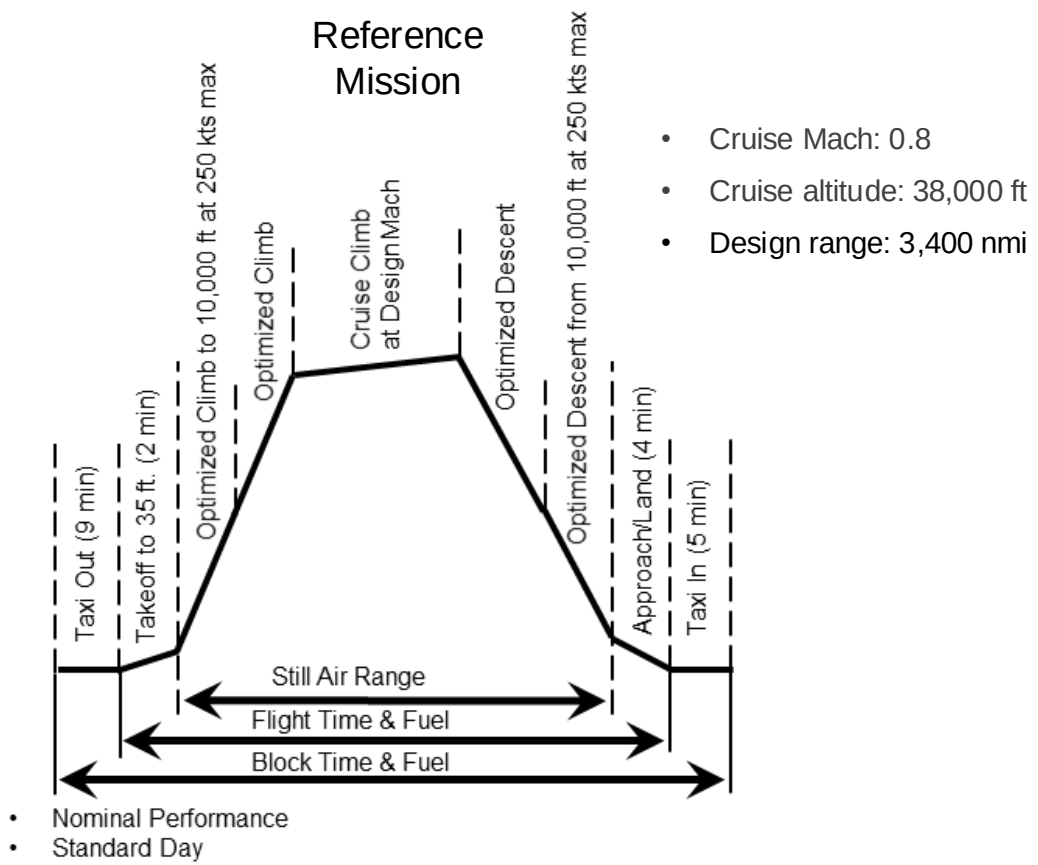
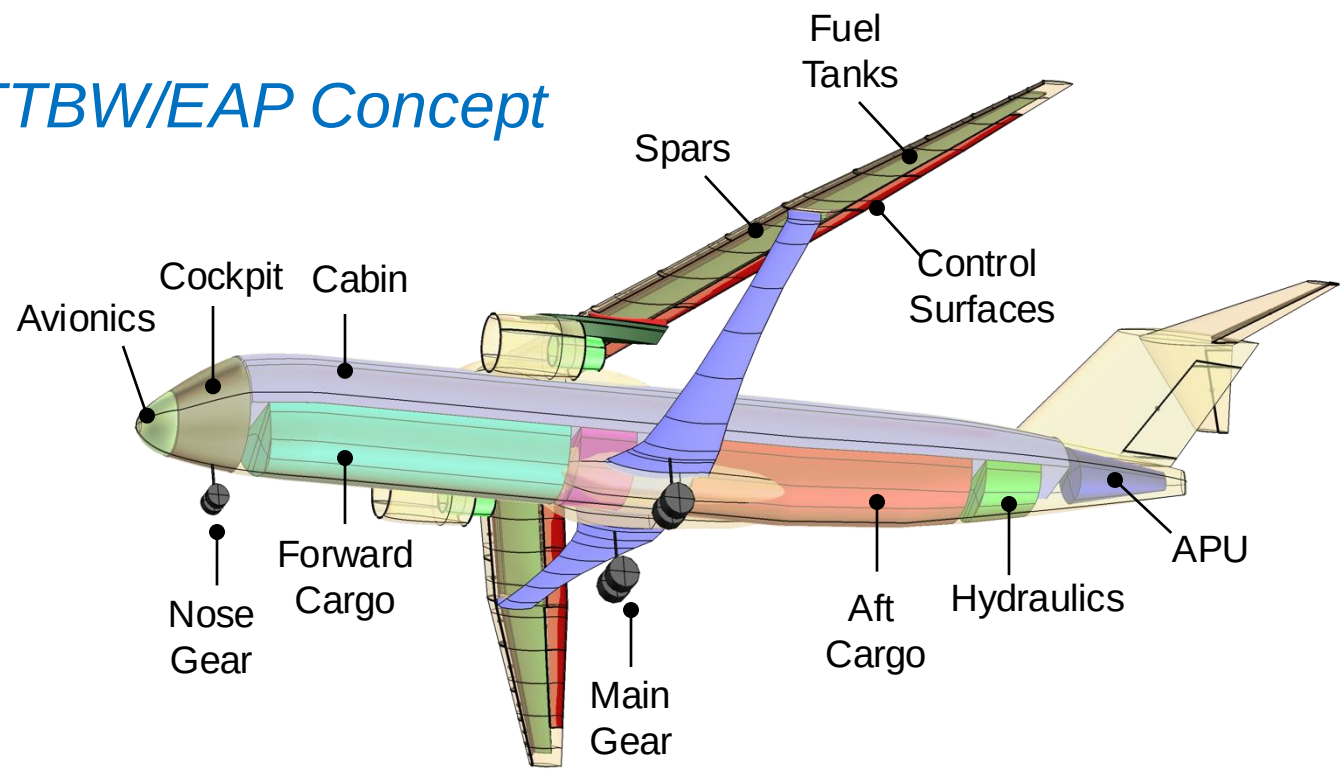
- Develop an open, cross-project, cross-program, external-capable MBSA&E framework building off ARMD investments and capabilities across AAVP/IASP/TACP in support of the SFNP
- Conduct coordinated, integrated systems analysis studies for SFNP
 - Common, open, reference and vision vehicle models
 - Technology benefit assessments and sensitivity studies informed by the SFNP demos



