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High-Lift Common Research Model (CRM-HL)

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Session 5: Certification

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Background – Certification by Analysis

- **Aircraft certification is a \$1 Billion to \$2 Billion investment, depending upon whether for a derivative or a new aircraft**
 - Meet Regulator requirements as well as performance guarantees to Operators
 - Significant program delays/penalties if requirements/commitments not met
- **Certification by Analysis (CbA) could save about \$300 million in an aircraft development program by reducing development through certification flow time while improving the product safety & performance**
 - Reduce flight test time during certification
 - Reduce surprises during flight testing that cause a domino effect of rework, delay, & cost
 - Reduce time & cost to market
 - Enable insertion of new technology/design changes with minimal (without) new flight tests
- **Industry worldwide** identified this as a major need/opportunity and is expanding precompetitive collaboration, including with Regulators and Research Organizations (**working together to raise the water level**)
- **The computational technology/tools required for CbA will also improved design enabling better performing airplanes**



Background – CbA for Flight Test Reduction

- **Challenge** - Community Level

- **Applicant** (e.g. Boeing, Airbus) and **Regulator** (e.g., FAA, EASA) must have **sufficient confidence in analysis-based modeling and simulation Means of Compliance** to reduce flight test without compromise to aviation's gold standard safety bar
- Analysis-based modeling can involve both computational and ground-based physical simulation
- Requires robust, accurate, validated methods tied to relevant data
- **Mindset Change**
Flight test to **validate** airplane characteristics **rather than** to **discover** airplane characteristics during certification

- **NASA Role**

- **Tools & Methods validated with relevant data** at the airplane characteristic and underlying physics levels
 - confidence that one gets the right answer for the right reasons, consistently
- Broadly **disseminate** results to **build confidence/trust**, but only **US access to NASA tools**



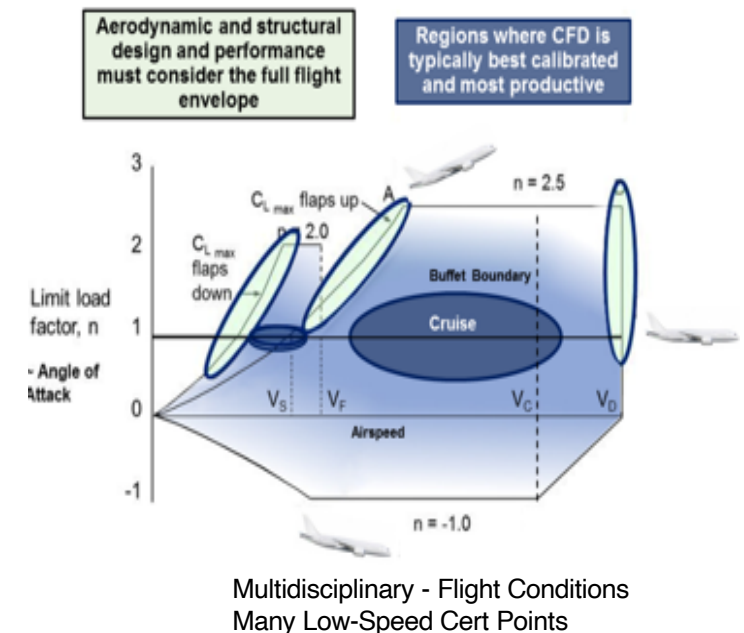
Background – CbA for Flight Test Reduction

- **Approach**

- **Partner** with US and Global Community
 - Already includes Boeing, Airbus, FAA, EASA, DLR, ATI/UK and many others
- **NASA leadership capabilities**
 - Computational Methods
 - Experimental Techniques & Facilities
 - Open Forum Dissemination of Data/Results
 - Independence from Applicant and Regulator
- Identified **Low-Speed Flight** Envelope as 1st focus
 - ~2/3 of certification flight test envelope
 - C_{Lmax} is key metric
- Raise the water level broadly, with targeted proprietary evaluation
 - Open/Relevant data for broad advancement/acceptance
 - Proprietary data with existing flight/ground data (limited partnerships)

- **Results** (expected from NASA)

- NASA provides data globally, and validated tools/methods to the US community
- **US industry internalizes tools/methods, and successfully implements Means of Compliance with Regulators**



