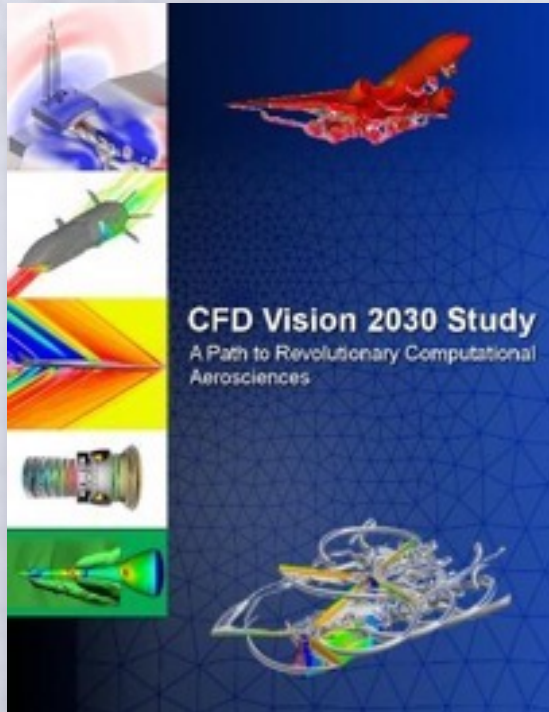


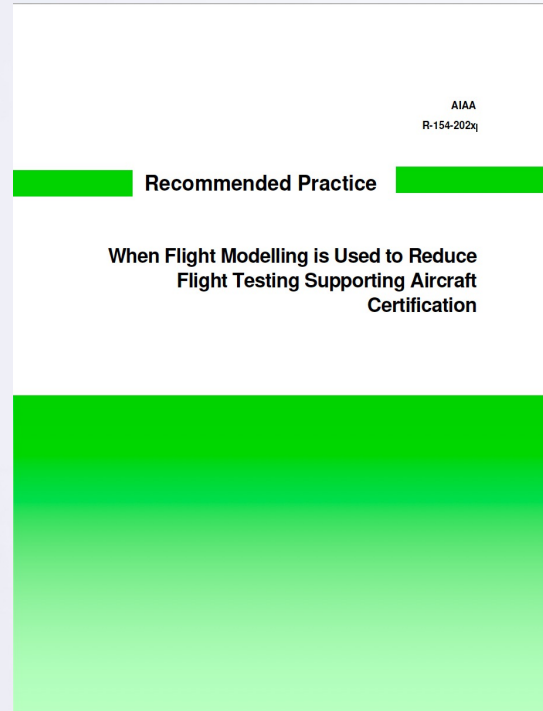
Transformational Tools & Technologies (T³) Project



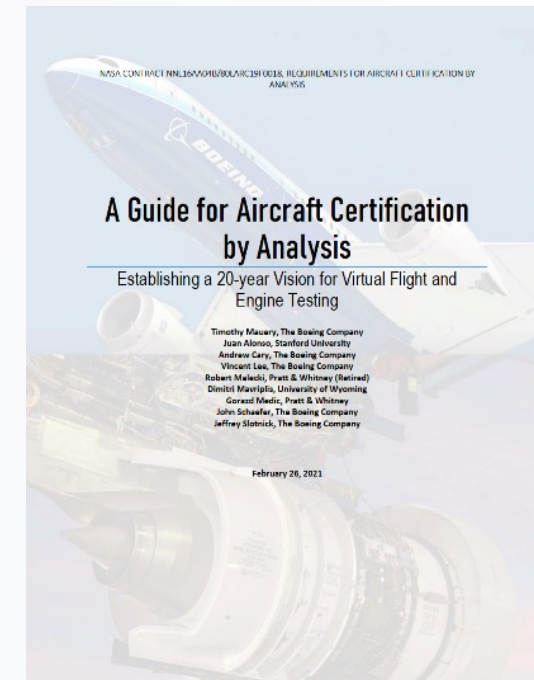
Enables fast, efficient design and analysis of advanced aviation systems from first principles by developing physics-based tools, methods, and cross-cutting technologies.



