



Pathway to a 21st Century NASA X-Plane Through Hampton Roads

Dr. Louis M. Edelman

NASA Langley Research Center

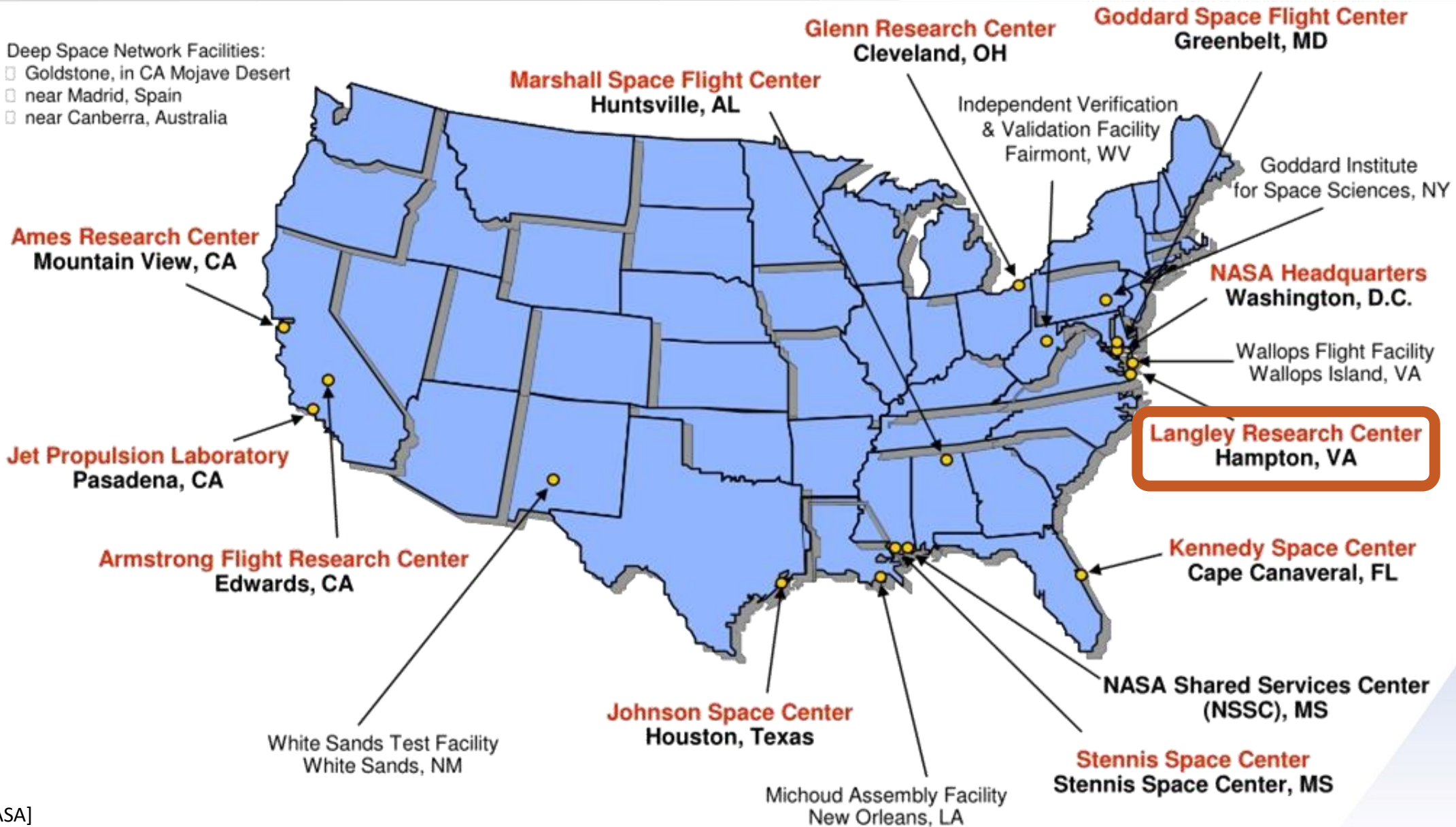
Research Directorate

Flow Physics & Control Branch



Not Just Launching Rockets: NASA Field Centers

- Deep Space Network Facilities:
- Goldstone, in CA Mojave Desert
 - near Madrid, Spain
 - near Canberra, Australia



Who Am I? A NASA Aeronautics Researcher

➤ NASA Langley Research Center

- Founded as Langley Memorial Aeronautical Laboratory in 1917
- In Hampton, VA (30 minutes from here!)

➤ NASA Aeronautics Mission Directorate

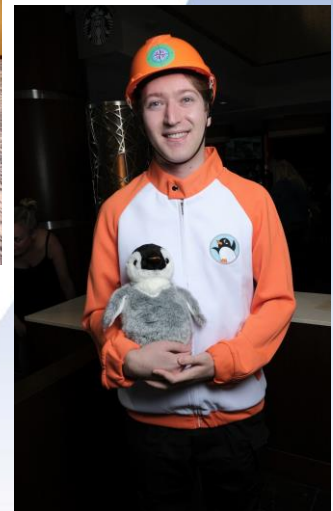
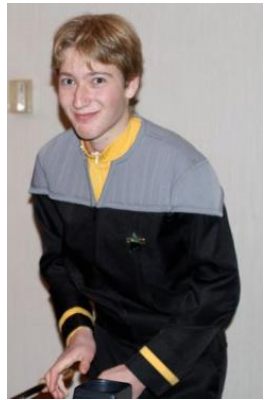
- Transforming aviation to make it more sustainable, equitable, and accessible.

➤ I work on:

- Wind Tunnel Experimental Methods
- Supersonic Fluid Dynamics
- Active Flow Control for Sustainable Flight
- History and Societal Impact of Aerospace