Collaborative Teams within NASA, within the US & Internationally

raise the water level together for the benefit of all



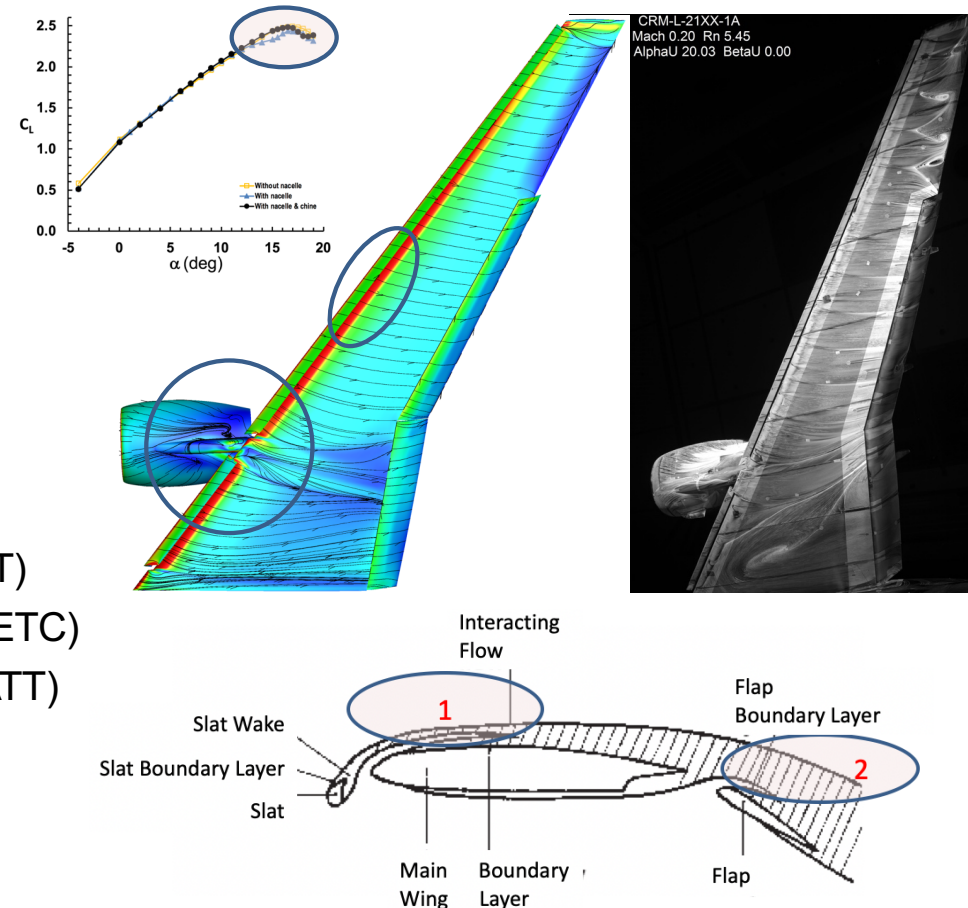
- **Key Elements Required**

- Integration/coordination
(across organizations/focus on big picture)
- Computational tools and technologies
- Wind tunnel test and evaluation
- Experimental tools and technologies
- Focused topics (e.g., icing)

- **Subject matter experts from NASA & partners in each area**

- NASA Transformative Tools & Technology Project (TTT)
- NASA Aerosciences Evaluation & Test Capabilities (AETC)
- NASA Advanced Air Transport Technology Project (AATT)

