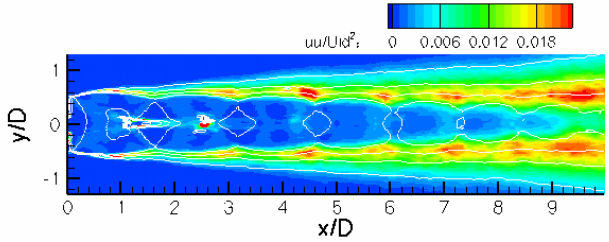
Supersonics Project Overview



Fundamental Aeronautics Annual Meeting

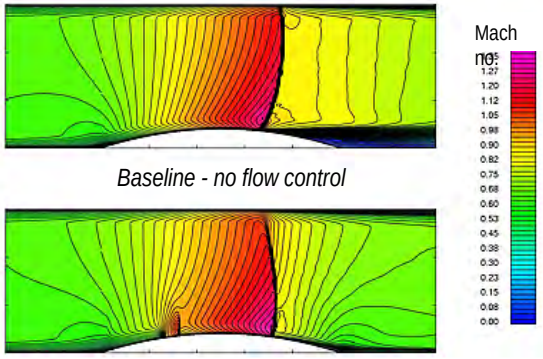
New Orleans, LA

October 30, 2007

PI: Peter Coen

PS: Lou Povinelli

PM: Kaz Civinskas

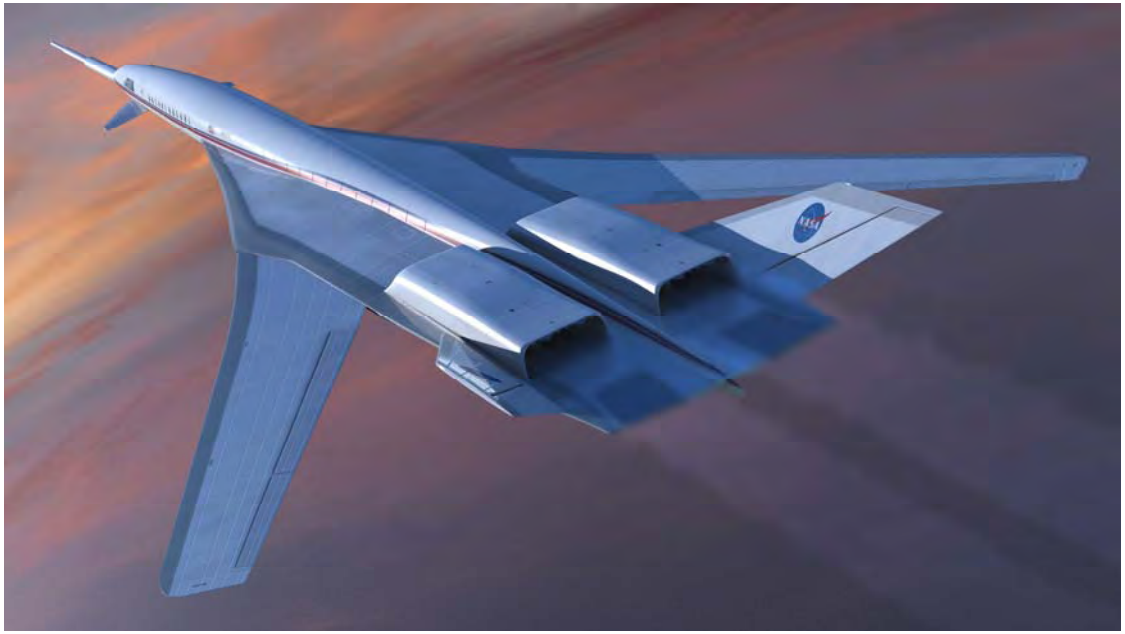


Baseline - no flow control

Micro-ramp flow control

Fundamental Aeronautics Supersonic Project

Project Goal: Tool and technology development for the broad spectrum of supersonic flight.