NASA CR 2014-218178
March 2014



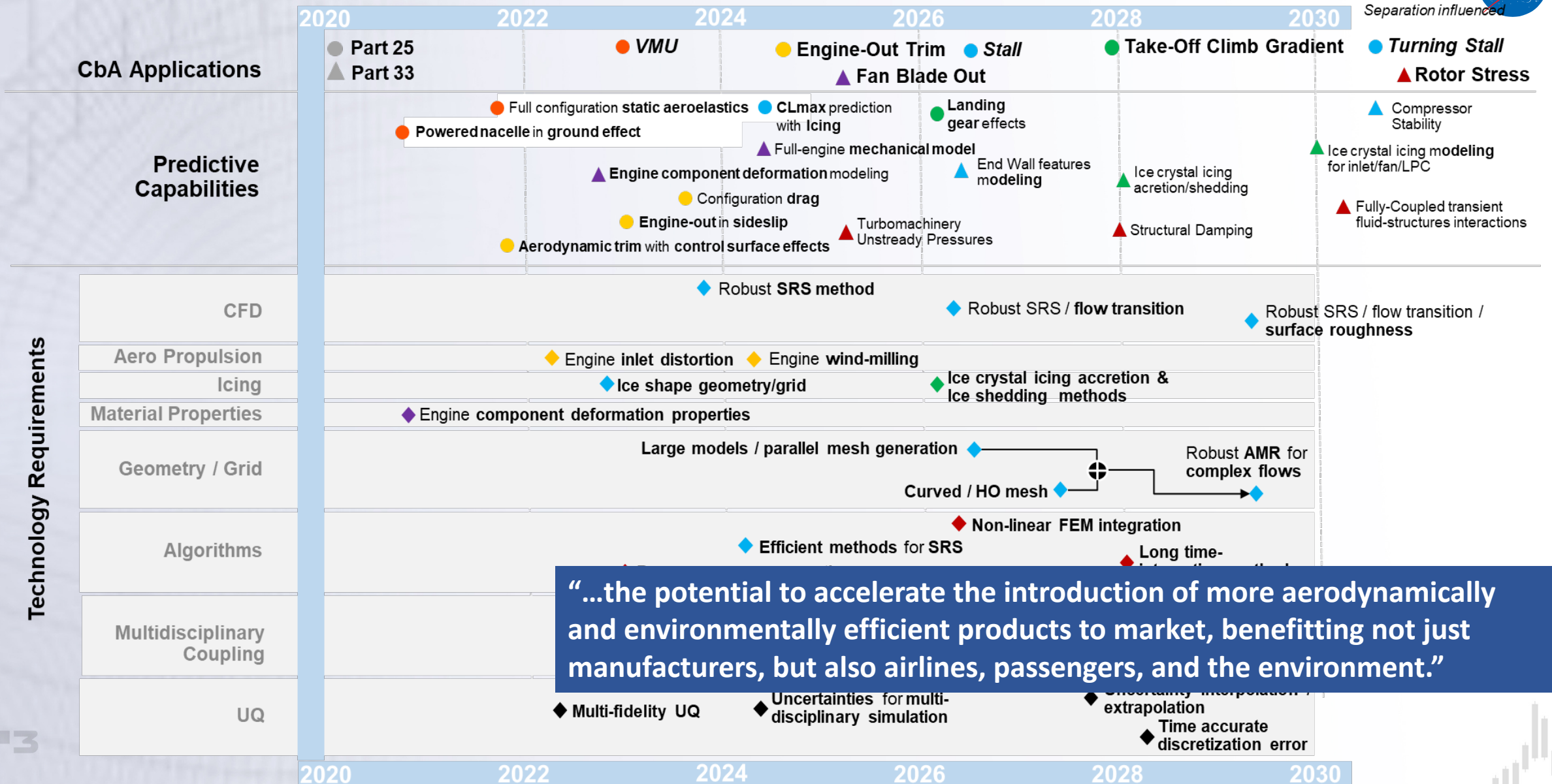
AIAA R-154-2021
April 2021



NASA CR 20210015404
May 2021



Certification by Analysis – Near-term Roadmap



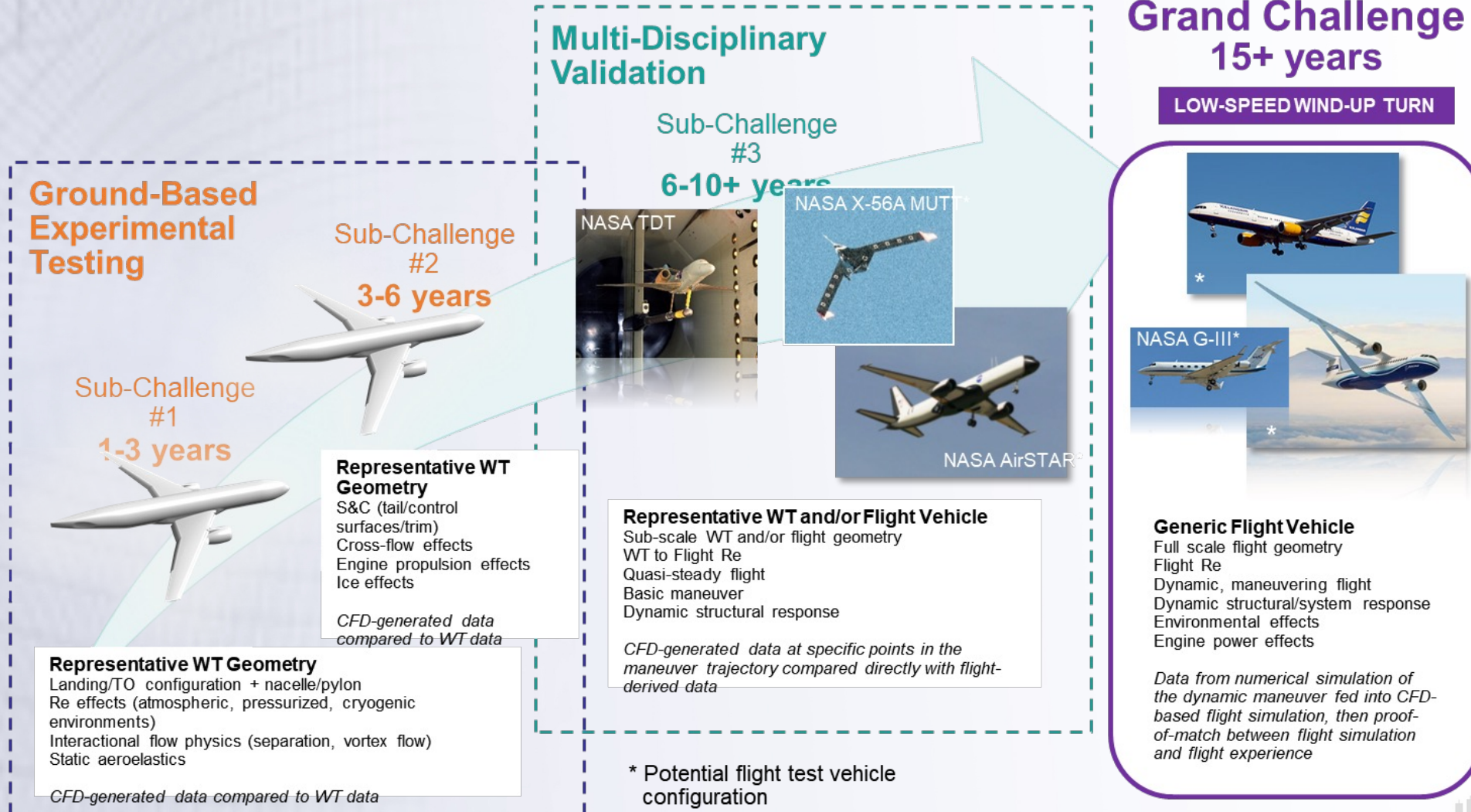
“...the potential to accelerate the introduction of more aerodynamically and environmentally efficient products to market, benefitting not just manufacturers, but also airlines, passengers, and the environment.”



