



An Overview of JAXA's High-Speed Flight R&D: From Supersonic Flight to Hypersonic Transportation

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September 14, 2026

ICAS2026, The International Convention & Exhibition Centre, Sydney, Australia.



JAXA Aviation Technology Directorate Strategies (FY2025-2031)

Enhancement of the R&D Lifecycle

A Strategic Hub for Innovation

Bridges early-stage research with real-world applications through technology demonstrations, connecting industry, academia, and government.

＜4+1 Strategic R&D Programs＞

As a hub connecting **industry, academia, and government across multiple disciplines**

1. **Next-Generation Aircraft System**




2. **Advanced Air Mobility System**




3. **High-speed Flight System**




4. **Sky for Society**




5. **Industrial Fundamental technologies**



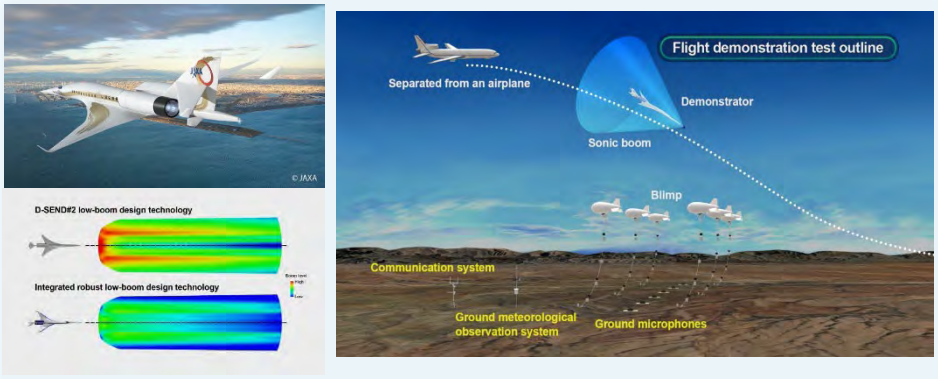

High-speed Flight System R&D Program

Objective : Develop aerospace vehicle technologies to enable seamless utilization across aviation and space domains.

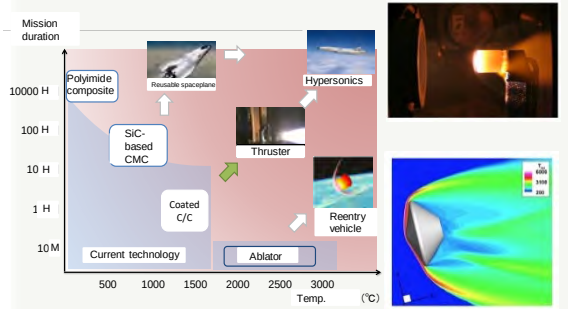
Key topic

- **Demonstrate robust low-boom design technology (Re-BooT Project)**
- Advance high-speed flight technologies and propose future system plans
- Collaborate with authorities※ to set global standards for high-speed flight
- Promote international partnerships to expand markets and create new business opportunities

※e.g. ICAO: International Civil Aviation Organization



Flight demonstration of robust low-boom design technology



Advanced fundamental technologies

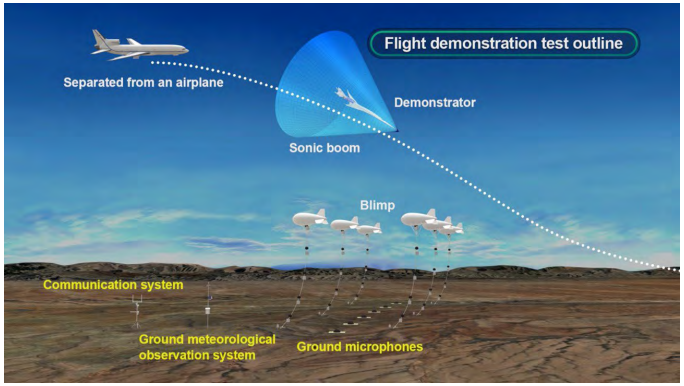
Our research covers a wide range of topics, including aerodynamics and high-temperature materials. Today I will focus on our supersonic flight demonstration project.

JAXA's Re-BooT project (Supersonic, Design M=1.6)

Robust **e**n-route sonic-**Boo**m mitigation **T**echnology demonstration：(Re-BooT)

Goal: develop **technologies for supersonic airplanes** and contribute to **international sonic-boom standard development**