Supersonic Cruise Aircraft

Eliminate the efficiency, environmental and performance barriers to practical supersonic cruise vehicles

High Mass Planetary Entry Systems

Address the critical supersonic deceleration phase of future large payload Exploration and Science Missions

Supersonics Project Technical Challenges

The Supersonics technical challenge areas are designed to break the traditional discipline "stovepipes" and foster innovative solutions "at the seams" between disciplines

- Efficiency Challenges - 30 % Improvement over HSR
  - Supersonic Cruise Efficiency
  - Light Weight and Durability at High Temperature
- Environmental Challenges - No greater impact than subsonic fleet
  - Airport Noise: Acceptable levels without weight or performance penalty
  - Sonic Boom: Propagation, prediction and design
  - High Altitude Emissions: Emissions impact must be minimized or eliminated
- Performance Challenges - Safe and comfortable flight for crew and passengers
  - Aero-Propulso-Servo-Elastic (APSE) Analysis and Design: Controlling flutter, gust, and maneuver loads in a manner that is synergistic with the vehicle structural design
- Entry Descent and Landing Challenges
  - Supersonic Entry Deceleration: Develop tools and technologies to support the design and validation of exploration systems capable of landing payloads in the 30 metric ton class
- System Integration, MDAO Challenges
  - Understanding and exploiting the interactions of all these supersonic technology challenges is the key to the creation of practical designs

Partners include: DARPA, AFRL, JPDO, U.S Aerospace Industry, Hypersonics Project, ESMD, SMD

Supersonics Project Technical Elements - Part 1

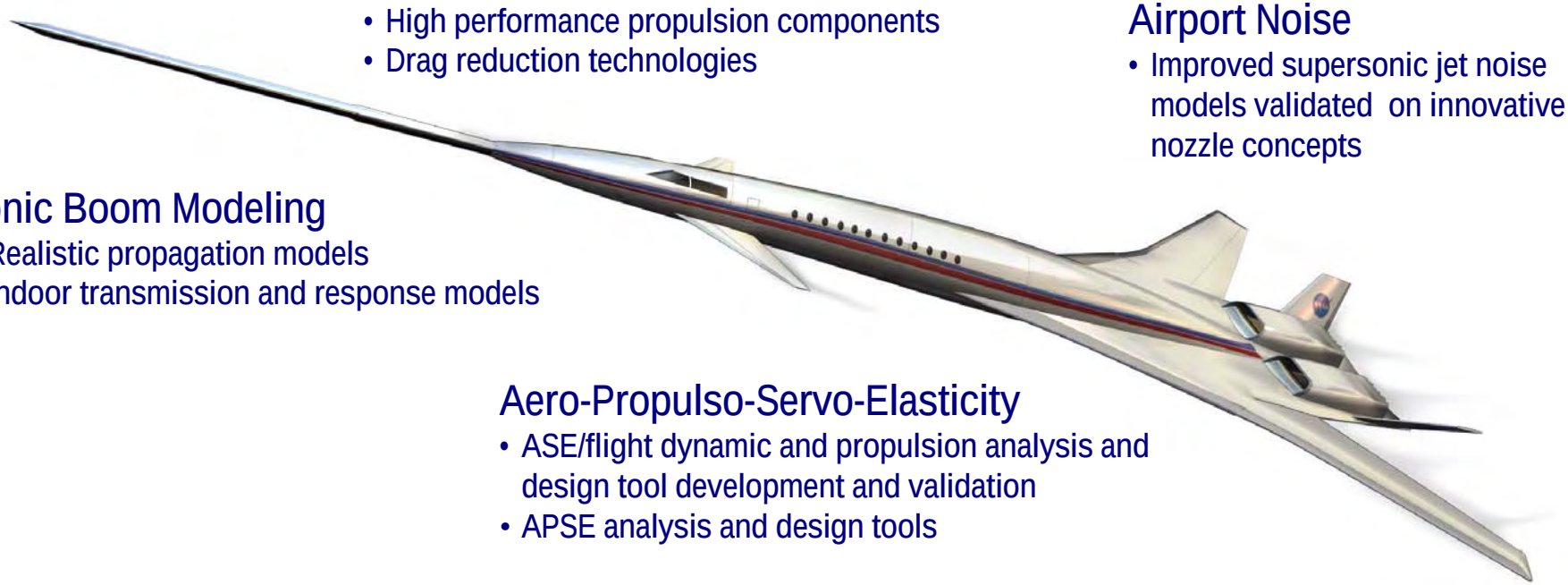
Deliver Knowledge, Capabilities, and Technologies Addressing Supersonics Challenges

Cruise Efficiency

- Tools and technologies for integrated propulsion and vehicle systems level analysis and design
- High performance propulsion components
- Drag reduction technologies