MBSA&E represents a systems-level, digital integration across SFNP projects supporting assessment, advancement, and technology adoption for 2030s entry into service subsonic aircraft.

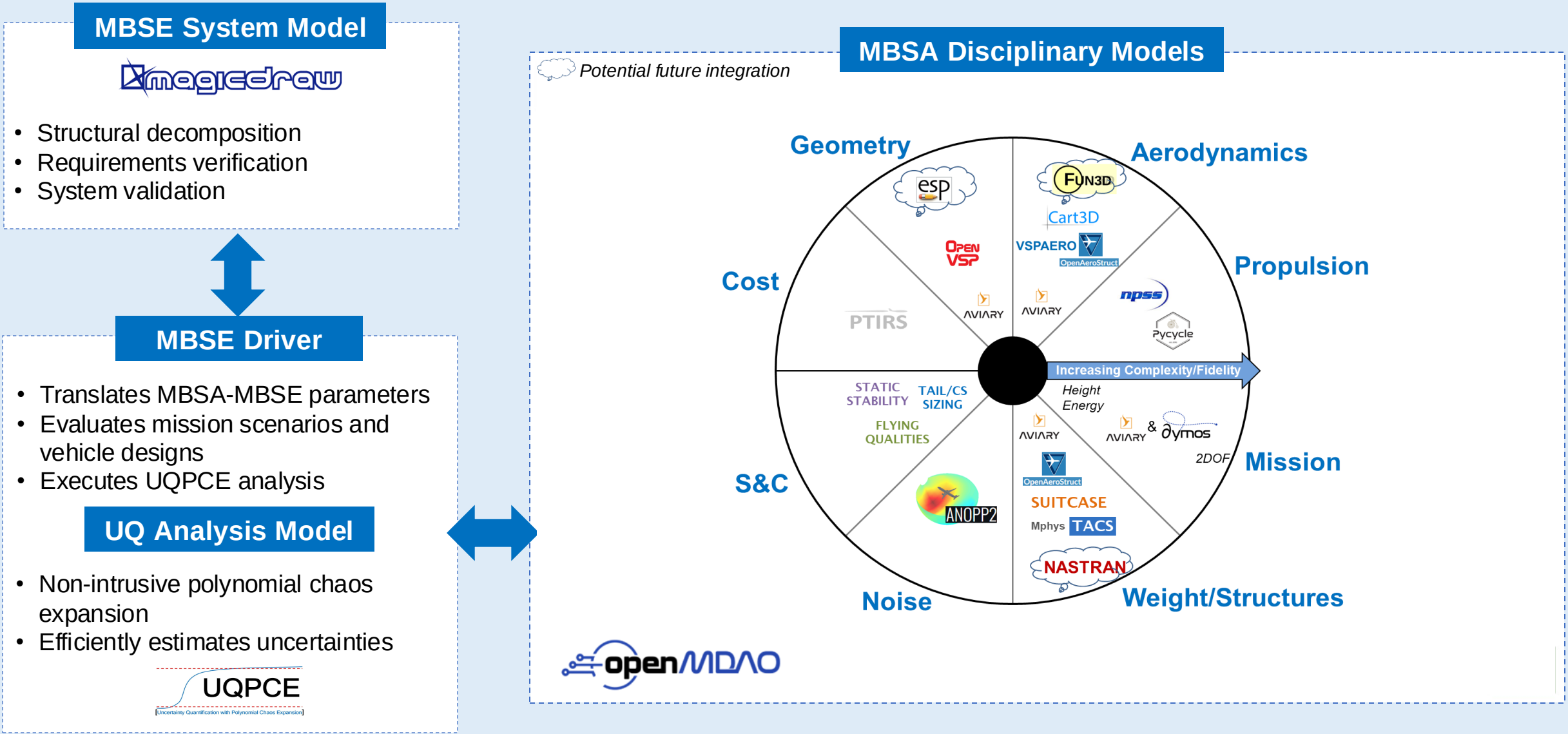
Development of Digital Aircraft Concept Models

TTBW/EAP Concept



Framework development and capabilities are driven through targeted use cases. Advanced tube-and-wing and truss-braced wing aircraft models form the first set.

Development of a Digital Cross-Domain, Multi-Fidelity Architecture

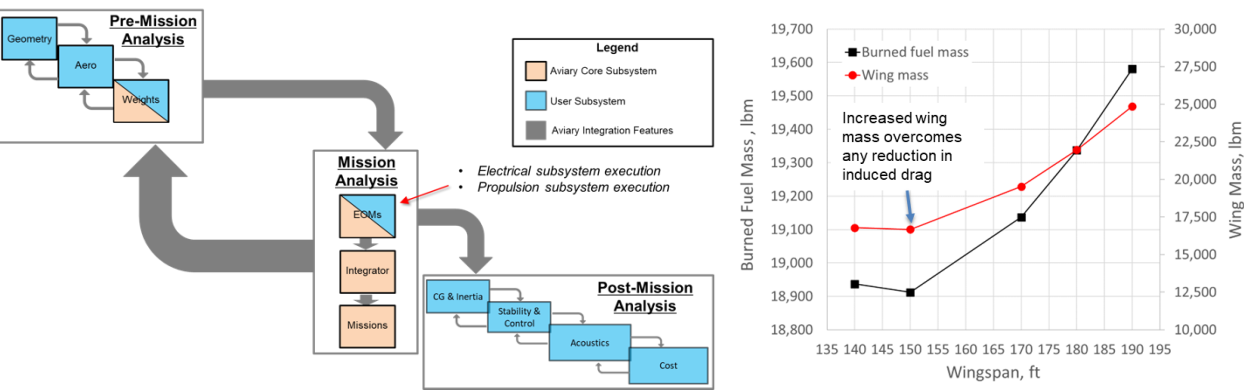


The MBSAE digital workflow enables multi-fidelity design, analysis, optimization, and uncertainty quantification with a combination of commercial and open source tools