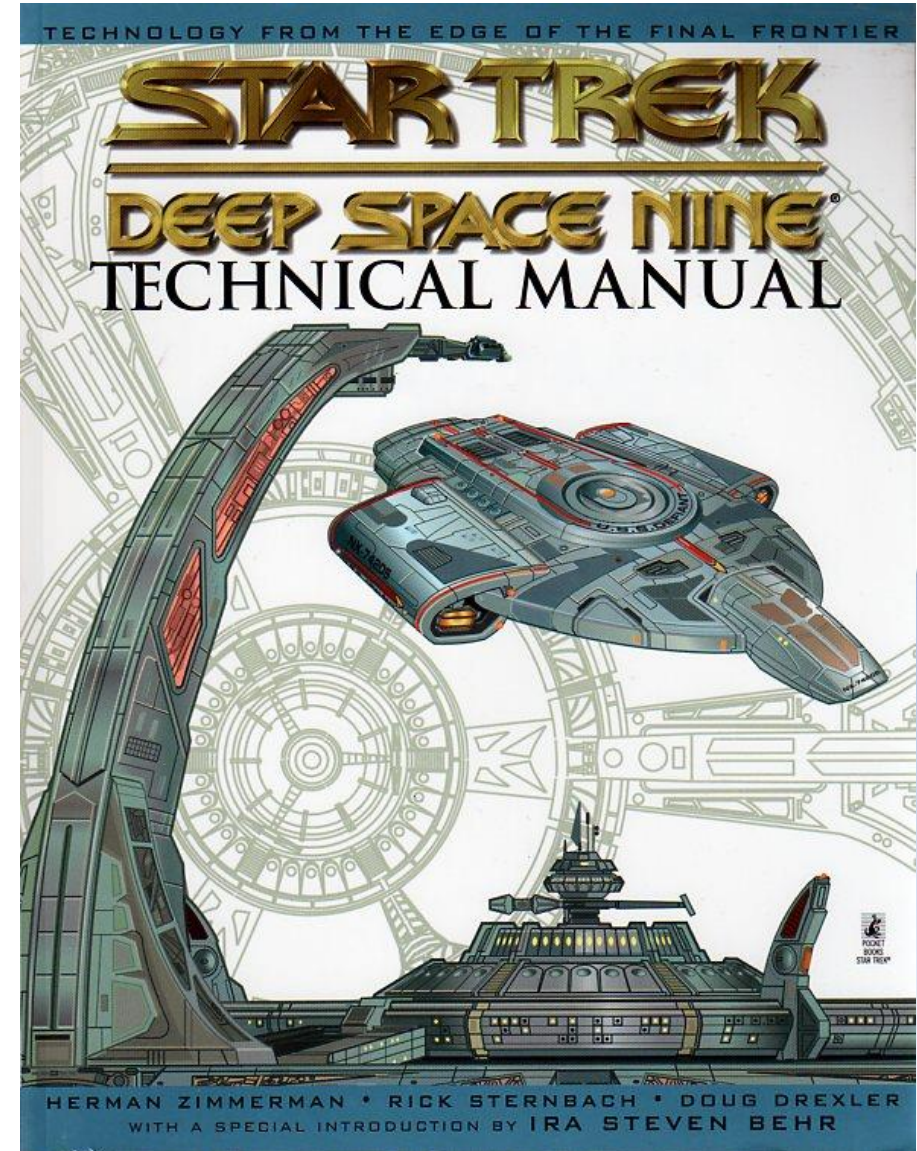


Who Am I? A Cosplayer 2008-Present

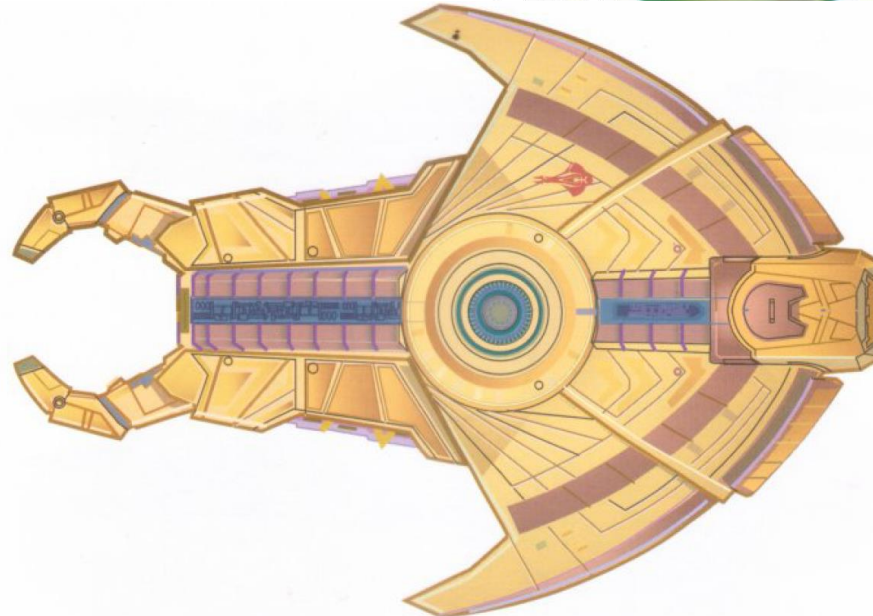
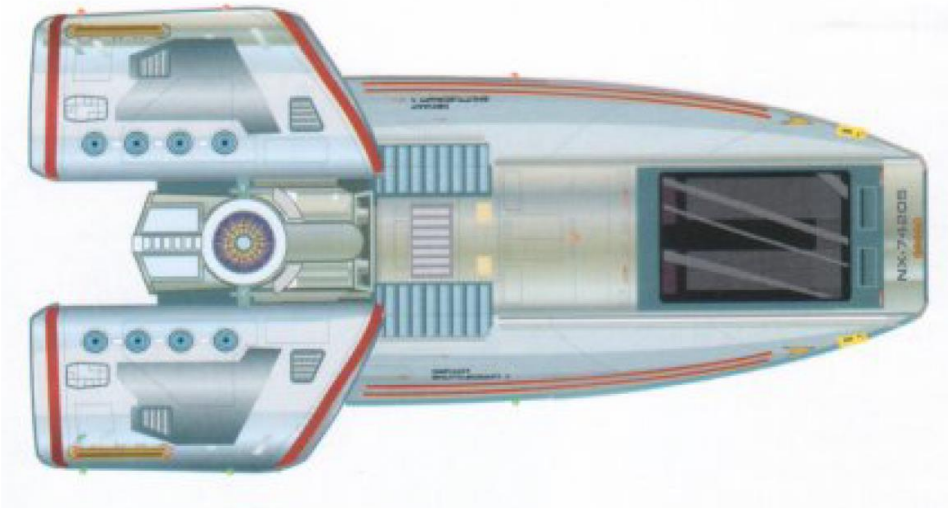
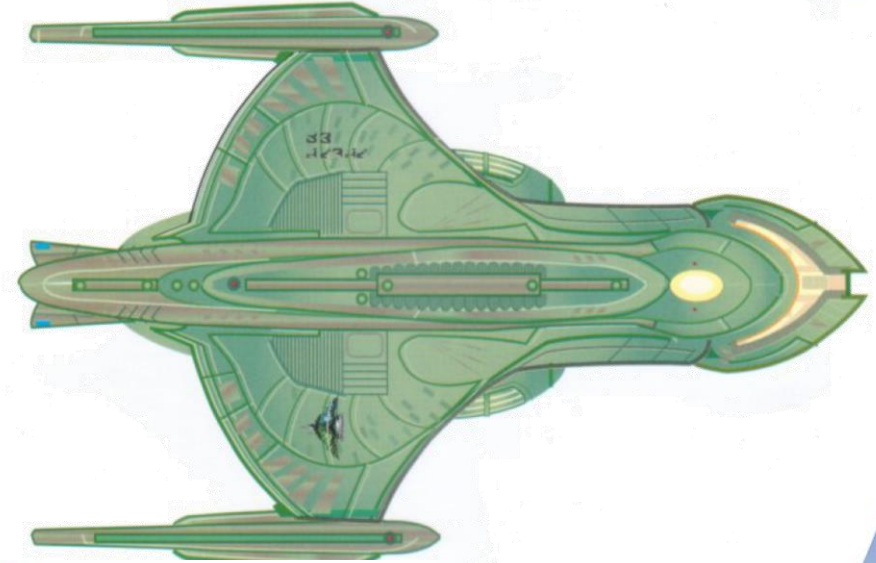
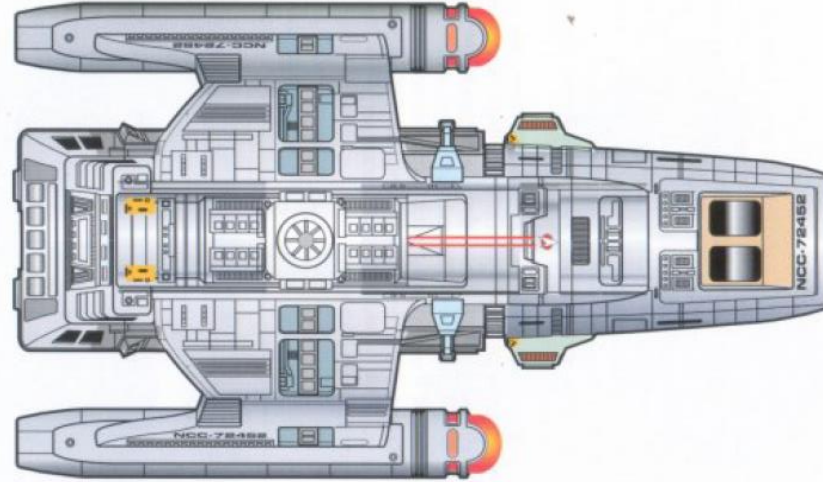


Start of My Aerospace Story in a Public Library

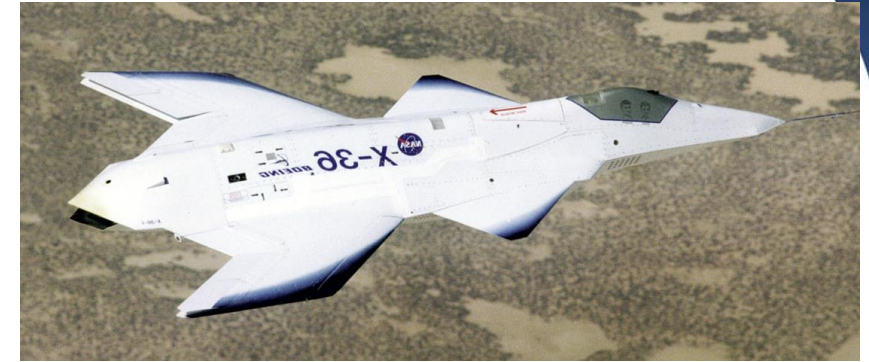
- **“Star Trek: Deep Space Nine Technical Manual** is a reference book that contains technical information about the milieu of Star Trek: Deep Space Nine. Written from an entirely in-universe point of view.”
– Memory Alpha



A Fleet of Little Ships: Diversity of Shuttles



A Fleet of Little Ships: NASA X-Planes



NASA's X-Planes of Today

➤ X-59 Quiet Super Sonic Transport (QUESST)

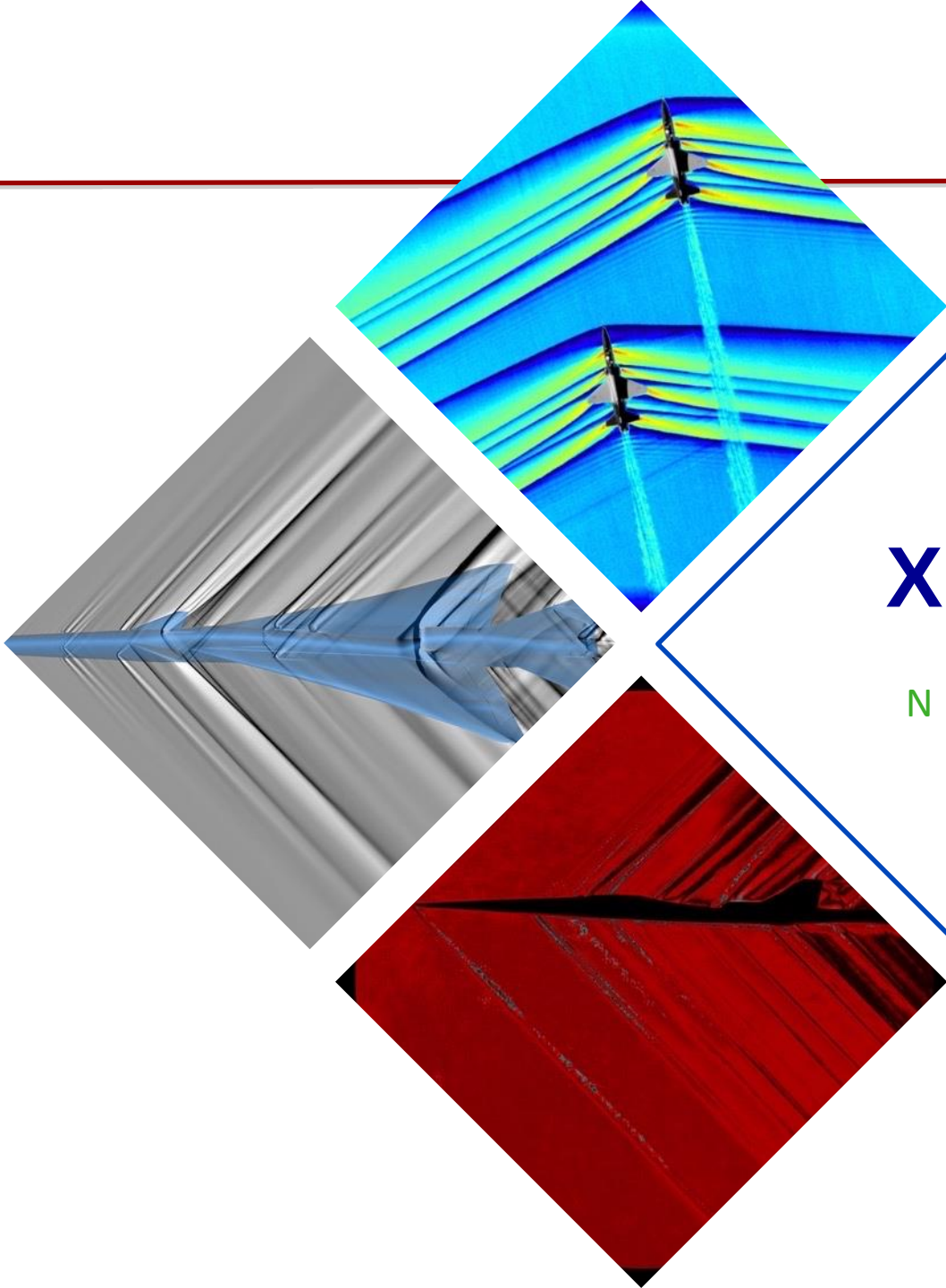
- “Demonstrate how the X-59 can fly supersonic without generating loud sonic booms to create new sound-based rules to lift the ban on faster-than-sound flight over land.”