Airport Noise

- Improved supersonic jet noise models validated on innovative nozzle concepts



Sonic Boom Modeling

- Realistic propagation models
- Indoor transmission and response models

Aero-Propulso-Servo-Elasticity

- ASE/flight dynamic and propulsion analysis and design tool development and validation
- APSE analysis and design tools

Light Weight and Durability at High Temperature

- Materials, test and analysis methods for airframe and engine efficiency, durability and damage tolerance

High Altitude Emissions

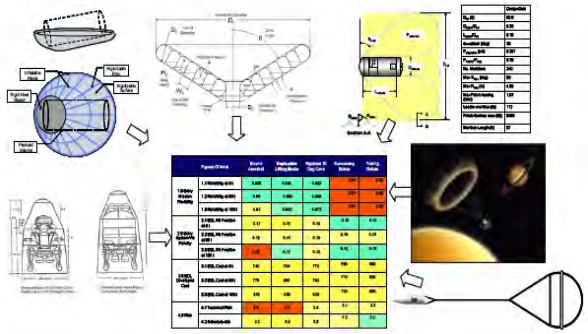
- Improved prediction tools
- Low emissions combustors

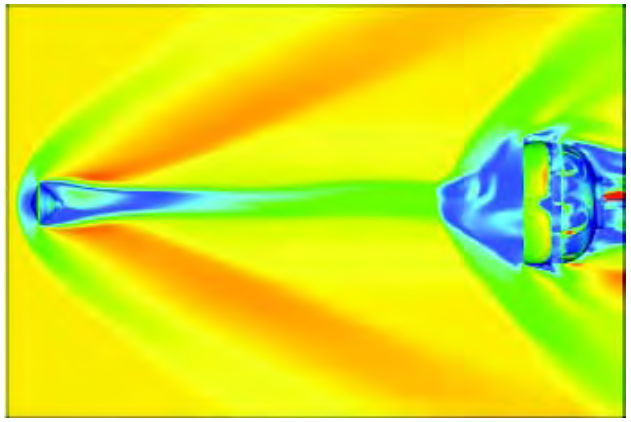
Supersonics Project Technical Elements - Part 2

In partnership with the Hypersonics Project, Lay the Groundwork for Future High Mass Entry Systems