1.Flight demonstration of robust low-boom design technology



JST　K Program 経済安全保障重要技術育成プログラム

co-proposer 三菱重工

2. Conceptual design of robust low-boom supersonic passenger aircraft



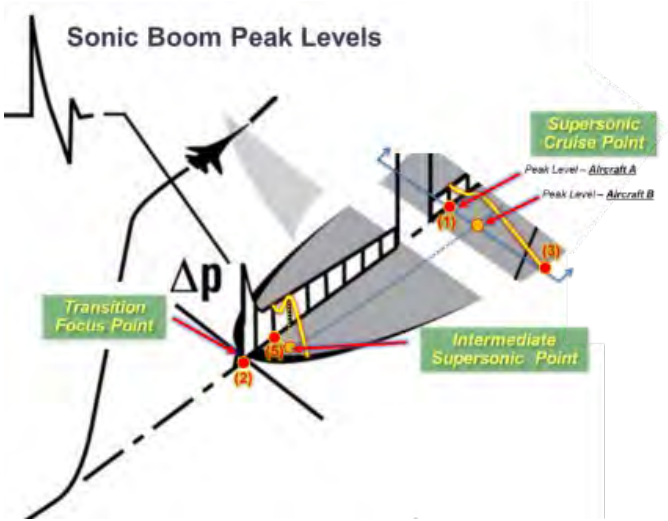
Collaborative Research Partnership　BOEING　NASA

Civil Aviation Bureau, Ministry of Land, Infrastructure, Transport and Tourism, Japan　MLIT

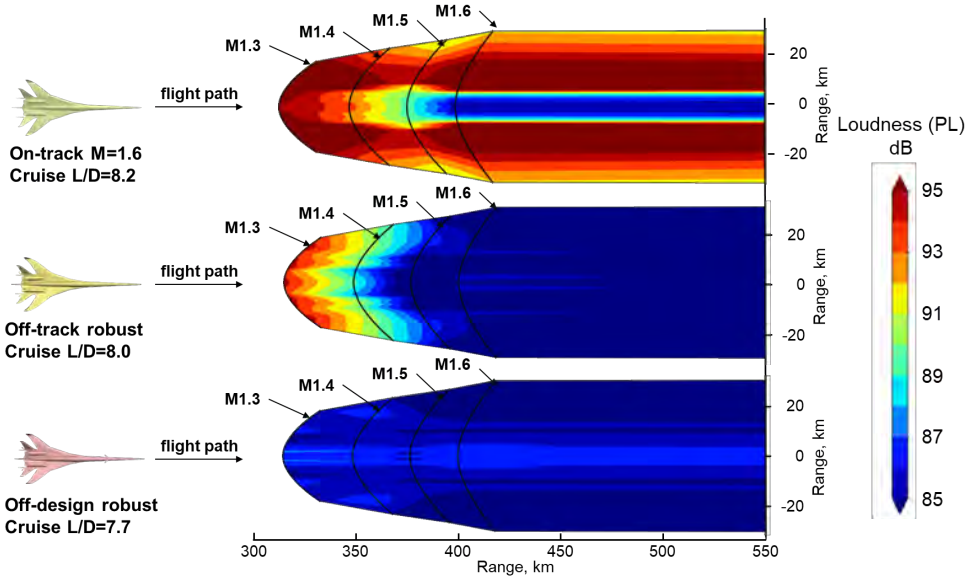
ICAO

Key technologies : Robust low-boom design*

- JAXA has developed robust low-boom design technologies that reduce sonic booms both laterally from the flight track (**off-track robustness**) and during non-cruise operating conditions such as acceleration and climb (**off-design robustness**).
- Under a collaborative research partnership, JAXA's robust low-boom technologies have been applied to the NASA/Boeing N+2 supersonic airliner concept, and a flight demonstration is planned.



Sonic-boom evaluation points to be measured in the future certification



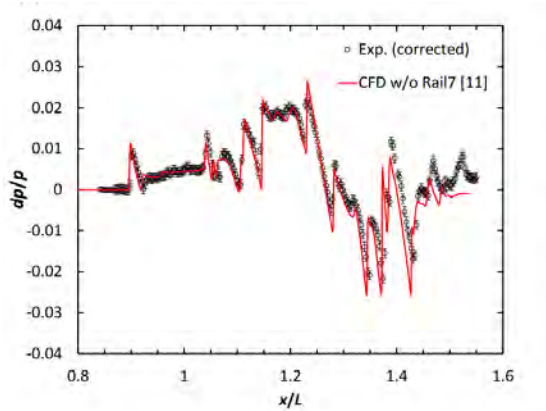
Robust low-boom design in primary boom carpet
Cruise off-track low-boom / Off-design/off-track low-boom

*Atsushi Ueno, Hiroaki Ishikawa, Shinya Koganezawa, Yoshikazu Makino; Robust sonic boom reduction in primary boom carpet. *Proc. Mtgs. Acoust.* 4 December 2023; 52 (1): 040013.

International collaboration

NASA / Boeing / JAXA Tri-lateral X-59 Collaboration[*1-3]

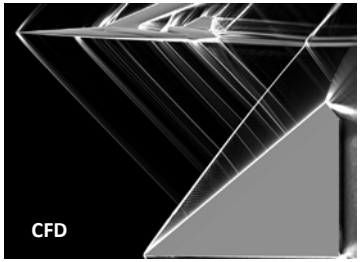
- Collaboration Objective
  - Validate the NASA X-59 nearfield sonic-boom signature with CFD, wind tunnel data, flight test data
- Approach
  - Conduct X-59 sonic-boom wind tunnel testing at JAXA with improved pressure rail and compare the NASA/Boeing/JAXA's CFD results
  - Compare the CFD data with flight data



Comparison with near-field pressure signatures obtained via numerical analysis: X-59 model, M∞ =1.4 [*2]

This collaboration helps improve confidence in sonic-boom prediction methods and contributes to future standards development.