Complex – Challenging – Impactful Problem

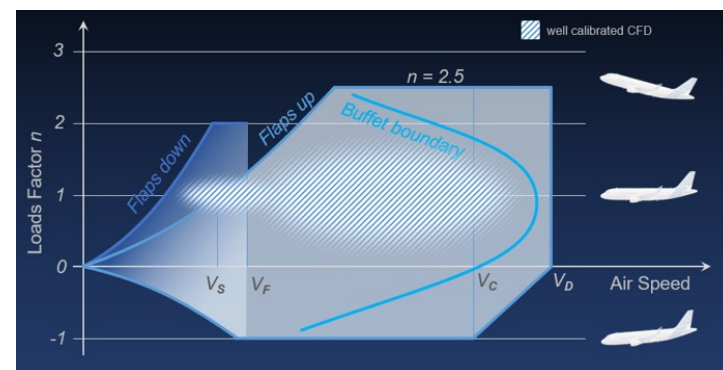


Computational Tools/Technology

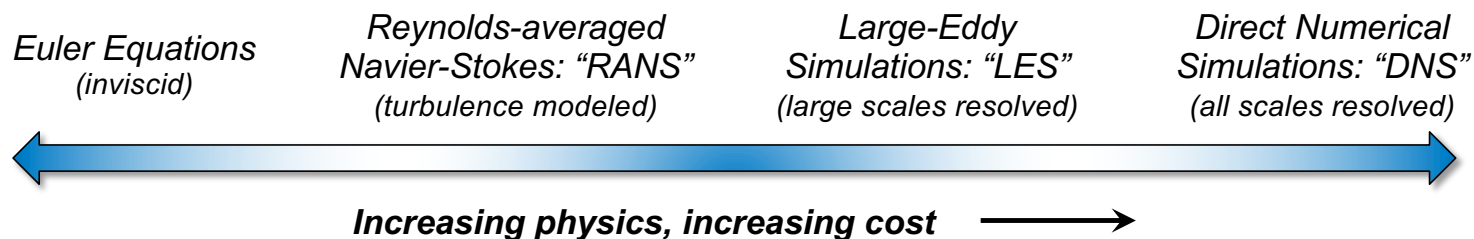


- NASA CFD Technical Challenge

- “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” (Level 1 milestone due 9/30/2025).
- Can we efficiently model the physics of complex flow separation with today's HPC capability, algorithms, grid resolution, and physical models?



- CFD has been calibrated only in **relatively small regions of the operating envelope** where the external flow is well modeled by current RANS methods





Integrated Test and Evaluation

- Responsible for planning, integrating requirements and conducting validation focused WT tests including incorporating WT corrections using high fidelity CFD tools
- Define Reference Configuration: CRM-HL (open/relevant) (NASA/Boeing)
 - Based on the original, broadly used CRM for high speed
 - Present representative flow physics of interest for CFD methods development & validation, improved testing and data acquisition methods, high lift technology development and high lift aerodynamics knowledge enhancement
 - Provide reference performance metrics for a conventional high lift system
 - Be easy to replicate across a wide user base
 - AIAA-2020-2771 – Lacy, D., et al., “Definition of Initial Landing and Takeoff Reference Configurations for the High Lift Common Research Model (CRM-HL)”
 - Final refinement nearing completion

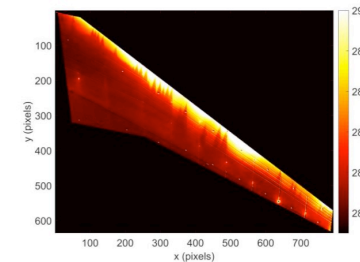


Initial 10%-scale CRM-HL in 14x22 at Langley

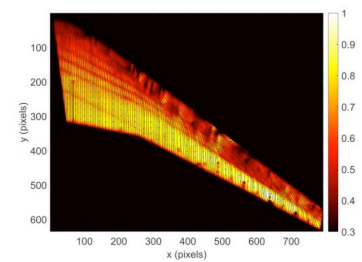


Experimental Tools and Technology

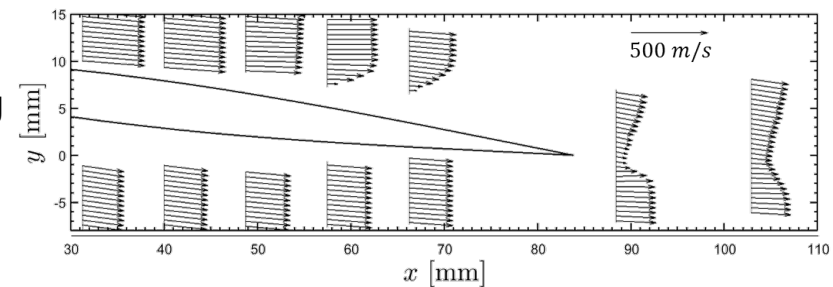
- **Advanced measurement initiatives**
(beyond standard measurements)
 - “get the right answer for the right reasons”
 - On-body to high Reynolds number in cryogenic environment
 - Model deformation
 - Surface flow visualization
 - Skin friction, transition, flow separation
 - Off-body to high Reynolds number in cryogenic environment
 - FLEET (Femtosecond laser electronic excitation tagging)
 - High Speed Velocimetry including PIV
 - New Measurement Techniques being investigated
 - Stereo PTV, Stereo FLEET, Filtered Rayleigh Scattering
- **Wind Tunnel test environment**
 - Reynolds number to full scale
 - Semi-span vs full-span
 - Model support
- **Test efficiency initiatives**
 - Remote control actuation, for example