➤ X-66A Sustainable Flight Demonstrator

- “Seeks to inform a potential new generation of more sustainable single-aisle aircraft – the workhorse of passenger airlines around the world. ”





X-59: Quieting the Boom

NASA IS TURNING A BOOM INTO
A THUMP

An Abbreviated History of Commercial Supersonic Flight

**1947 Yeager breaks
the sound barrier in
the X-1**



An Abbreviated History of Commercial Supersonic Flight

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**1964 “Operation
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[USAF]

An Abbreviated History of Commercial Supersonic Flight

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**1973 FAA Prohibits
Civilian Supersonic
Flight Over Land**

§ 91.817 Civil aircraft sonic boom.

- (a) No person may operate a civil aircraft in the United States at a true flight Mach number greater than 1 except in compliance with conditions and limitations in an authorization to exceed Mach 1 issued to the operator in accordance with § 91.818.
- (b) In addition, no person may operate a civil aircraft for which the maximum operating limit speed M_{MO} exceeds a Mach number of 1, to or from an airport in the United States, unless—
 - (1) Information available to the flight crew includes flight limitations that ensure that flights entering or leaving the United States will not cause a sonic boom to reach the surface within the United States; and
 - (2) The operator complies with the flight limitations prescribed in paragraph (b)(1) of this section or complies with conditions and limitations in an authorization to exceed Mach 1 issued in accordance with § 91.818.

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1976 Concorde
Supersonic Over
Water Routes



By Eduard Marmet - http://www.airlineairways.com/Aerospatiale-BAC-Concorde-102/1406076/L/&width=1024&height=1024&photo_id_DESC_&photo_nr=67&prev_id=1406075, CC BY-SA 3.0,
https://commons.wikimedia.org/w/index.php/File:Concorde_102_1406076.jpg

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[Smithsonian Institution]

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2005 Shaped Sonic
Boom
Demonstrator



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2020 FAA Notice of
Proposed Rulemaking
Regarding Supersonic
Flight

2020 NASA SonicBAT
F-18 Shaped Boom
Profile Flight Tests



[NASA]

QUESST: A Vision for Commercial Supersonic Flight

An emerging potential market has generated renewed interest in civil supersonic aircraft

- Evidenced by the appearance of several commercial programs despite lack of standards for enroute noise or landing and takeoff noise, emissions

Overland Flight Restrictions based on unacceptable sonic boom noise are viewed as the main barrier to this vision

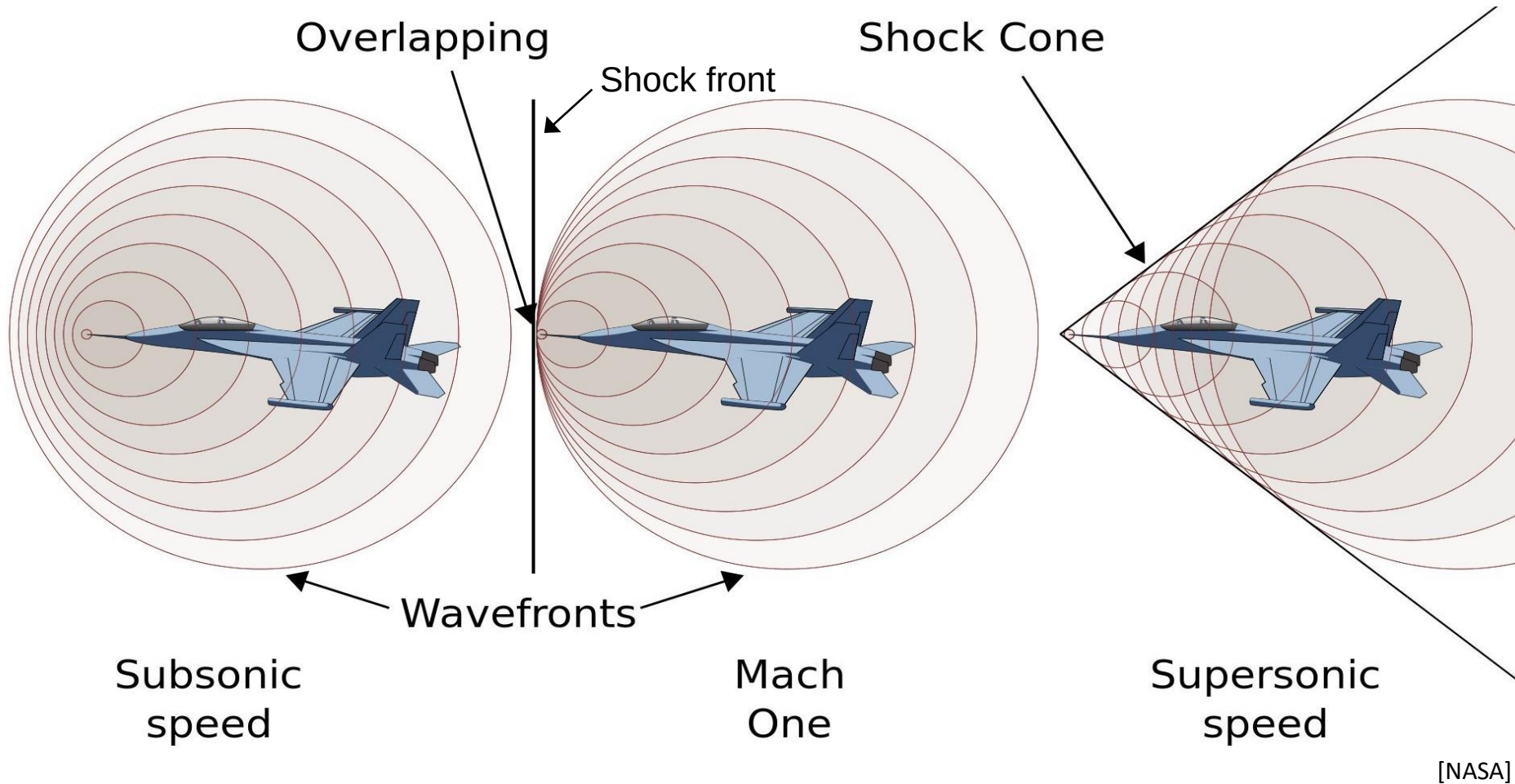


The vision of the Supersonics Community is a future where fast air travel is available for a broad spectrum of the traveling public.

- Future supersonic aircraft will not only be able to fly overland without creating an “unacceptable situation” but will also be environmentally responsible, affordable and sustainable

NASA plays a vital role in developing technology and the data that will enable this transformative new market

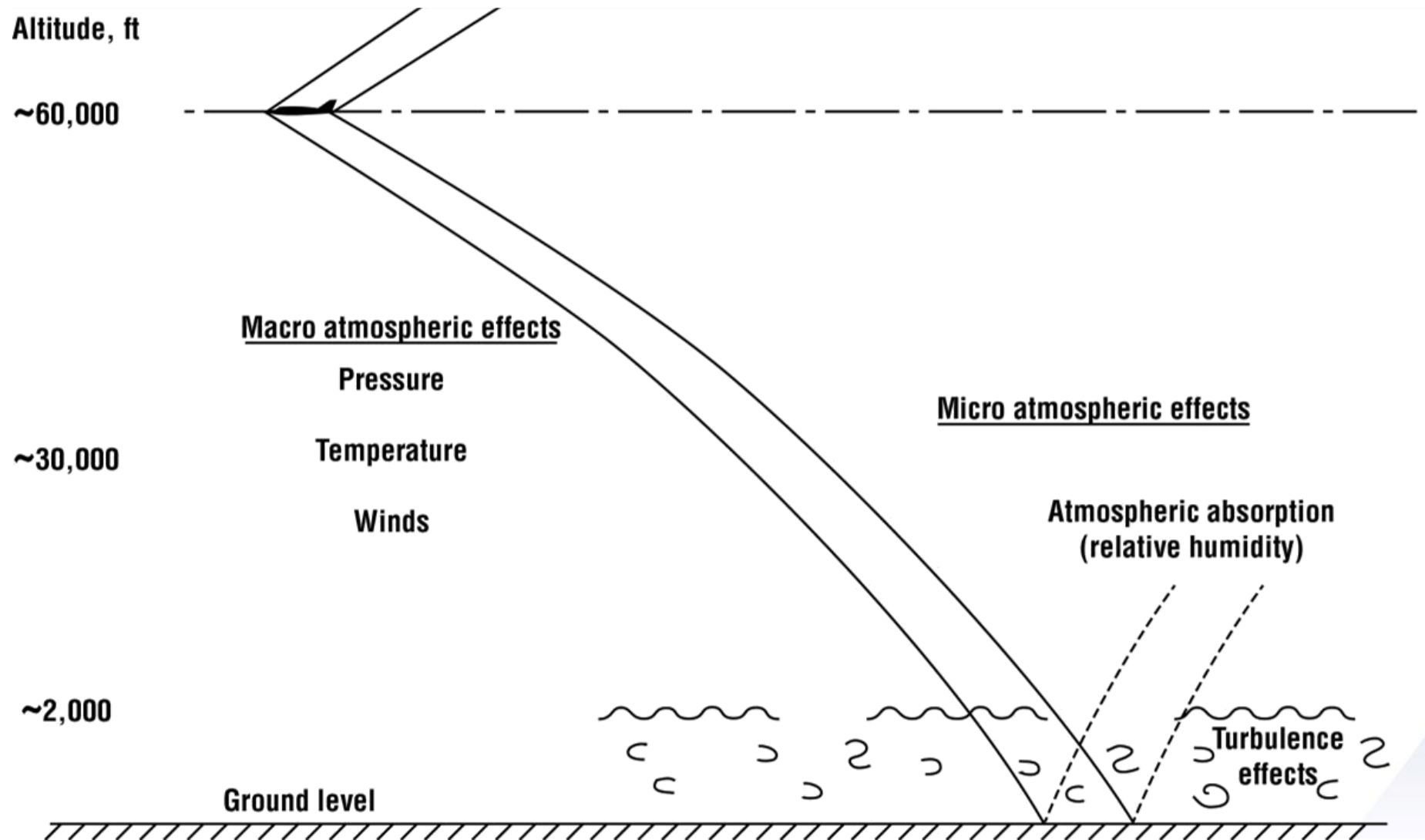
What Makes a Sonic Boom?