Innovative Concepts

- Integrated elements
- System-level trade studies





Fluid Dynamics

- Highly Unsteady Flow
- Turbulence

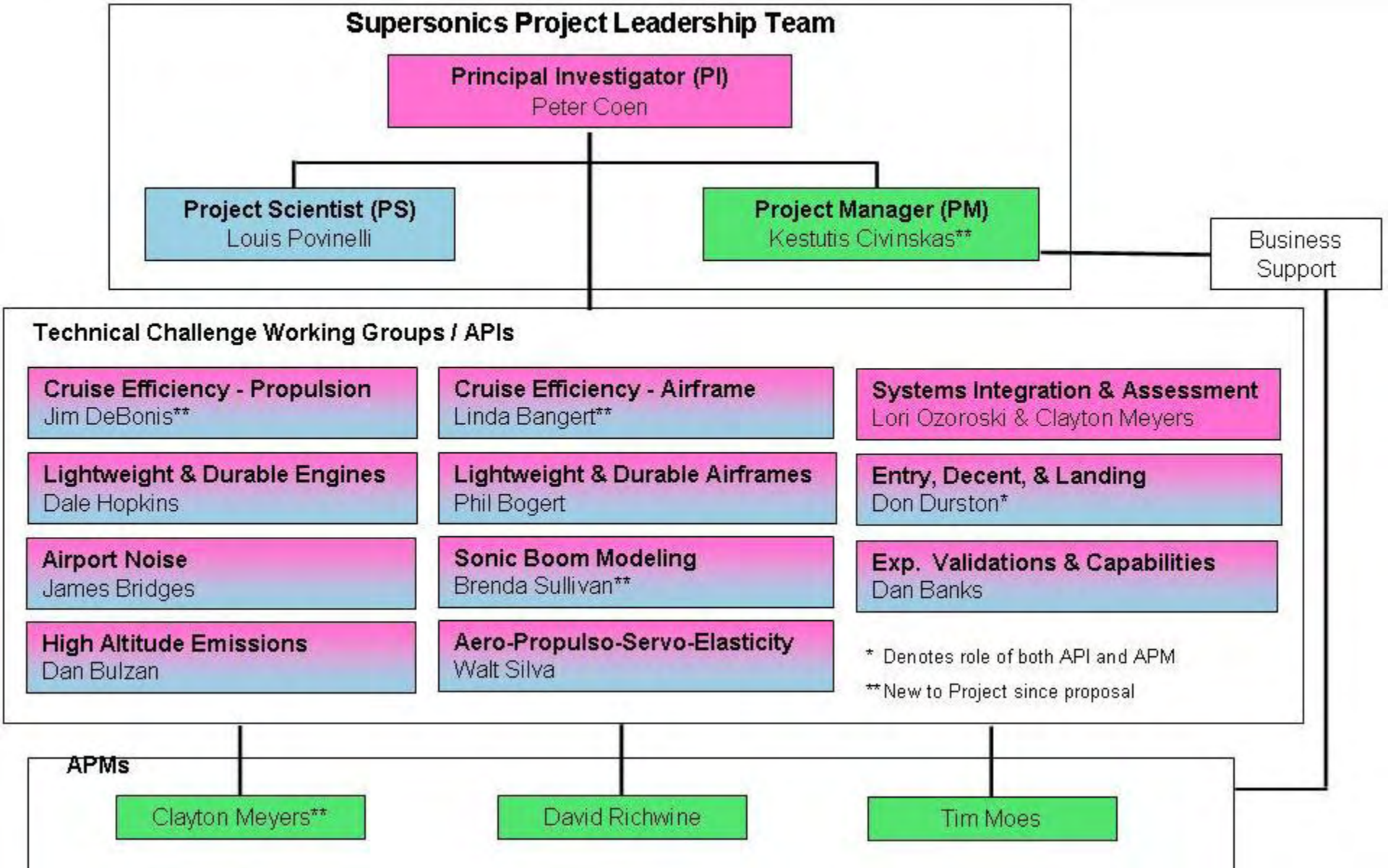
Fluid-Structures Interaction

- Simulation tools for design
- Flexible membrane structures
- High-speed deployment