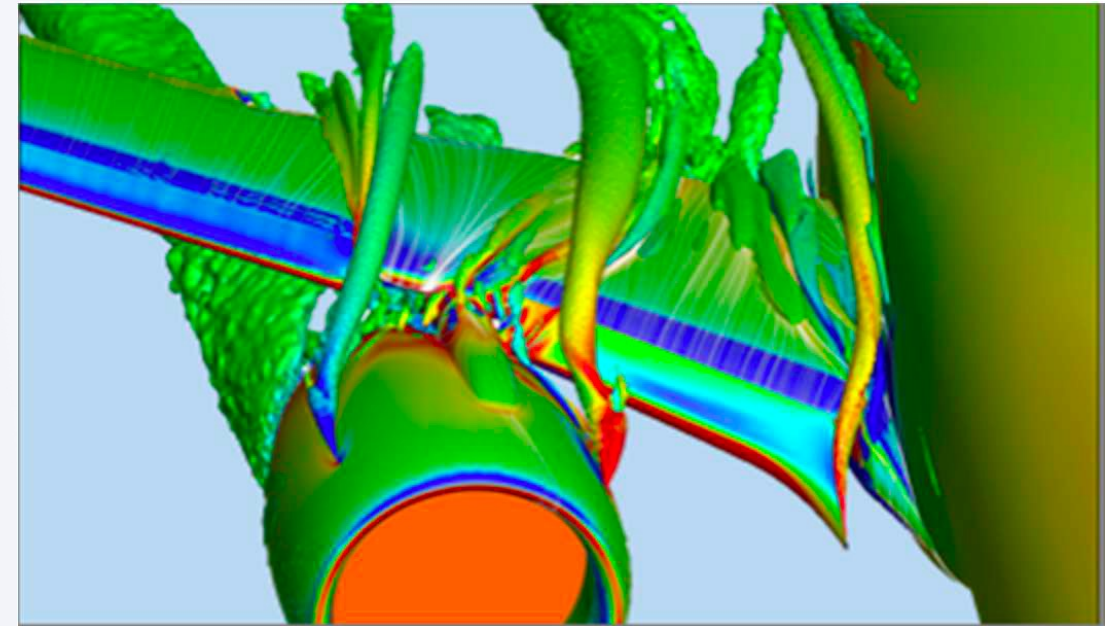
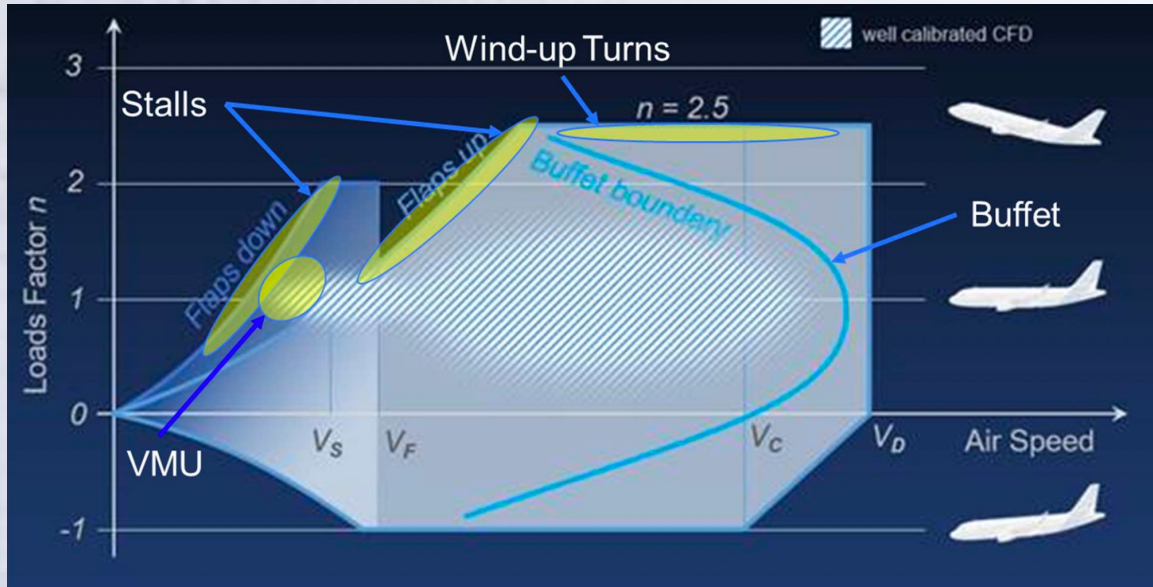
Figure 7. Near-Term Certification by Analysis Roadmap

High Lift Grand Challenge

Focus on key technical obstacles over specific time periods to make progress towards solving the grand challenge