- Conical shock wave produces sonic boom at ground which moves with the airplane
- Boom is created over entire length of supersonic flight path, just as a boat wake

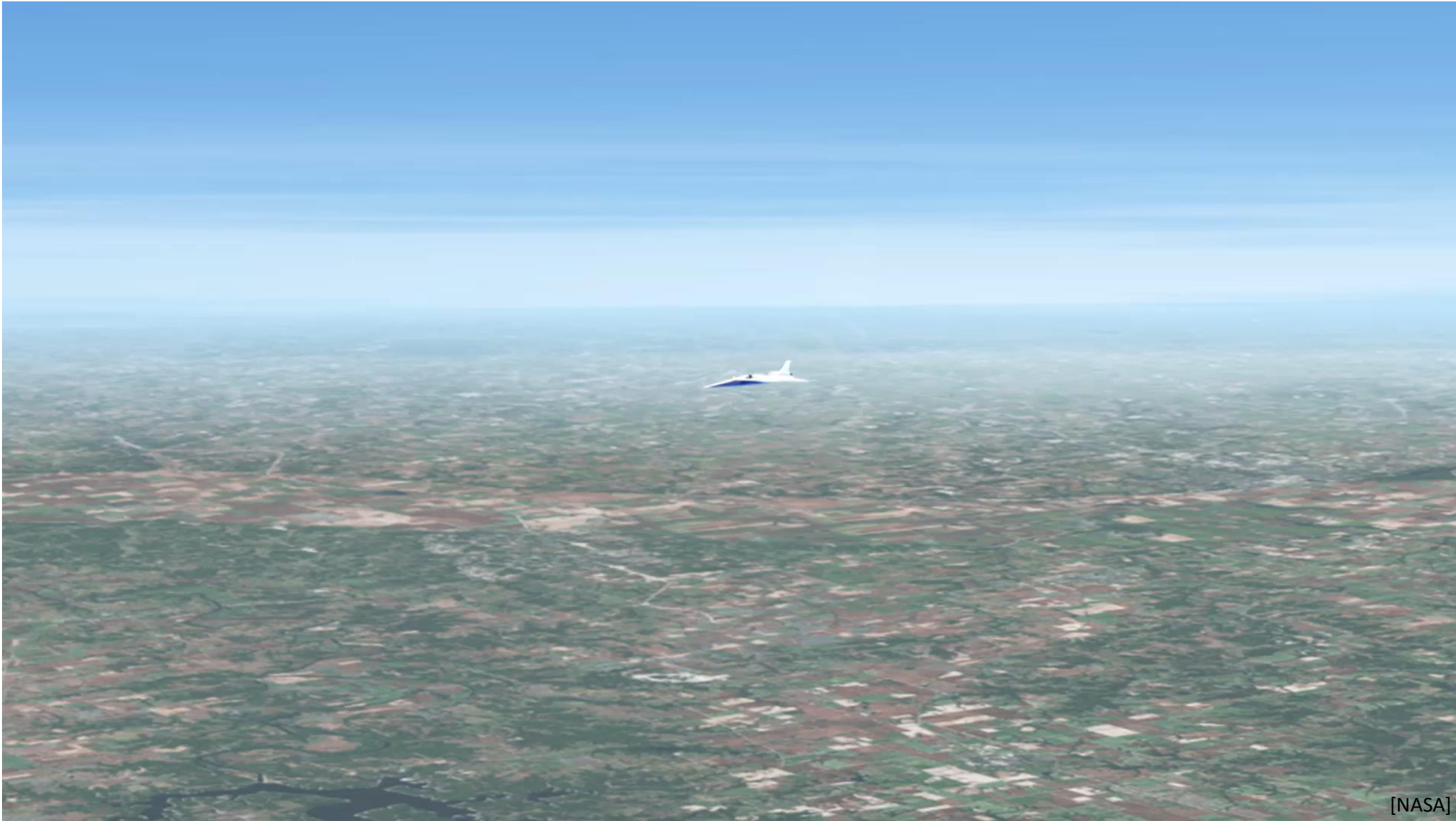
What Makes a Sonic Boom?