Propulsive Deceleration

- Analytical tools and methods
- Reaction control systems

Organization and Key Personnel



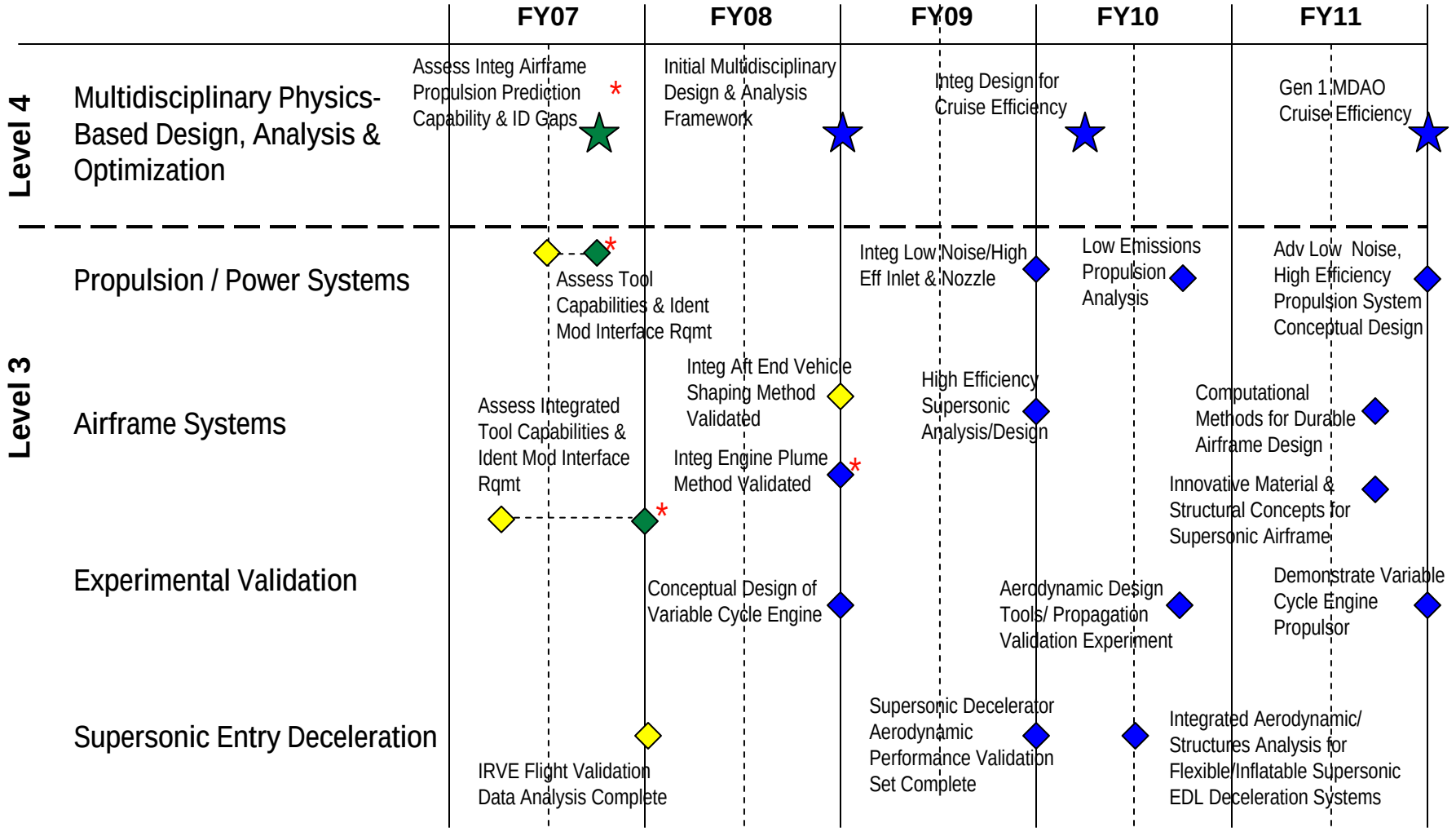
Project Contact Information

Last Name	First Name	Email	Phone	Role
Coen	Peter	peter.g.coen@nasa.gov	757-864-5991	PI
Civinskas	Kaz	Kestutis Civinskas	216-433-5890	PM
Povinelli	Lou	louis.a.povinelli@nasa.gov	216-433-5818	PS
Richwine	David	david.m.richwine@nasa.gov	757-864-4533	APM
Moes	Tim	timothy.r.moes@nasa.gov	661-276-3054	APM
Meyers	Clayton	clayton.l.meyers@nasa.gov	216-433-3882	2. SIAV / APM
Ozoroski	Lori	l.p.ozoroski@larc.nasa.gov	757-864-5992	2. SIAV
DeBonis	Jim	james.r.debonis@nasa.gov	216-433-6581	3. SCE-P
Bangert	Linda	linda.s.bangert@nasa.gov	757-864-3022	4. SCE-A
Bogert	Phil	philip.b.bogert@nasa.gov	757-864-3188	5. LDA
Hopkins	Dale	dale.a.hopkins@nasa.gov	216-433-3260	6. LDE
Bridges	James	james.e.bridges@nasa.gov	216-433-2693	7. AN
Sullivan	Brenda	brenda.m.sullivan@nasa.gov	757-864-3585	8. SBM
Bulzan	Dan	Dan.L.Bulzan@nasa.gov	216-433-5848	9. HAE
Silva	Walt	walter.a.silva@nasa.gov	757-864-2834	10. APSE
Banks	Dan	dan.banks@dfrc.nasa.gov	661-276-2921	11. EC
Durston	Don	Don.Durston@nasa.gov	650-604-1515	12. EDL / APM

Key:
Principal Investigator (PI), Project Manager (PM), Project Scientist (PS)
Associate Principal Investigator (API); Associate Project Manager (APM)

2. System Integration, Assessment & Validation (SIAV)
3. Supersonic Cruise Efficiency- Propulsion (SCE-P)
4. Supersonics Cruise Efficiency- Airframe (SCE-A)
5. Lightweight and Durable Airframes (LDA)
6. Lightweight and Durable Engines (LDE)
6. Airport Noise (AN)
7. Sonic Boom Modeling (SBM)
8. High Altitude Emissions (HAE)
9. Aero-Propulso-Servo-Elasticity (APSE)
10. Experimental Capabilities (EC)
11. Planetary Entry, Descent, and Landing (EDL)
Associate Project Manager (APM)
Technical Challenge Working Group (TCWG)