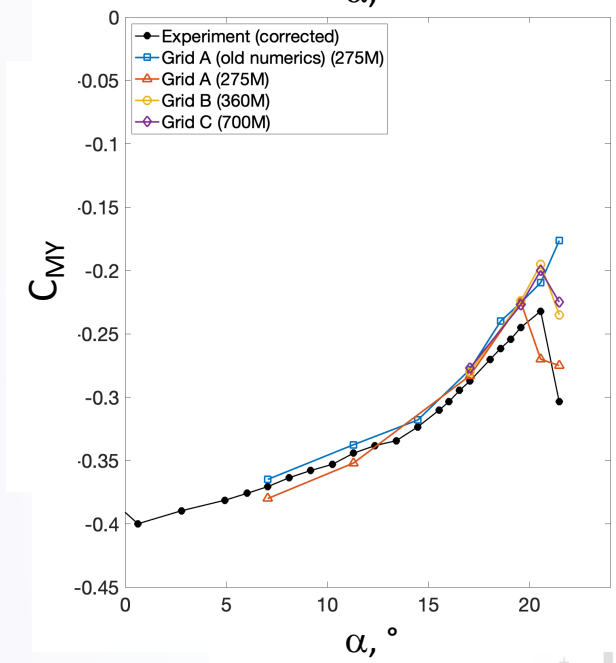
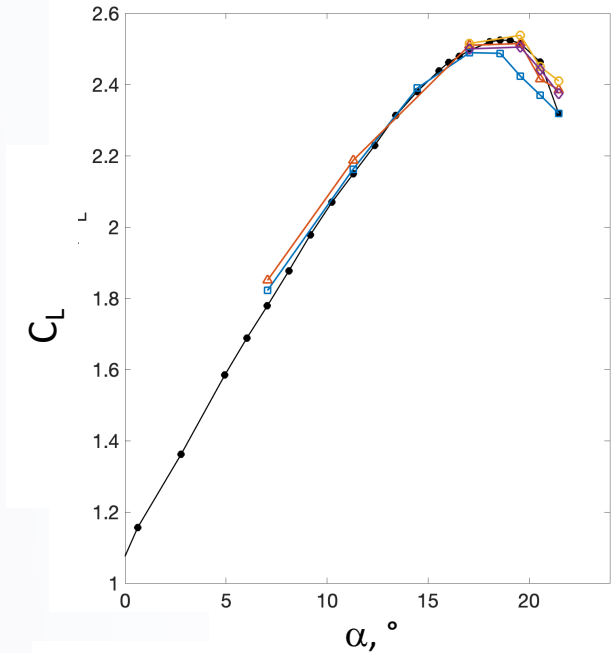
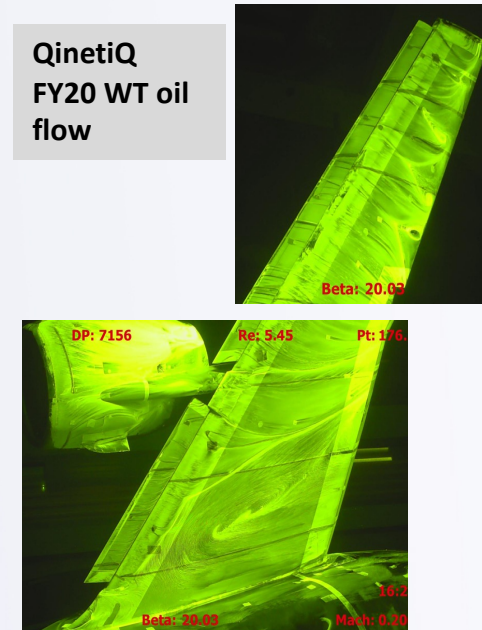
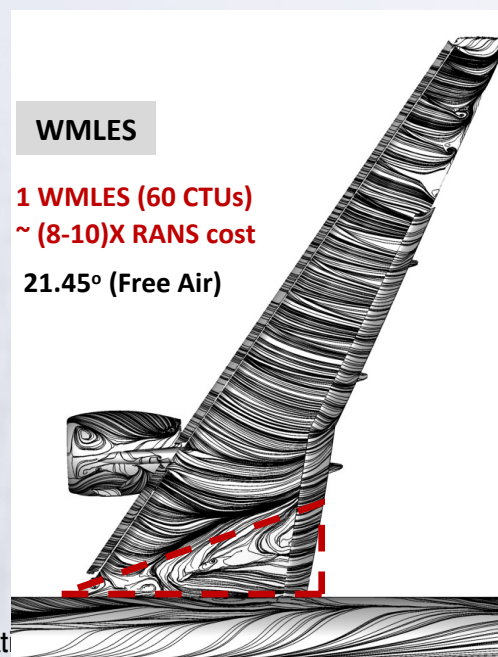
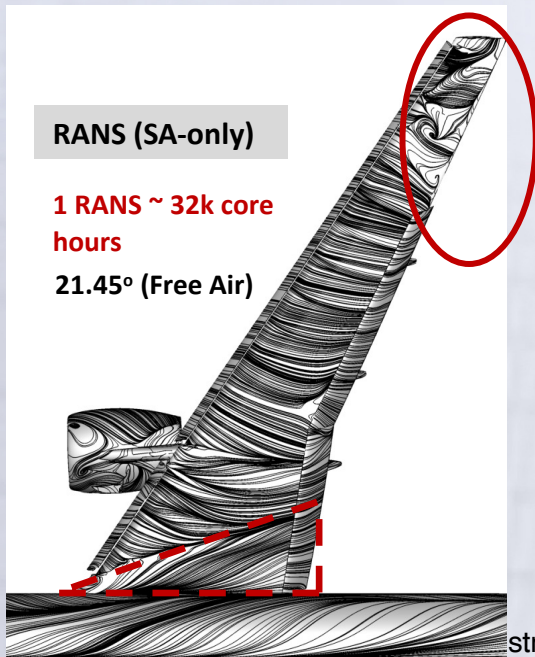
Challenges predicting complex flow fields associated with high-lift configurations