- Shockwaves propagate to the ground to create a boom you can hear on the ground



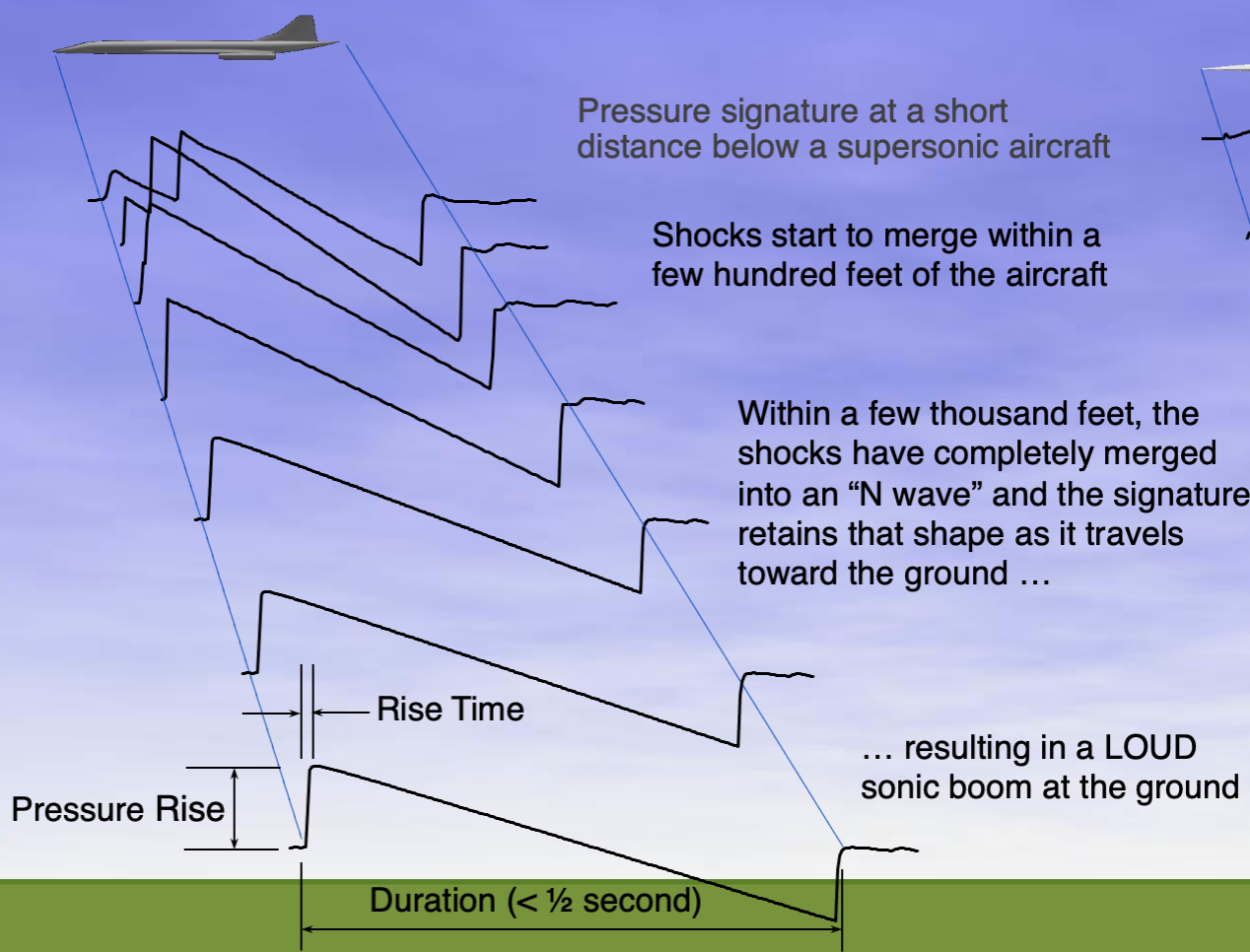


The Sonic Boom Carpet

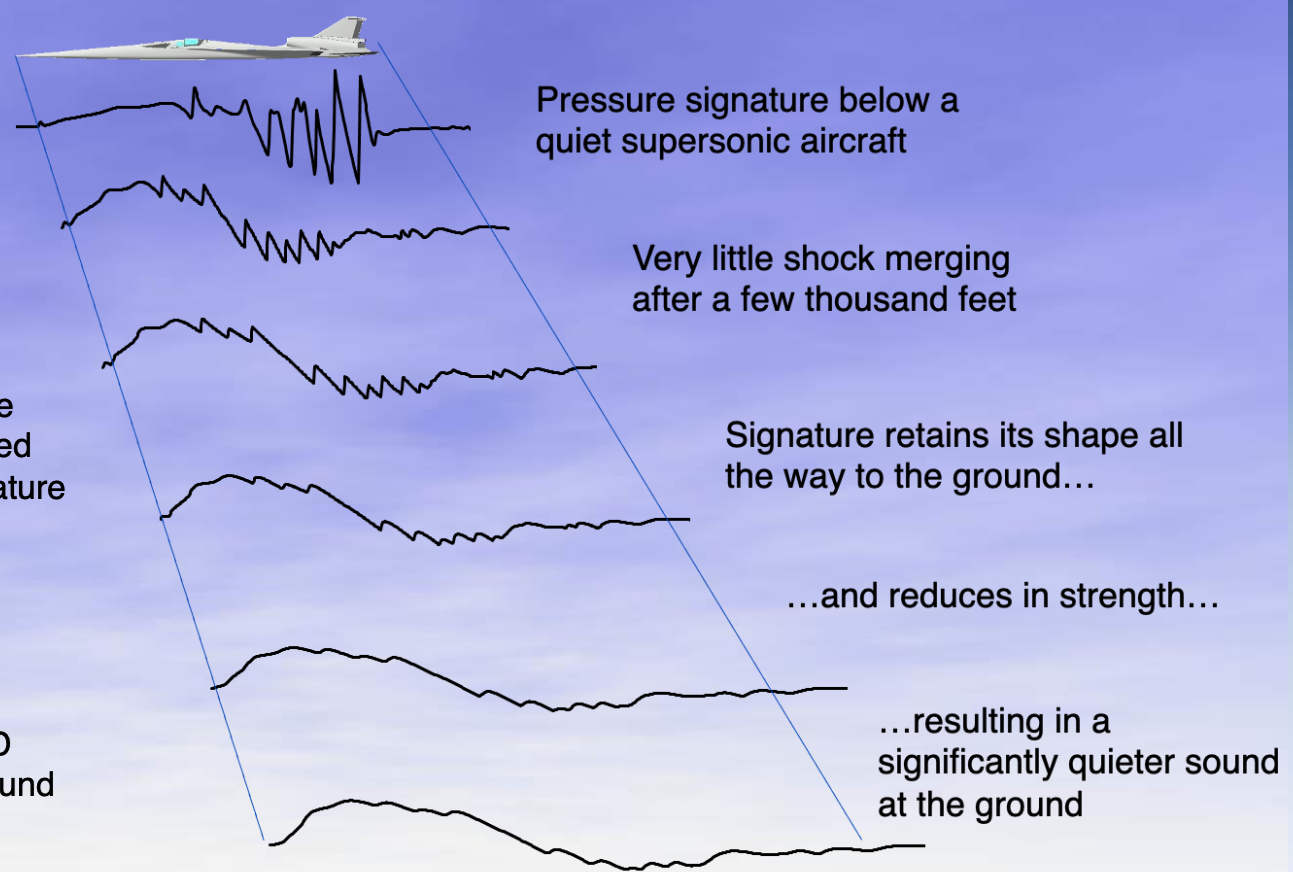


Sonic Boom to Sonic Thump

Traditional N-Wave Sonic Boom Pressure Signal



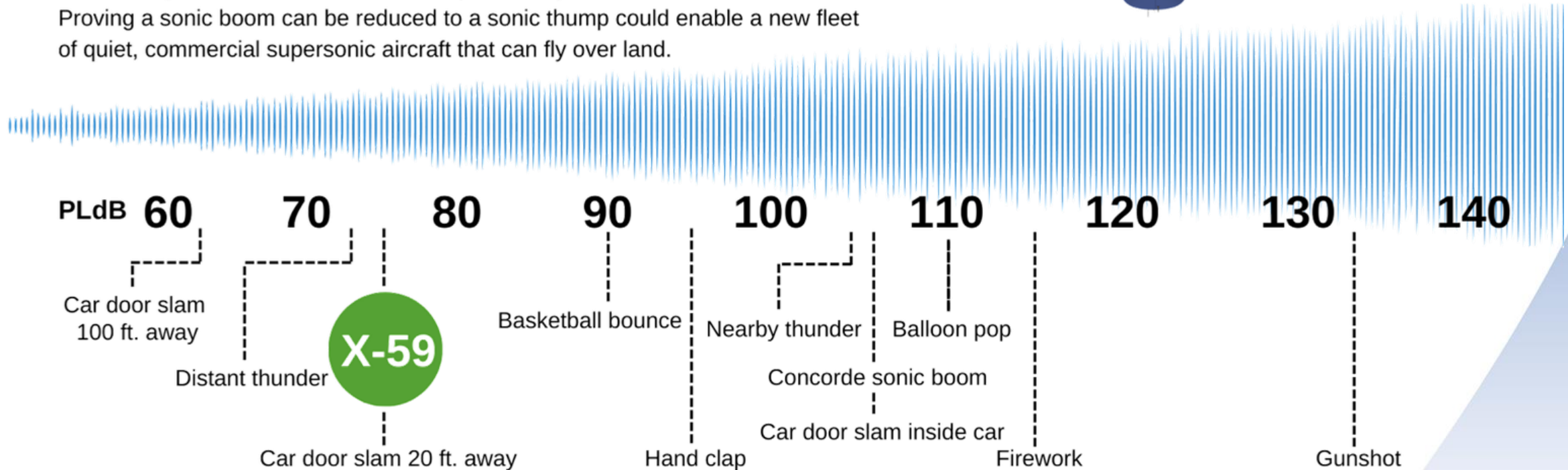
Low Boom Shaped Sonic Thump Pressure Signal



How Quiet is a Sonic Thump?

Just how quiet will NASA's X-59 be?

NASA's single-seat X-59 experimental aircraft will produce a barely audible sonic thump to people on the ground when cruising at supersonic speeds. In technical terms, the X-59's sonic thump will be around 75 Perceived Level decibels (PLdB) or less. PLdB is one of numerous scales, in decibels, that is used to understand human response to sounds and is used particularly for short duration sounds. Proving a sonic boom can be reduced to a sonic thump could enable a new fleet of quiet, commercial supersonic aircraft that can fly over land.



Overview of X-59 Aircraft Features

X-plane approach that meets key requirements in a cost-effective design

T-tail to minimize aft shock

Single GE-F414 engine with standard nozzle to minimize cost and schedule

Conventional tail arrangement to simplify stability and control considerations

T-38 aft canopy and ejection seat to minimize qualification cost and schedule

External and forward visions systems for forward visibility

Long nose to shape forward shock

Fixed canard for nose-up trim at low-boom design point

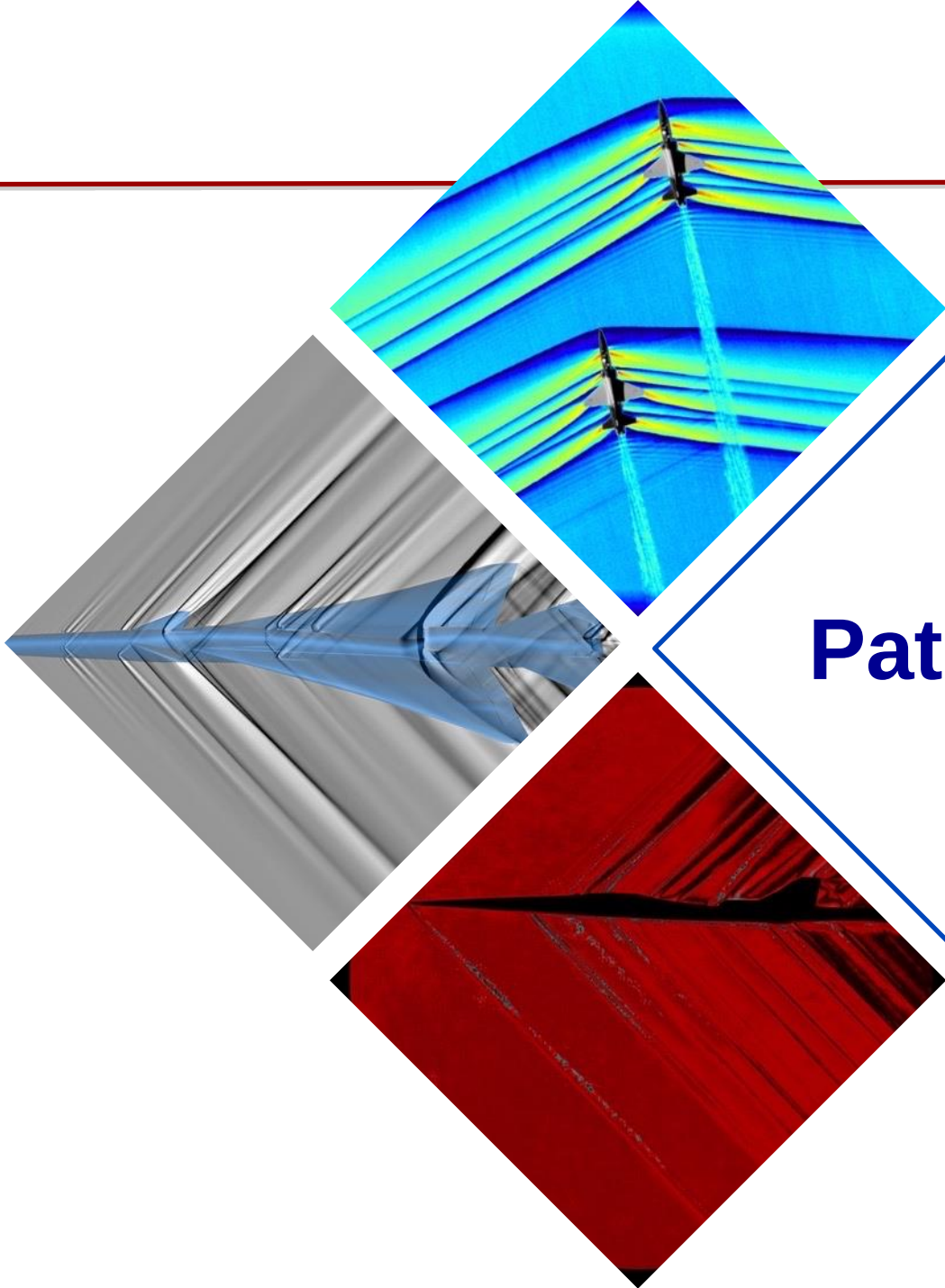
Large, unitized skins reduce parts count and manufacturing cost