X-59 Wind tunnel test（FY2021）

*1 Todd E. Magee, et al., "X-59 CFD and Wind Tunnel Data Comparisons," AIAA 2023-4320.
*2 Junichi Akatsuka, et al., "Near-Field Pressure Signature Measurements of NASA X-59 in JAXA 1 m × 1 m Supersonic Wind Tunnel," AIAA 2023-4318.
*3 Shinya Koganezawa, et al., ."Near-Field Pressure Signature Prediction of NASA X-59 using JAXA's Unstructured Grid Solver FaSTAR," AIAA 2023-4319.

International collaboration

Contribution to International Standards

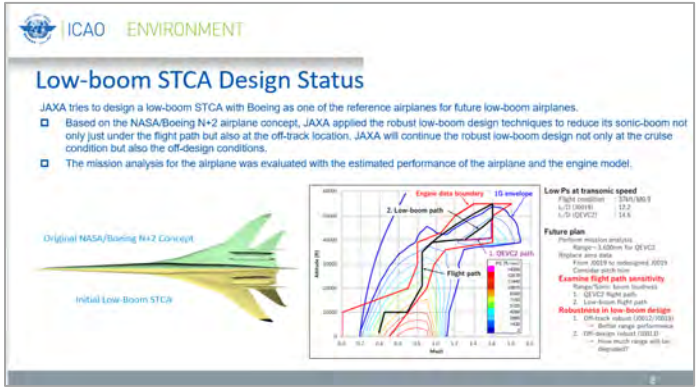
JAXA reported to ICAO CAEP WG1 about Boeing/JAXA designed future commercial supersonics model as a conceptual **reference** model (Low-boom STCA).

We support the development of international standards using the conceptual aircraft model from a technical perspective.

Our activities cover:

- ✓ Supersonic en-route noise (sonic booms and sonic thumps)
  - Characteristics of low-boom supersonic transport aircraft
  - Mission analysis
  - Noise metrics and human response assessment
  - Test procedures
- ✓ Landing and takeoff noise
- ✓ Climate impacts of supersonic aircraft

Both technology development and standards development are essential for the realization of practical supersonic transportation.





ICAO Aviation Climate Week 2026

The second person from the right is Yoshi Makino, the project manager.

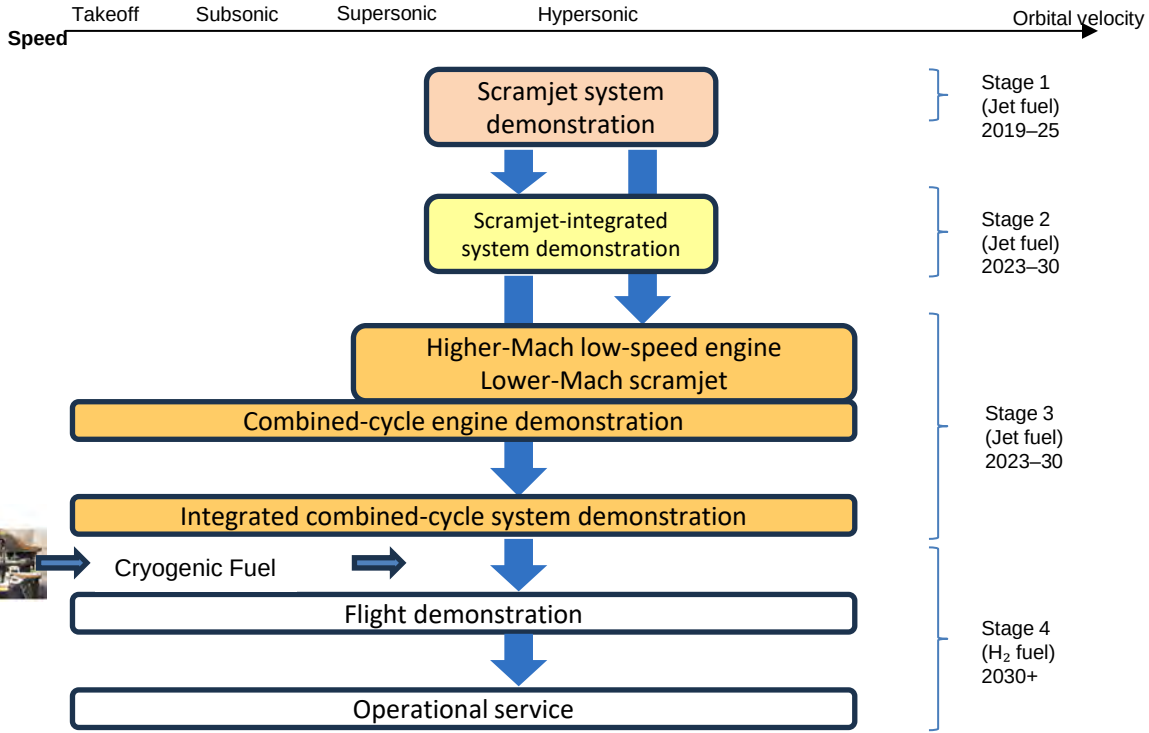
JAXA R&D Directorate Space Transportation Technology Area