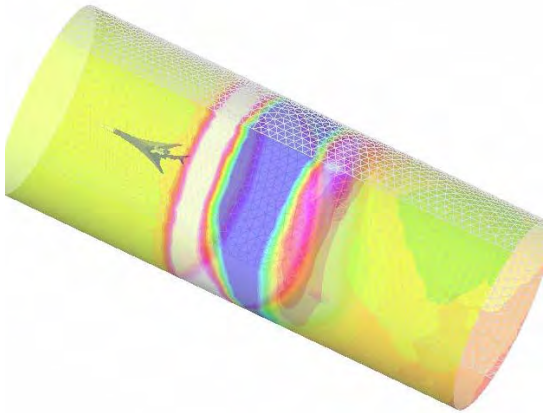
Project Key Milestones

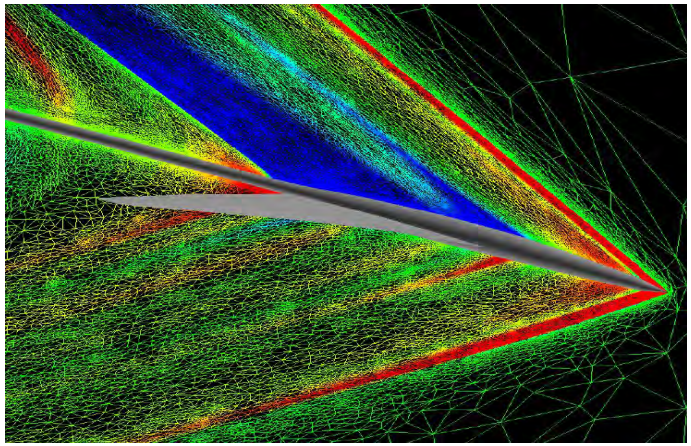


◆ Completed ◆ At risk or Date has Slipped ◆ Planned

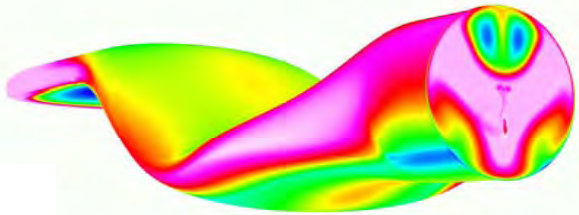
•Supports Annual Performance Goal Milestone

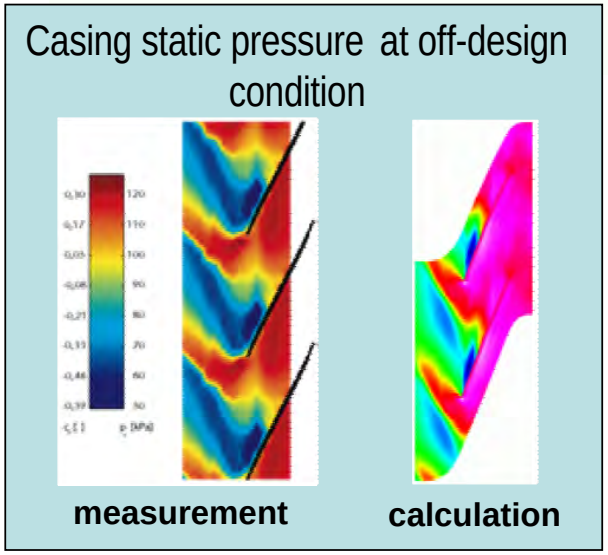
Highlights: Efficiency Technical Challenge





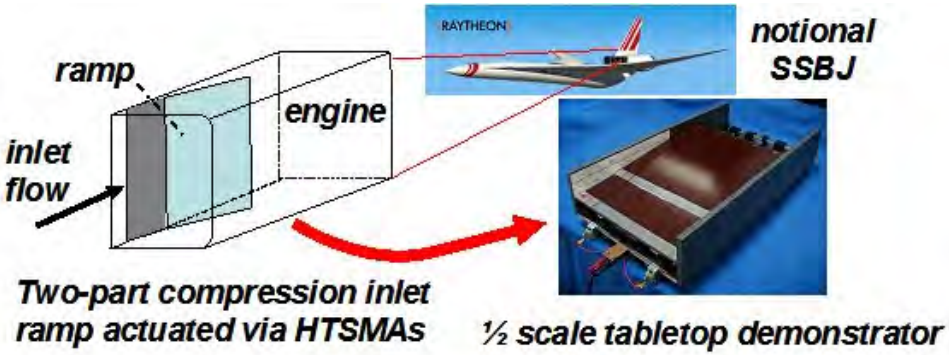
Characterized grid requirements and developed grid adaptation approaches for rapid/efficient analysis of supersonic flow fields