Technical Challenge: Develop and demonstrate computationally efficient, eddy-resolving modeling tools that predict maximum lift coefficient (CL_{max}) for transport aircraft with the same accuracy as certification flight tests.

Eddy Resolving Simulations

- Eddy Resolving Simulations are showing promise
 - Hybrid Reynolds Averaged Navier Stokes/Large Eddy Simulations (HRANS/LES) and Wall Modeled Large Eddy Simulations (WMLES) predict the smooth body separation better than the legacy Reynolds Averaged Navier Stokes (RANS) simulations



CRM-HL Ecosystem Development Plan



MODEL

NASA 10% SS

NASA 5.2% SS cryo

NASA 2.7% FS cryo

NASA 2.7% SS cryo

NASA 5.2% SS (LE treatment, HBR nacelle)



Boeing 6.0% FS 3atm

Boeing 4.0% SS



ONERA 5.1% FS 3atm



KHI 3.23% FS



JAXA 8.0% SS



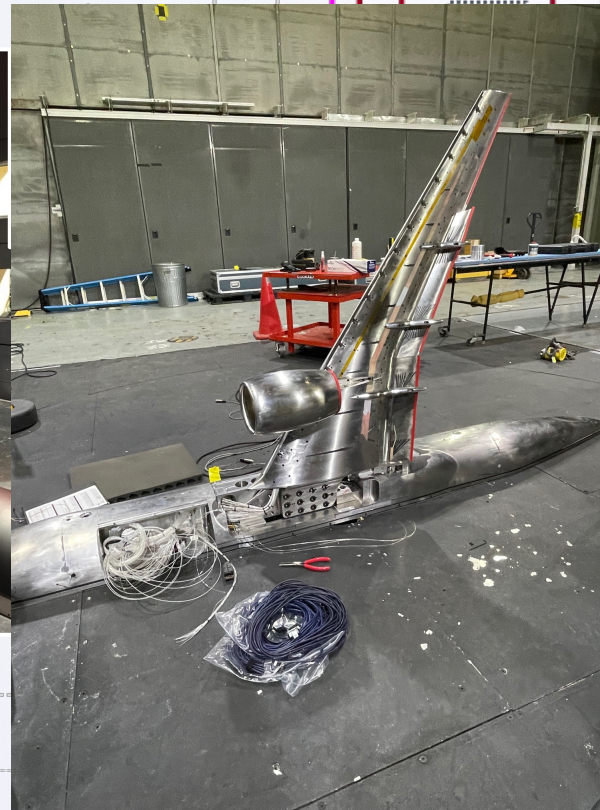
1. Reference Configuration

2. Optimization/Sensitivity Data

3. Reynolds Number Effects

4. WT Mod
National Aeronautics and Space Administration
Developing Innovative Measurement Techniques
to acquire needed CFD validation data