- JAXA's Space Transportation Technology Area is developing future launch-system concepts.
  It is strengthening common technology through advanced flagship launch vehicles while studying **high-frequency Reusable Launch Vehicle** for space tourism and high-speed point-to-point (P2P) transportation, with the goal of autonomous next-generation capability in the 2040s.
- Japan's Basic Plan on Space Policy identifies **hypersonic propulsion as a key technology** for new space transportation systems. JAXA is pursuing phased demonstrations centered on scramjet engines.

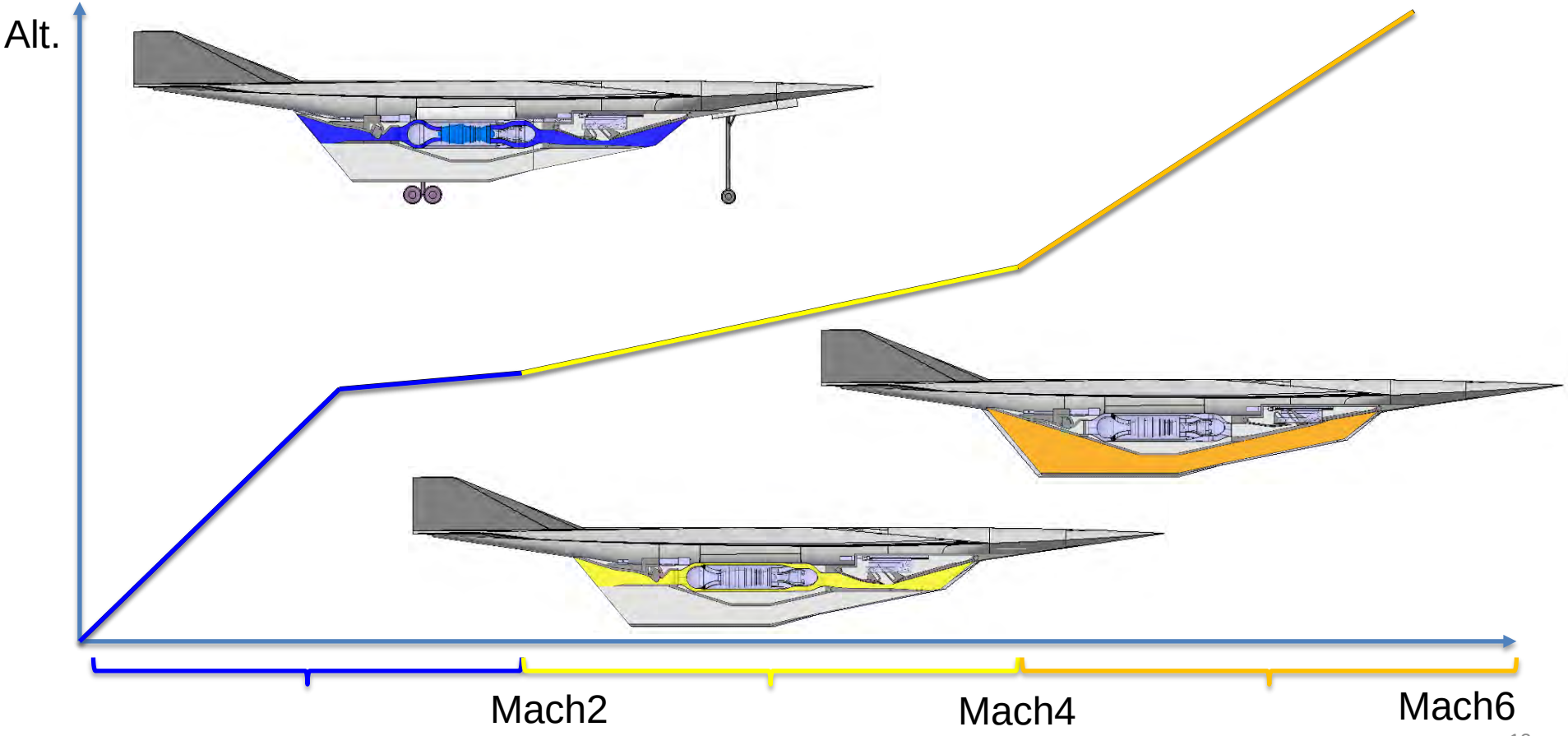


Hypersonic Flight Technology Roadmap

- Japan's Program for Developing Key Technologies for Economic Security(**K Program**)is developing a TBCC experimental vehicle covering takeoff to about Mach 6. Jet fuel is the initial focus for a small demonstrator and future high-speed point-to-point transportation.
- For space transportation, the program will evolve toward hydrogen fuel, which is better suited to acceleration.