F-16 landing gear and other systems from high performance aircraft to minimize qualification cost and schedule

Wing shielding to minimize impact of inlet spillage on sonic boom

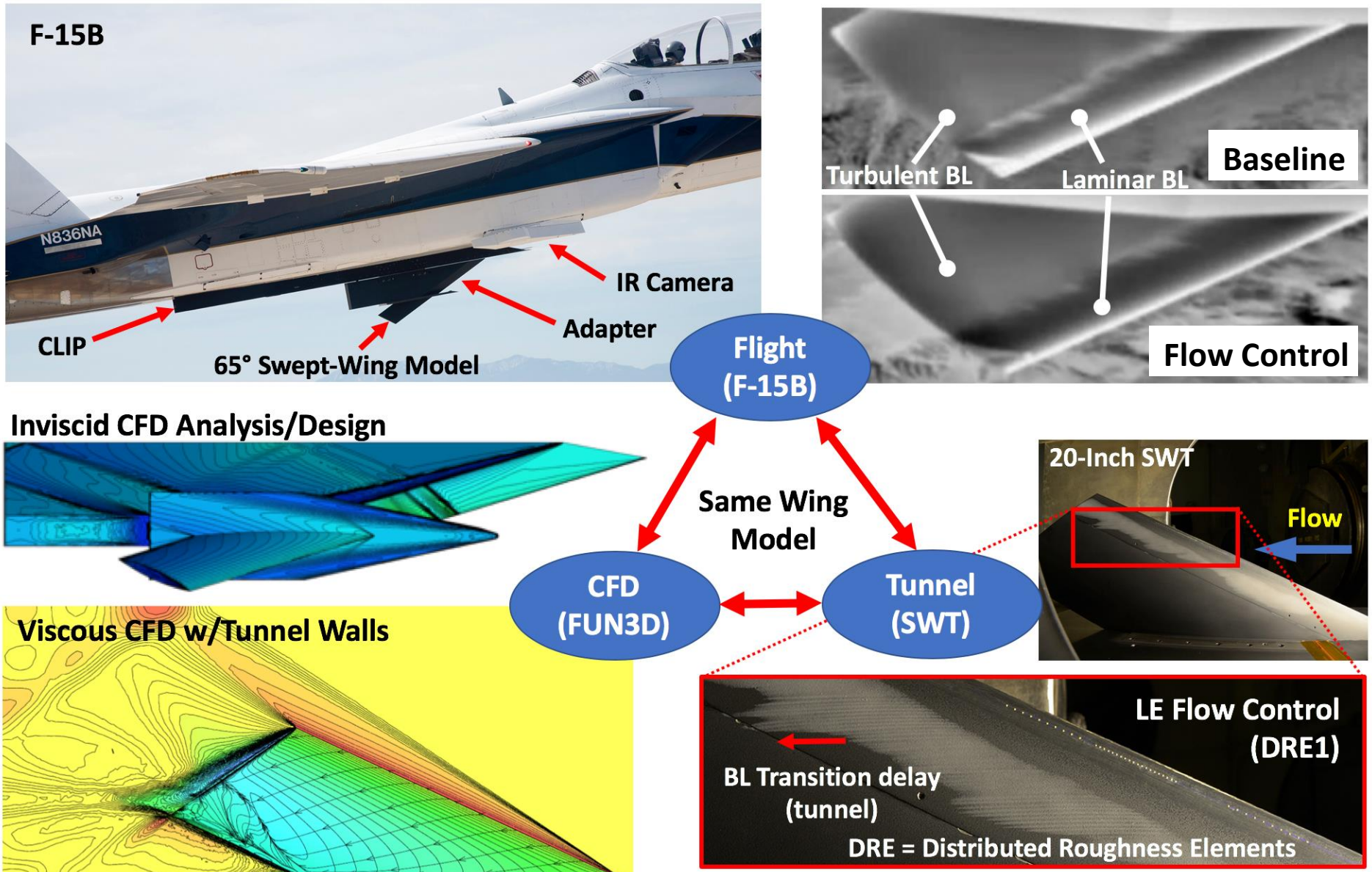
Design Parameters

- **Length: 99 ft**
- **Span: 29.5 ft**
- **Speed: Mach 1.4 (925 mph)**
- **Altitude: 55,000 ft**

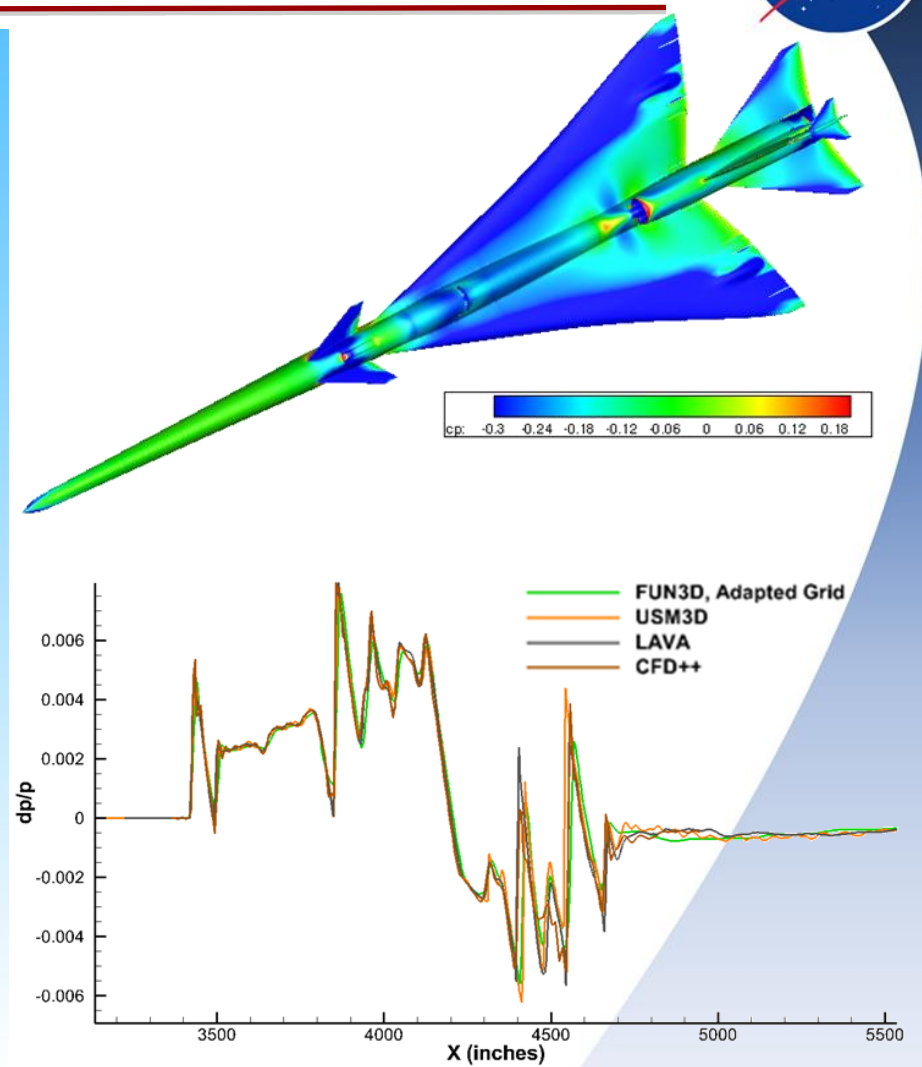
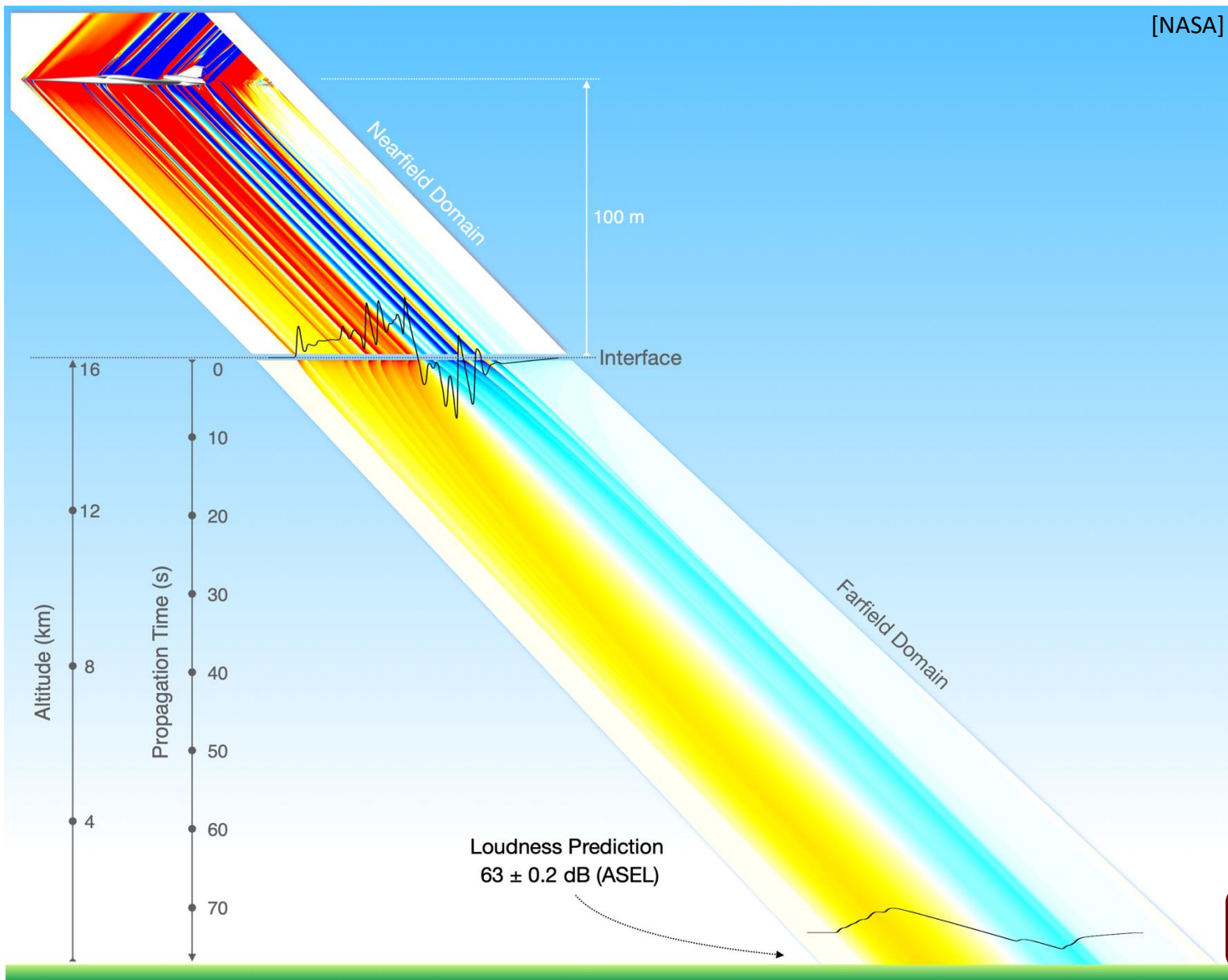