Digital Integration Demonstrations

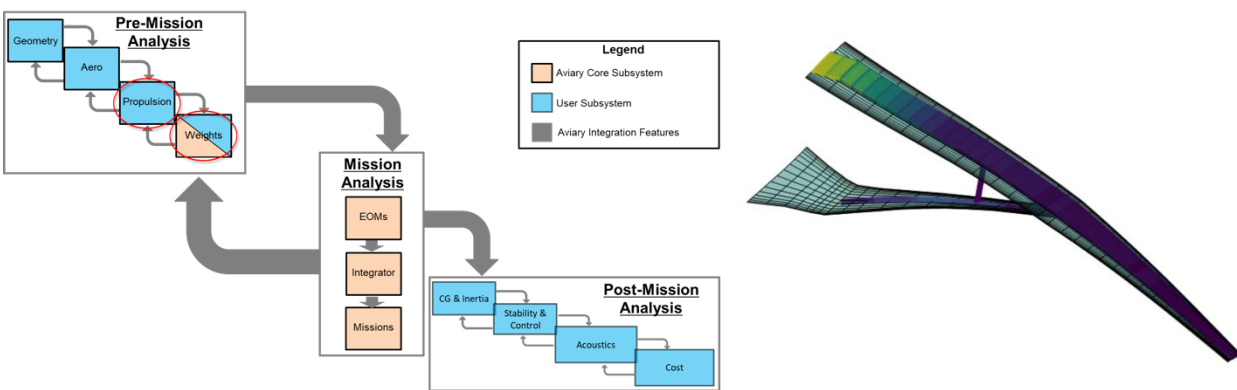
Parametric Verification / Sanity Checks

- Minimize fuel burn
- Design variables include gross mass, engine mass flow, battery current and capacity, motor max power, and trajectory
- Constraints placed on mass residual, state of charge, and trajectory



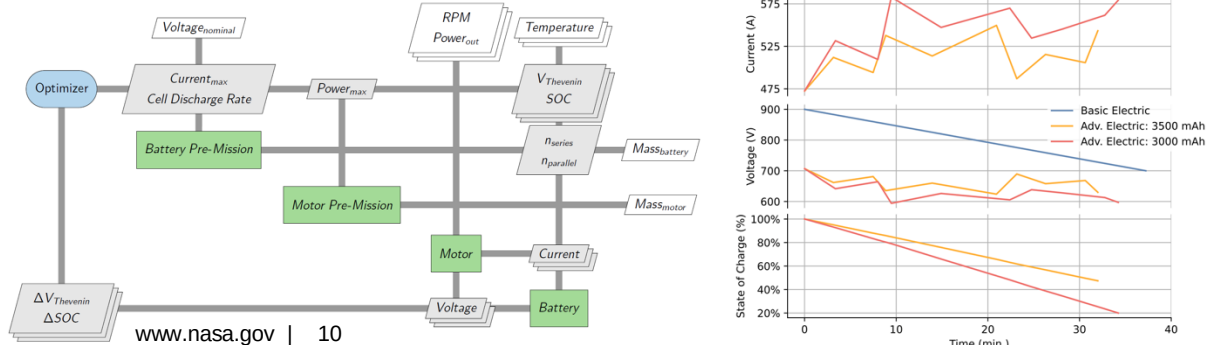
Aerostructural Optimization

- Minimize fuel burn
- Design variables include gross mass, structural sizing, and trajectory
- Constraints placed on mass residual, structural strength, lift-equals-weight, pitching moment trim, and trajectory



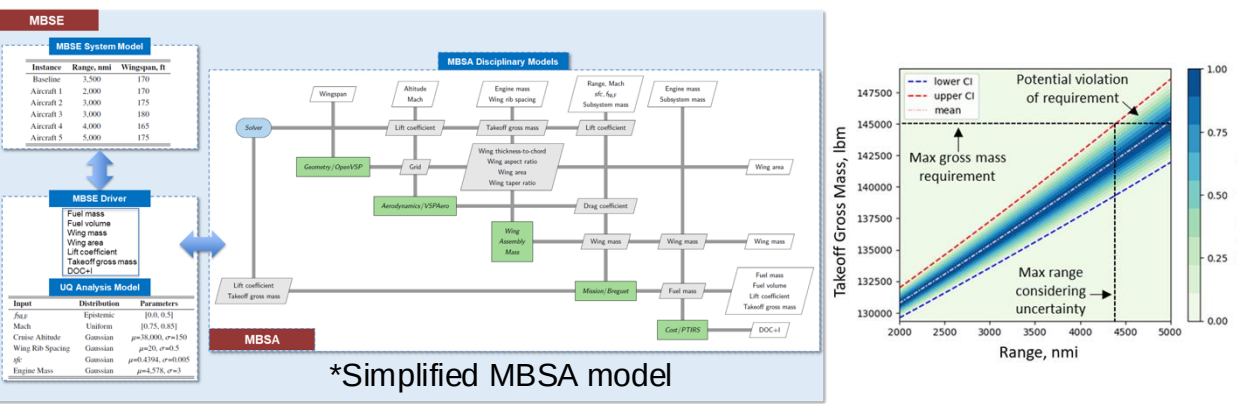
Hybrid-Electric Propulsion Optimization (AIAA Aviation 2024)