TBCC Flight Concept



TBCC Research and Development

Hypersonic Element Technologies

Task A — Lower-Mach Scramjet Operation

- At the expected TRJ-to-SJ transition (Mach 3–4), demonstrate SJ operation and sufficient thrust for acceleration.

Task B — High-Speed Turbojet

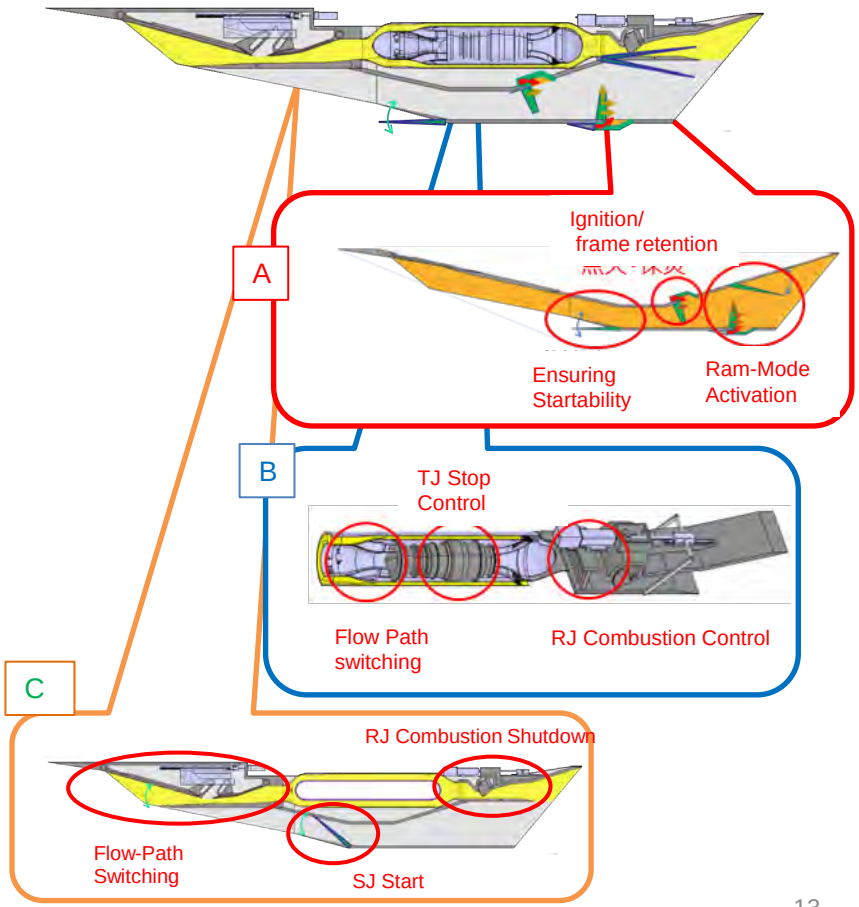
- With a coaxial TRJ sharing the TJ afterburner and RJ combustor, demonstrate full TJ-to-RJ transition.

Task C — Engine Mode Transition

- Complete the transition within the engines' overlapping operating ranges and minimize thrust loss.

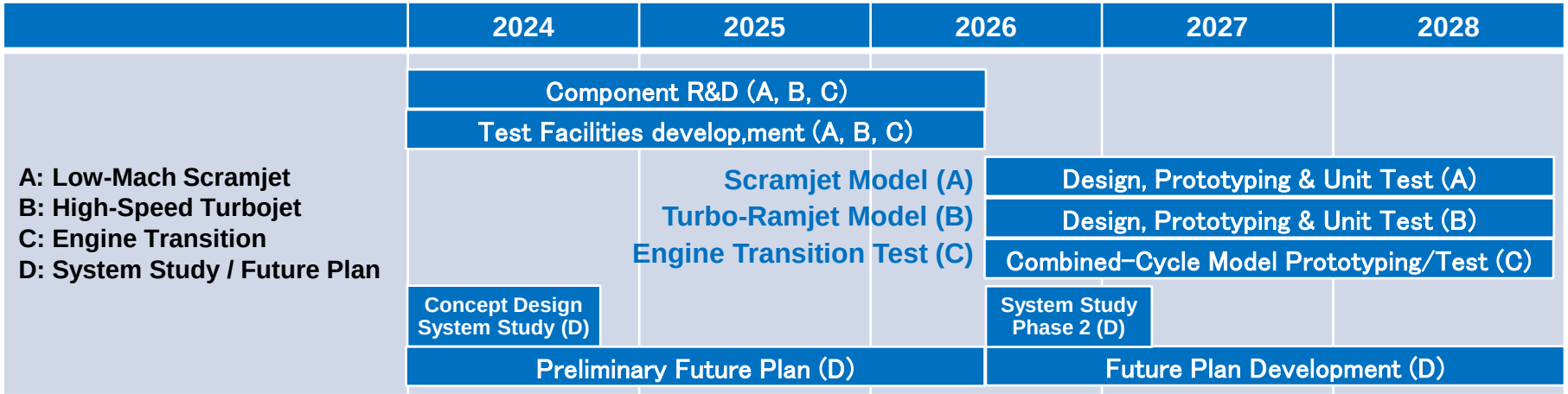
Task D — System and Demonstration Planning