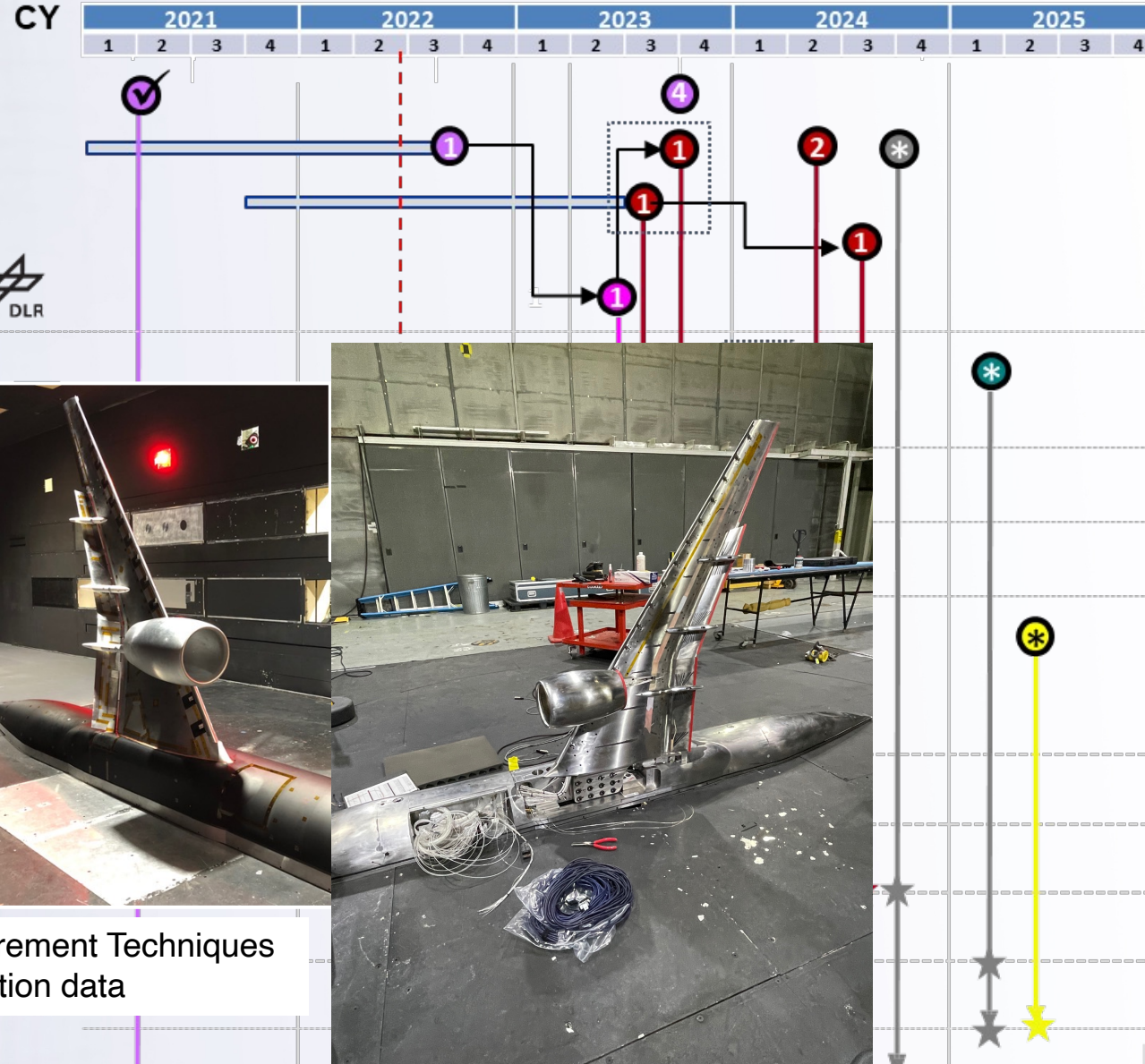
5. Flow Physics CFD Validation Data



HLPW-4

HLPW-5 *

HLPW-6 *



CRM = Common
Research Model

HL = High Lift

SS = Semi-Span

FS = Full Span

atm = Atmosphere

● NASA NTF

● ETW

● Q5m

● NASA 14x22

● NASA TDT

● ONERA F1

● DNW-NWB

● Imperial College

● KHI 3.3m

● JAXA 6.5x5.5

Design/Fab



A Look Ahead to FY23

- **High-Reynolds-Number test campaign begins, including two CRM-HL validation experiments in the NASA Langley National Transonic Facility**
- **Design a dynamically scaled aeroelastic CRM model for the NASA Transonic Dynamics Tunnel**
- **Focus on Uncertainty Quantification**
- **Application of Artificial Intelligence / Machine Learning to accelerate modeling**