Path from Lab Experiment to X-Plane

Component Analysis and Fundamental Science

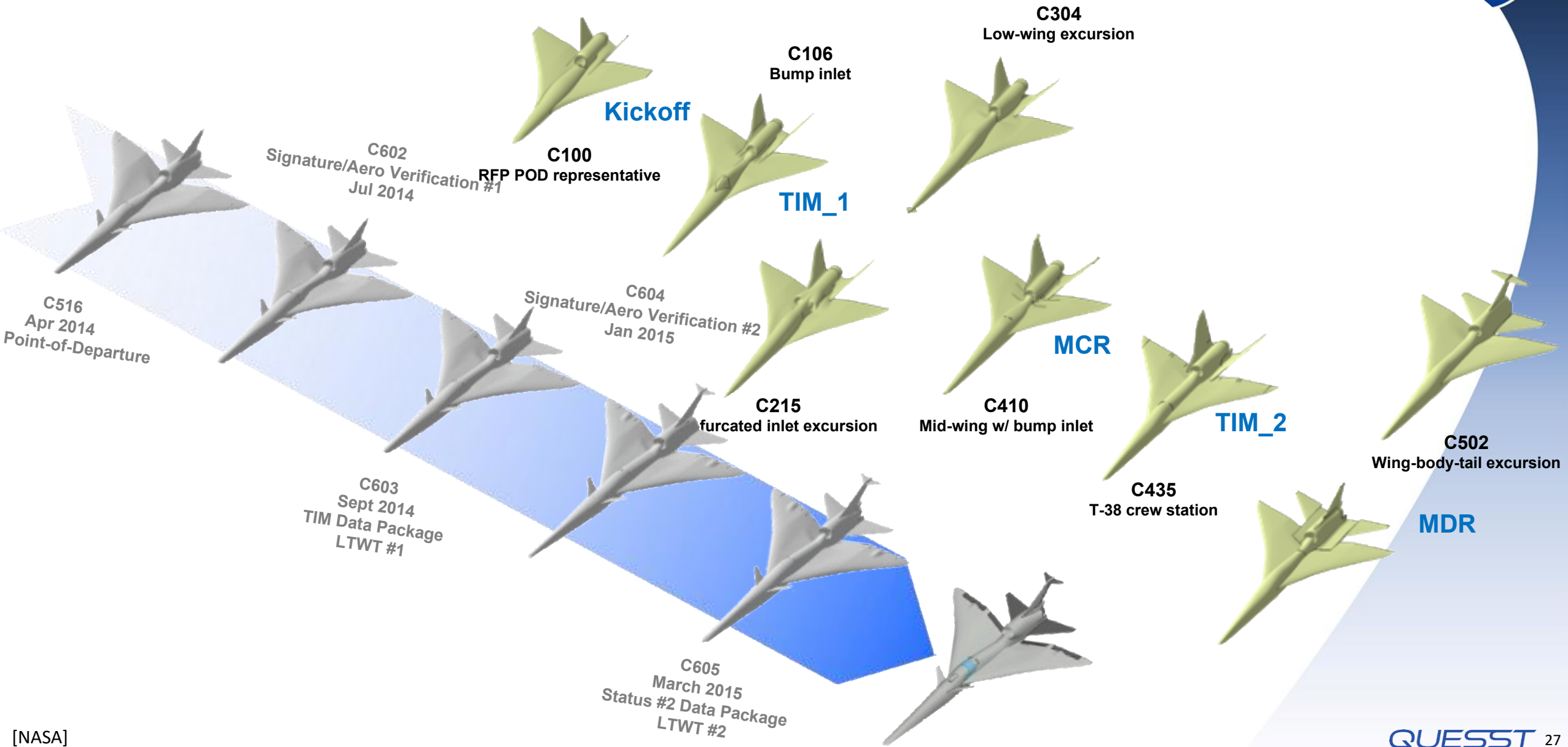


Modeling and Prediction Tool Development

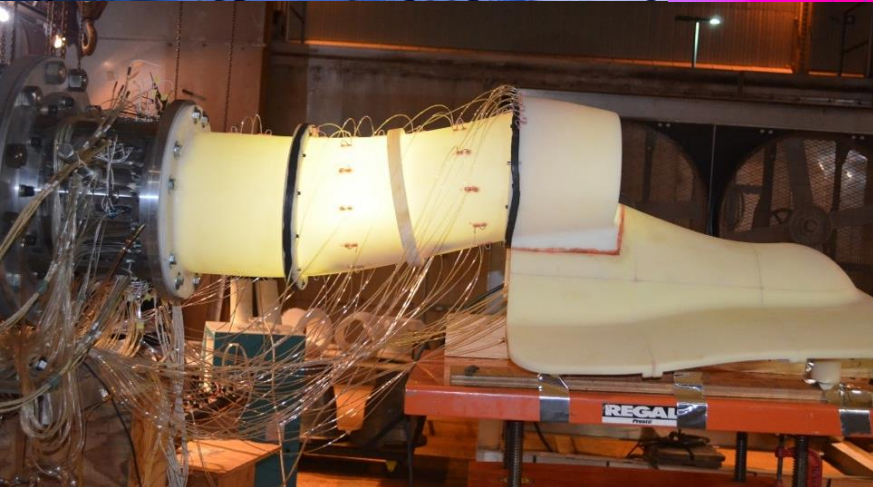
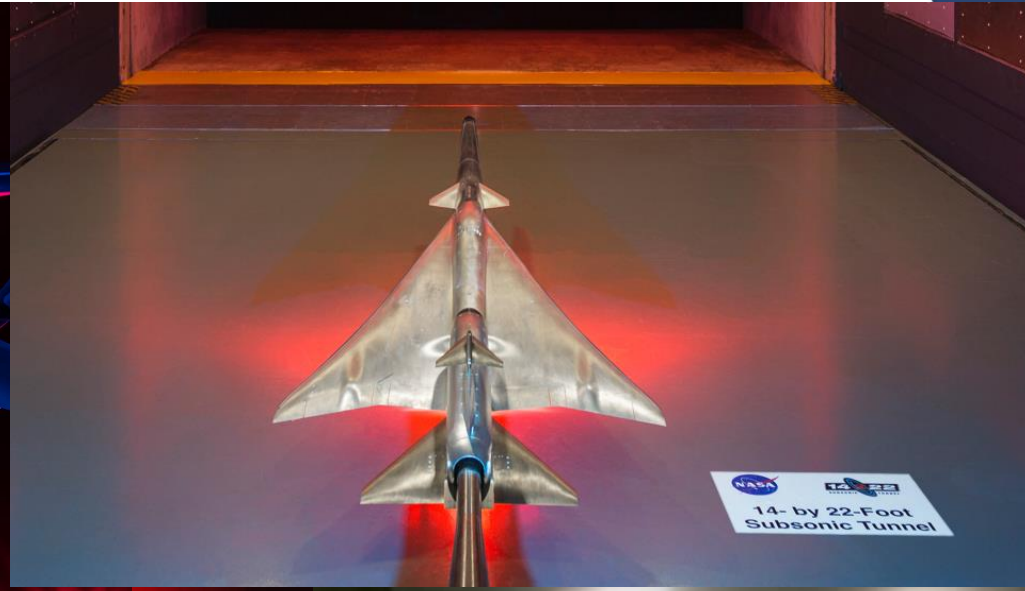


Sonic Thump on the Ground
(75 PLdB Target)