- Analyze a representative flight-demonstration system and select practical technologies and tests once feasibility is established.
- Prepare a feasible program covering critical-technology flight tests, ground engine-system demonstrations, and integrated flight tests.



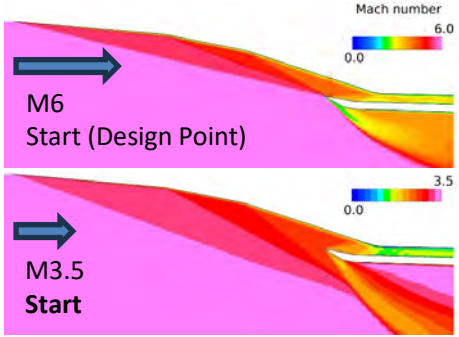
K-Program Schedule Overview

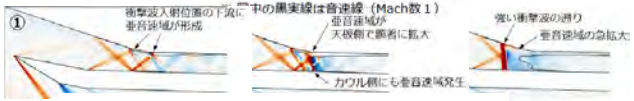
Yr.	R&D Plan	Activities
1	**Combined-Cycle Concept**	Define the combined-cycle engine concept by integrating a scramjet with a takeoff/acceleration engine. Start component R&D and facility planning.
2	**Component R&D / Facility Setup**	Conduct component tests and design studies. Prepare the test facilities.
3	**Begin Standalone Model Build**	Consolidate component R&D, commission the facilities, conduct the transition review, and begin designing and building the two standalone engine models.
4	**Standalone Model Build and Test**	Complete the standalone engine models and performance tests. Begin building the combined-cycle engine model.
5	**Combined-Cycle Test**	Demonstrate combined-cycle engine mode transition.



A: Low-Mach Scramjet Operation

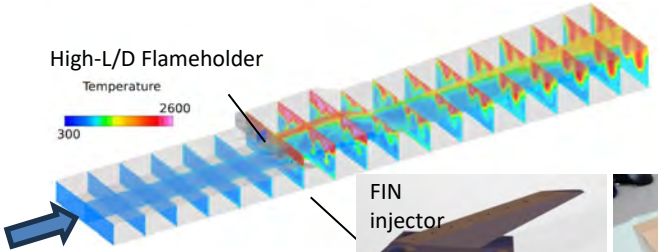
- **Intake**
  - Use variable geometry to ensure inlet starting at low Mach numbers.
- **Combustor**
  - FIN and Hyper Mixer injectors are being compared in testing.
  - A rotating-detonation igniter is under evaluation.
  - A multi-cavity flameholder is being studied to enhance flame propagation.
- **Nozzle**
  - Assess the need for nozzle switching after thrust and thermal-structure checks.



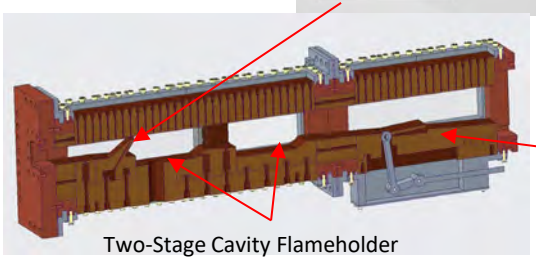


M3.5 CFD: start, then unstart

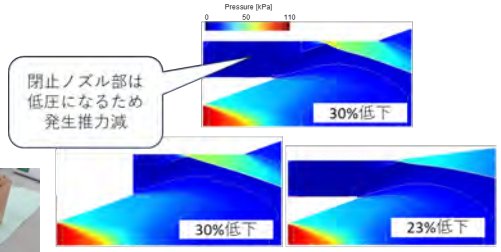
Air







Two-Stage Cavity Flameholder



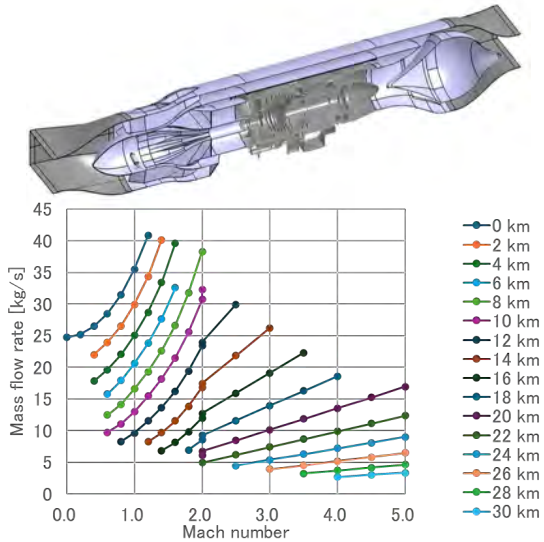
Effect of Ram-Nozzle Opening on Scramjet Nozzle Thrust