TSP image



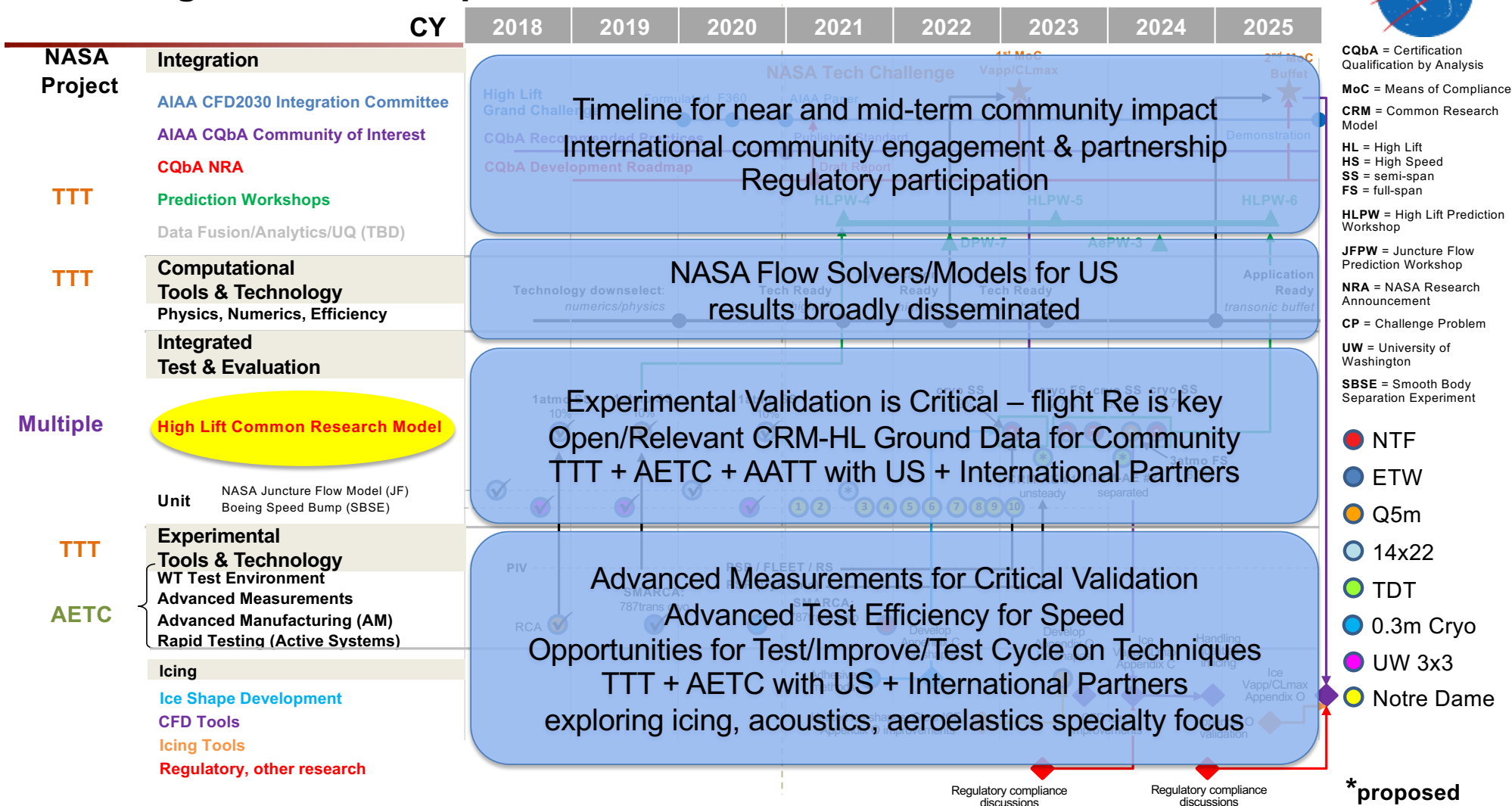
Extracted skin friction lines



Mean Velocity - FLEET

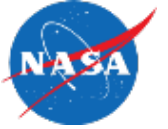
CbA Integrated Roadmap

version: 17 December 2020



CRM-HL Ecosystem Overview

involving anyone who is willing and able to contribute

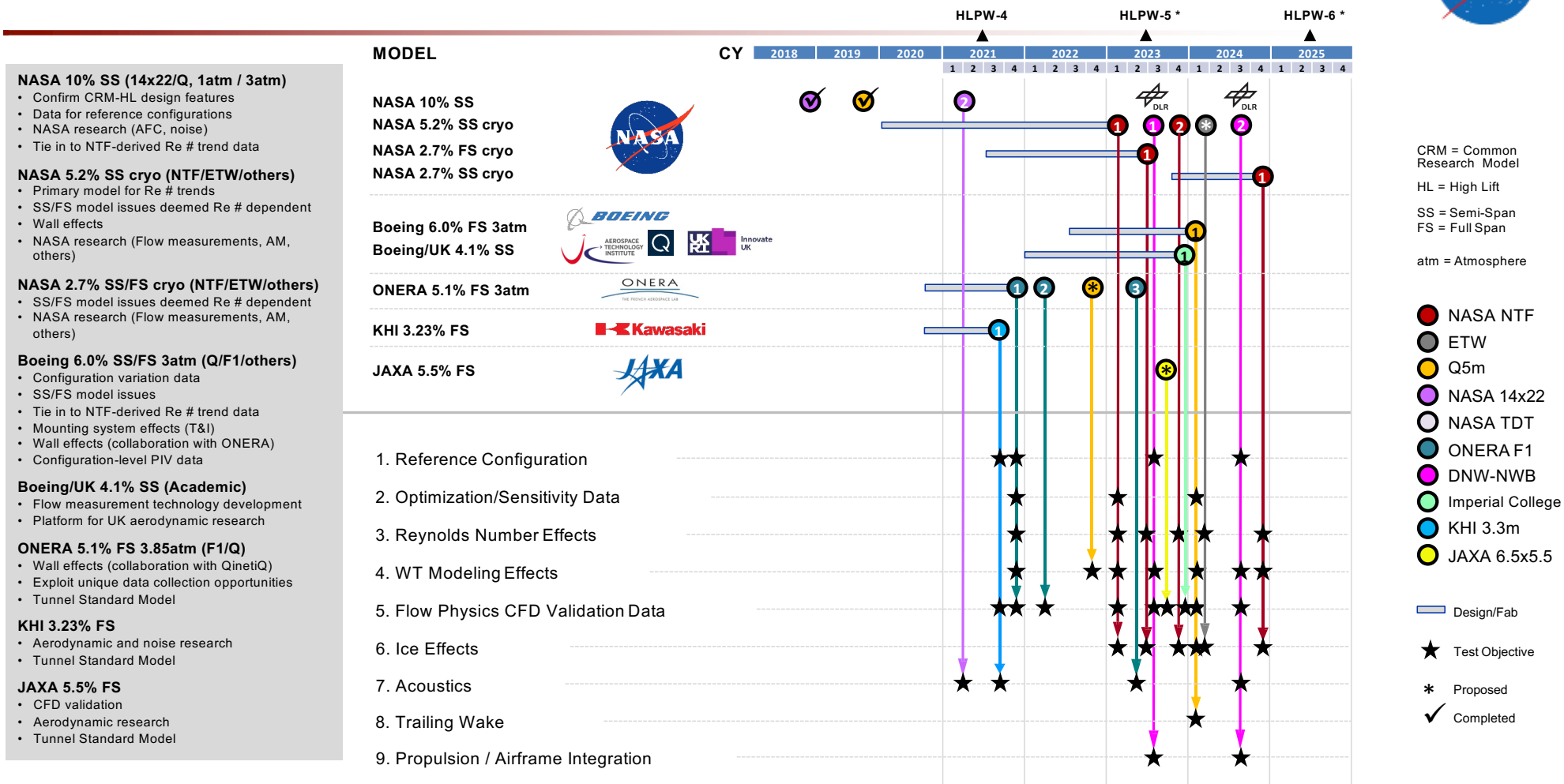


- Develop a “**community-sourced**” set of resources or “**Ecosystem**” related to the CRM-HL
 - Common controlled geometry
 - Wind tunnel models (potentially designed for use in multiple facilities)
 - Wind tunnel datasets (e.g., force & moment, noise, on & off body flowfield)
 - CFD grids (with and w/out tunnel & support system)
 - CFD results
- Enable it to continue to grow over time (add new geometry elements, configurations, models, datasets, etc.)



CRM-HL Ecosystem Development Plan

Version: 5 January 2021





Concluding Remarks

- Collaboration has started using CRM-HL as precompetitive approach/mechanism for sharing
- Draft 5-year roadmap has been developed – it is a living document
- Initial wind tunnel model and tests completed
- Next set of model and test requirements being finalized
 - Coordination ongoing between CFD and test communities
 - Some activities funded, others in proposal stage, others TBD
- The value is in partnering and leveraging investment for mutual benefit
 - Opportunities in CFD Tools/Tech, Test Tools/Technology, and advance airplane technology
- Join in the fun CRM-HL Ecosystem Meetings typically at AIAA Aviation and SciTech Forums
 - Contact me and I'll put you in touch with someone who can help
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<http://commonresearchmodel.larc.nasa.gov/>

NASA Common Research Model
providing data worldwide

Search

High Speed CRM

CRM with Natural Laminar Flow Wing

High Lift CRM

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