Apply Tools to Conceptual Design

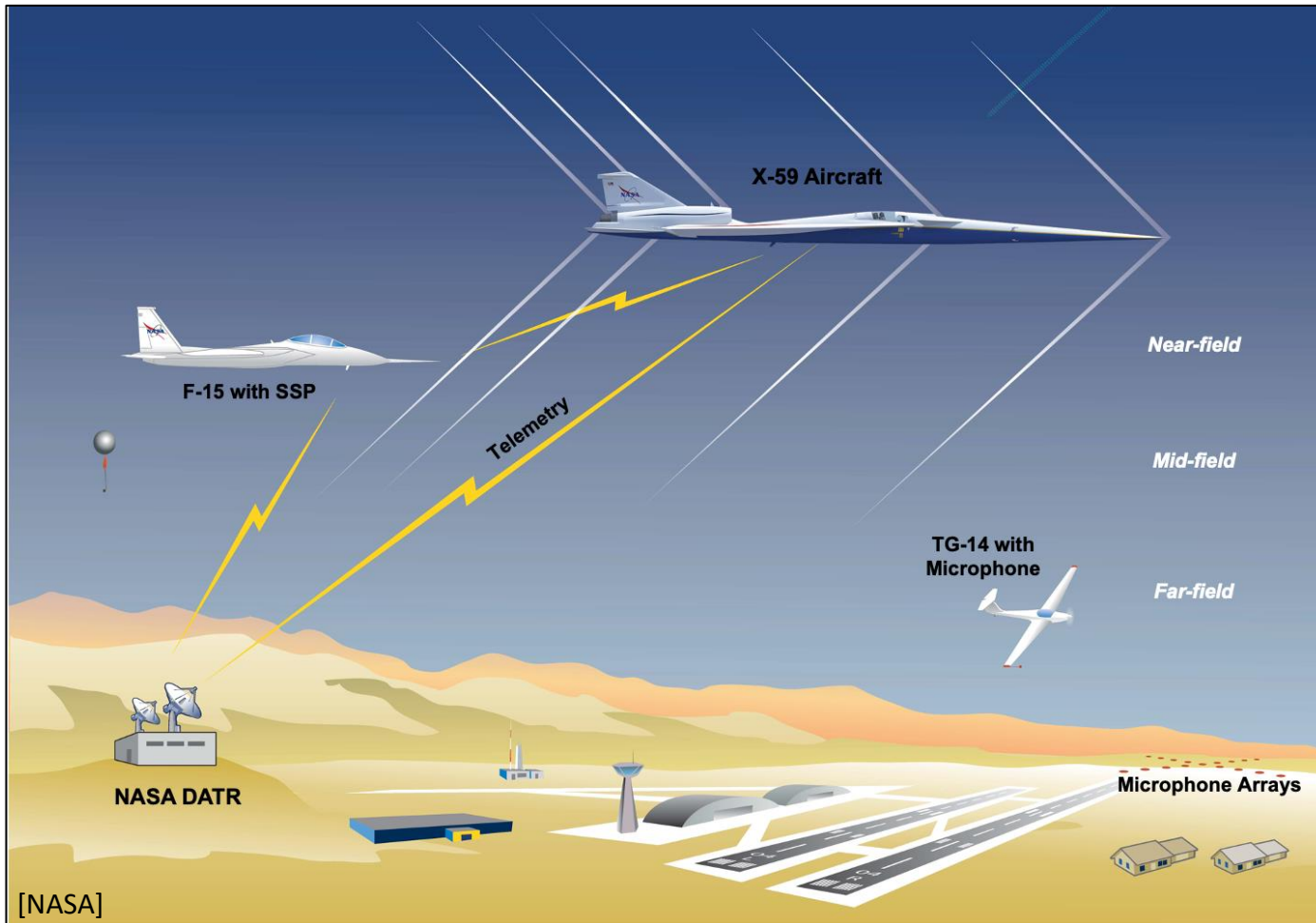


Validate Design and Tools in the Wind Tunnel

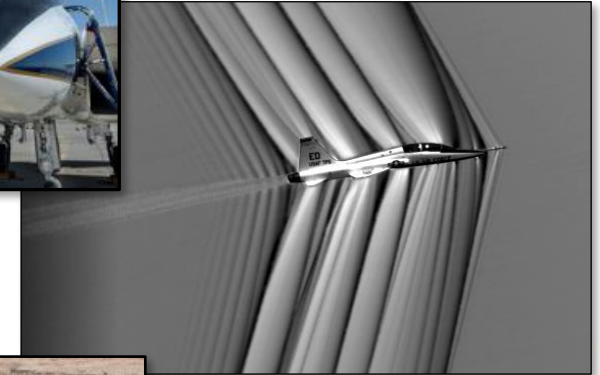


Acoustic Validation Test Planning and Execution

- Plan and execute a test at NASA Armstrong in California to validate ground acoustic signature



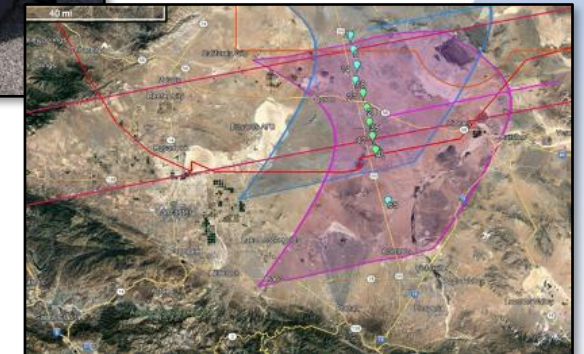
F-15 With Shock Sensing Probe



Advanced Air-Air Schlieren Imaging



Ground Recording Systems

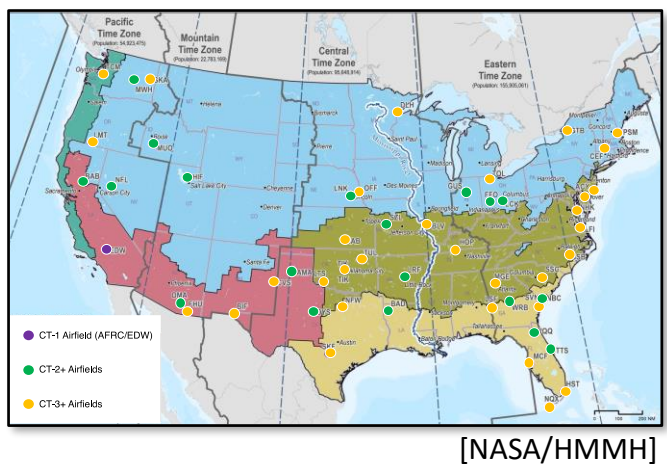


Flight Planning

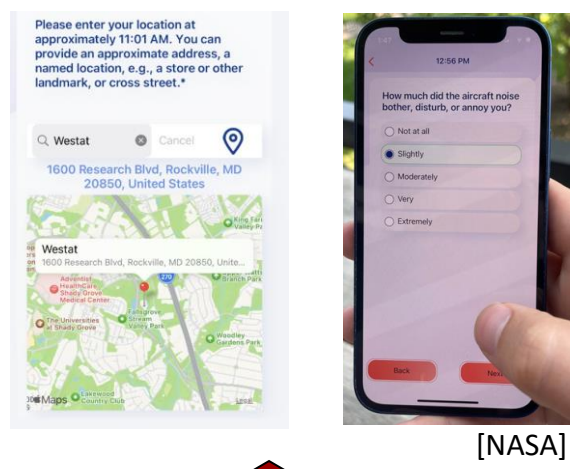
Community Test Planning and Execution

➤ Execute sonic boom tests with the X-59 aircraft over communities in the US

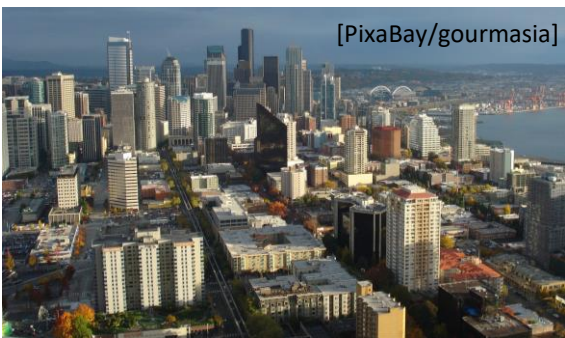
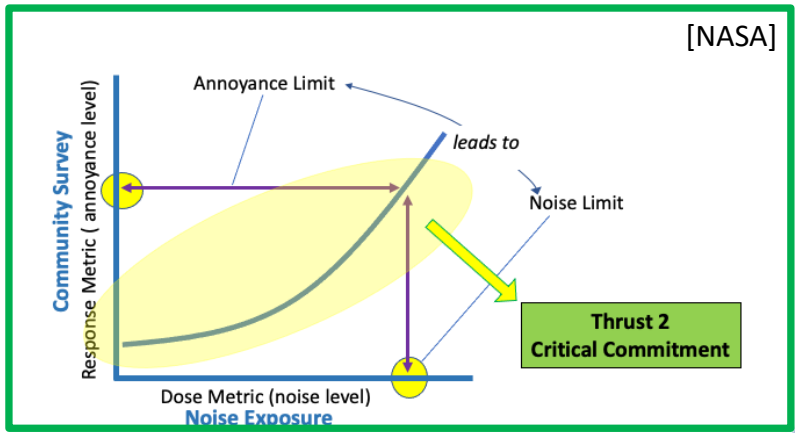
Airfield and Community Selection



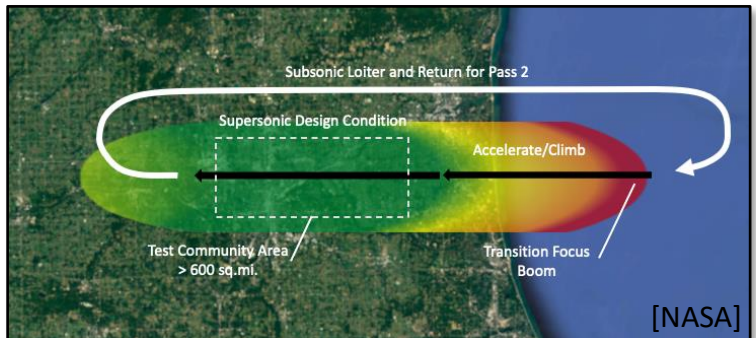
Survey Design and Analysis



Dose-Response Relationship



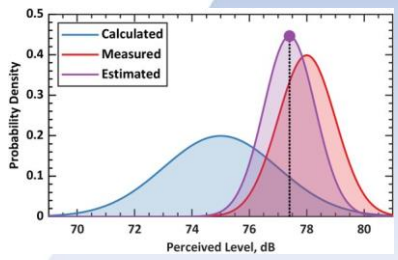
Community Engagement



Flight and Test Planning



Exposure Estimation



In Conclusion

- **Science fiction and your public library are a gateway to passion and a career in science.**
- **NASA X-Planes will be flying again soon!**
- **NASA Langley is pushing the boundaries of how we fly from fundamental science to flight in your backyard.**



Questions?