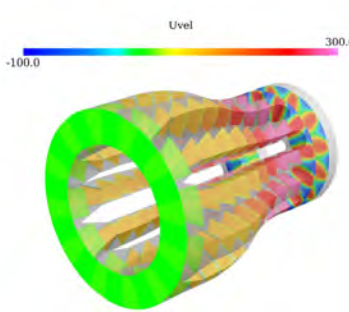
RD Torch ON + Main H_2 Fuel

B: High-Speed Turbojet Technology

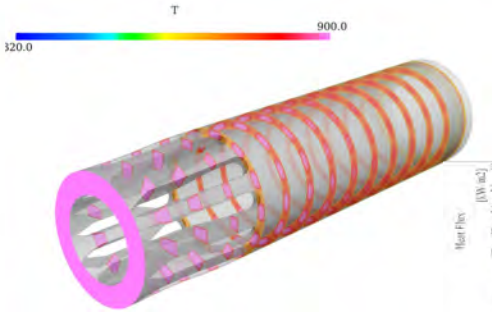
- **TRJ Architecture**
  - A ram duct surrounding the turbojet feeds the ramjet; the turbojet afterburner also serves as the ramjet combustor. (Japan demonstrated this arrangement in the HYPR project.)
  - A flow-path switching mechanism selects and controls turbojet or ramjet mode.
- **Technical Issues**
  - Develop transition control that avoids instability and thrust loss.
  - Use regenerative cooling to protect the turbojet from heat input through the ram duct.



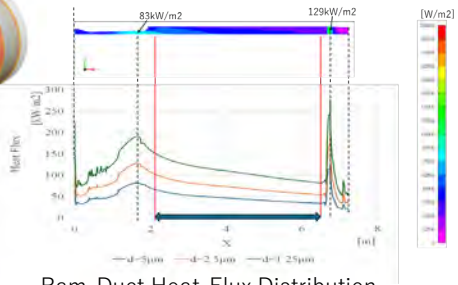
J85-Core Turbo-Ramjet Performance Prediction



Flow-Path Switching/
Velocity distribution
(Turbojet Mode, Mach 2)



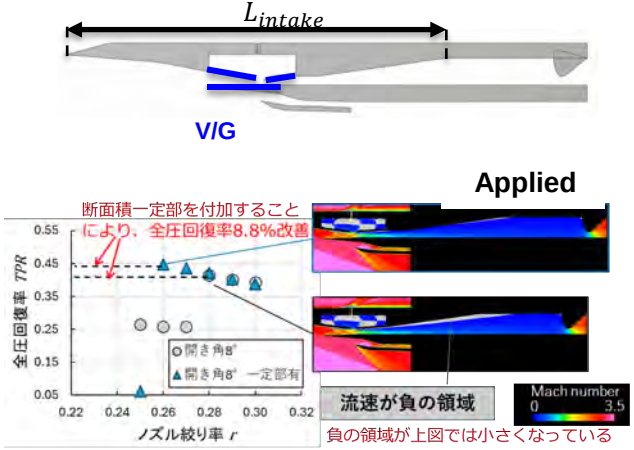
Ram-Duct
Temperature Distribution
(Ramjet Mode, Mach 4)