- Minimize fuel burn
- Design variables include gross mass, trajectory, engine mass flow, max power and current, battery cell discharge rate and total energy capacity
- Constraints placed on mass residual, trajectory, throttle, Thevenin voltage, min state of charge, and max power and current

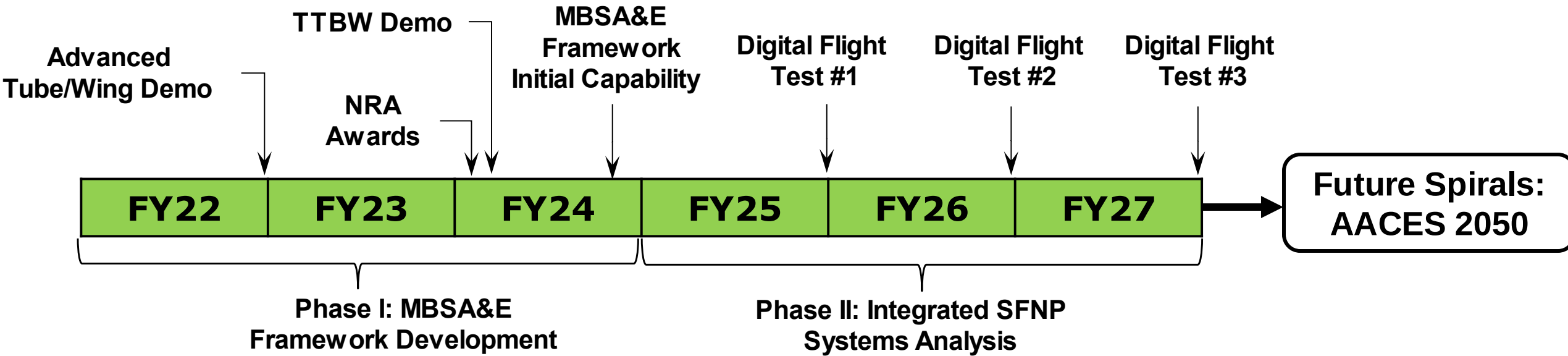


MBSA&E and UQ Integration (AIAA Aviation 2024)

Enables engineers to assess and mitigate uncertainties associated with a system model, design parameters, and constraint inputs, leading to more complete design studies and better-informed decision-making processes



Future Development through Industry, Academia Partnerships



While phase one prototyping emphasized NASA internal development, full success will leverage unique contributions across industry, academia, and government

Follow Us



www.nasa.gov/aero



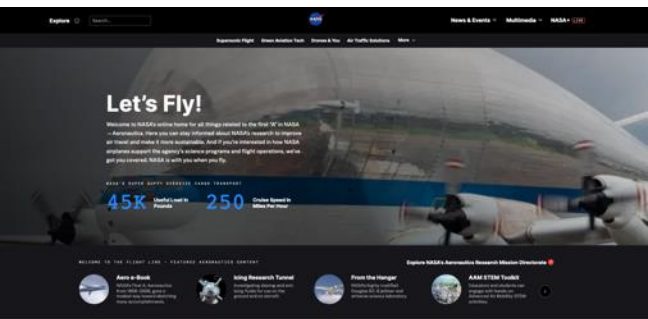
[@NASAAero](https://twitter.com/NASAAero)



[@NASAAero](https://www.instagram.com/NASAAero)



[@NASAAero](https://www.facebook.com/NASAAero)



Latest Aeronautics News



NASA Aeronautics

@NASAAero

- Advanced Air Mobility
- Quiet Supersonic Flight Over Land
- A Transformed Airspace
- Sustainable Aviation

Verification: nasa.gov/socialmedia

nasa.gov/aero Joined August 2014

70 Following 129.8K Followers