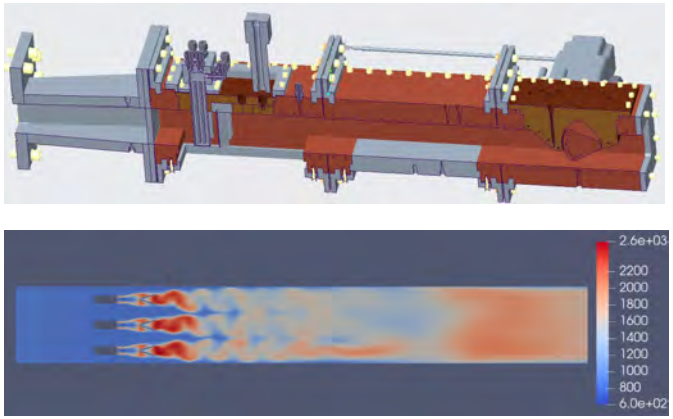
Ram-Duct Heat-Flux Distribution

C: Engine Mode Transition

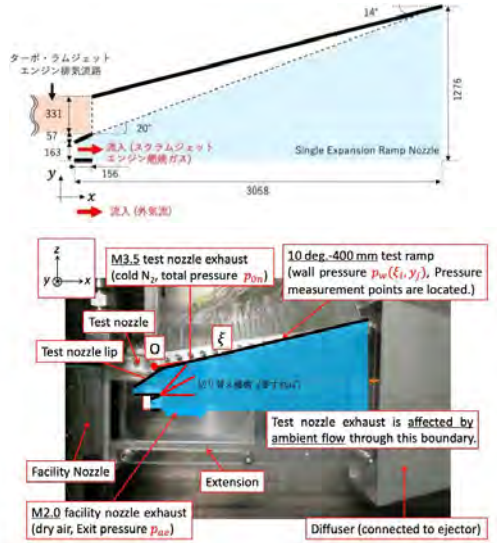
- **Switching Mechanism**
  - The turbo-ramjet inlet is embedded in the scramjet ramp and selected by a movable section.
  - A variable-throat nozzle at the aft end controls the flow.
- **Technical Issue**
  - Develop control technology that completes the transition without instability while maintaining the speed required to start the scramjet.



Shortened Inlet Diffuser



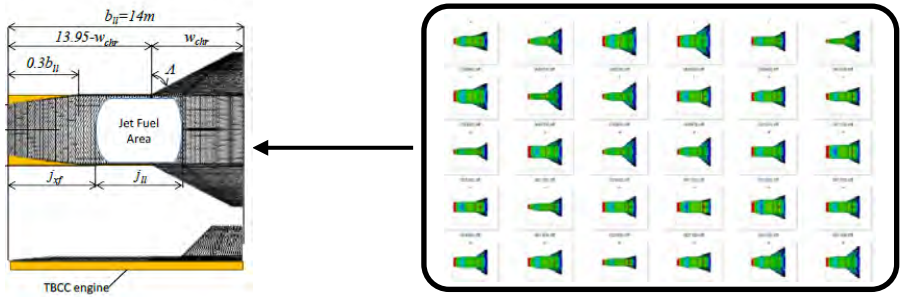
Ram-Combustor Flameholder Test Prep.



Ram-Nozzle CFD Test Setup

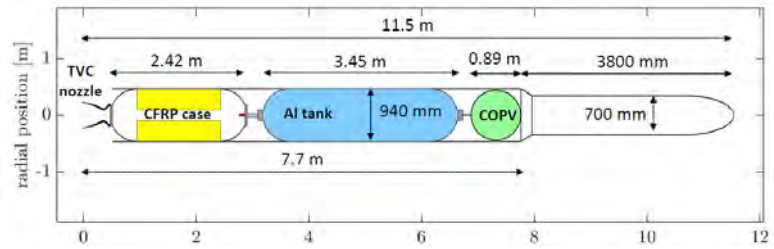
D: System Studies & Demonstration Planning

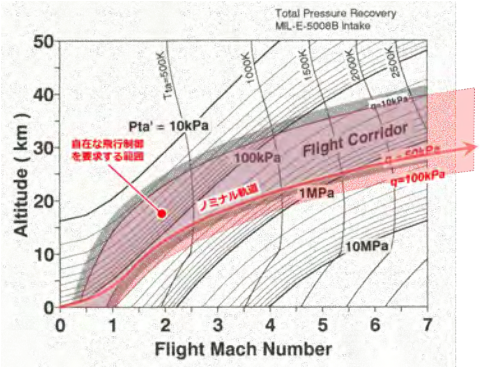
- Simultaneous optimization of vehicle geometry and flight trajectory based on predicted engine performance



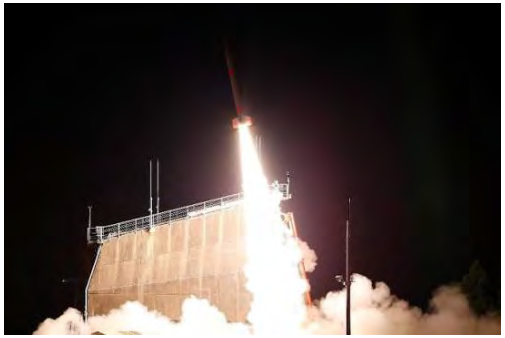
Vehicle Geometry Cases

- A conceptual rocket design is being developed for Flying Test Bed flight tests.





Controlled Flight-Test Trajectory



Summary

- For 20＋ years, JAXA has advanced R&D in supersonic and hypersonic technologies across both the aeronautics and space domains.

- In aeronautics, JAXA has been pursuing innovative R&D initiatives since 2025, aligned with the global trend toward high-speed flight research.
- In the supersonic regime, JAXA is advancing the Re-BooT project, a flight demonstration program for robust low-boom technologies supported by a national funding initiative known as the K Program.

- JAXA is steadily advancing R&D in the hypersonic regime under a phased roadmap.
- Current work focuses on a TBCC engine covering takeoff through about Mach 6, with ground demonstrations of the main element technologies planned for completion by 2028.
- This is envisioned be followed by flight demonstrations of the element technologies and the integrated system, leading toward application of hypersonic technology to space transportation and high-speed point-to-point transportation.