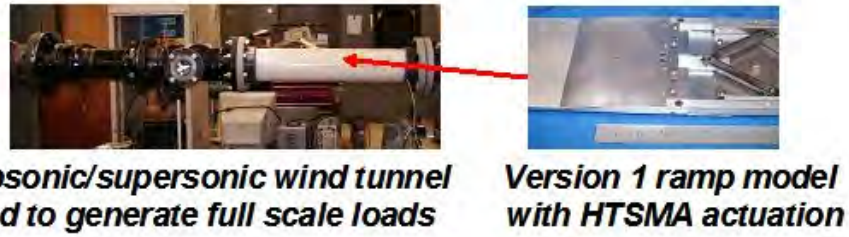




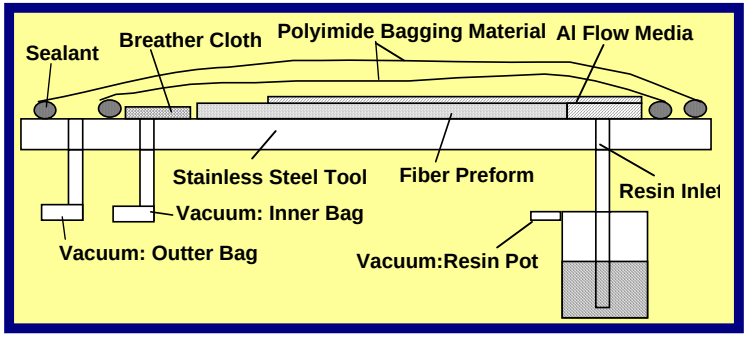
Developed 2 (LES and RANS/Euler) approaches to performing coupled inlet fan analysis

Highlights: Efficiency Technical Challenge

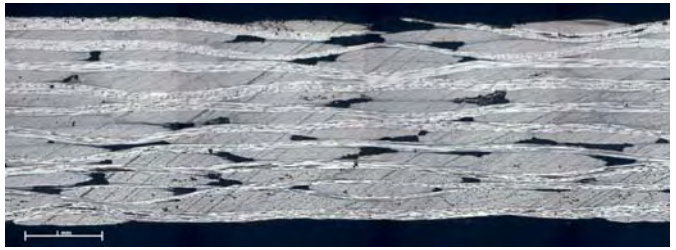




Demonstrated application of NiTiPt alloy based functional material as an actuator for supersonic inlet ramp



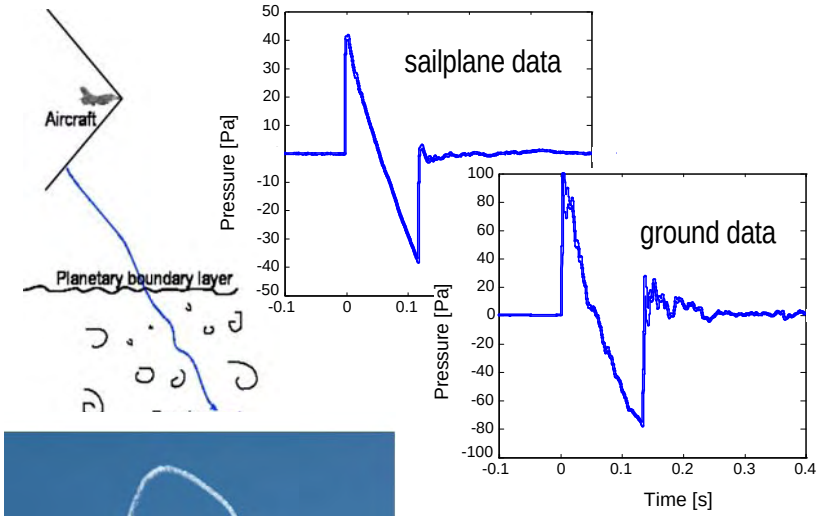
High Temperature VARTM Schematic

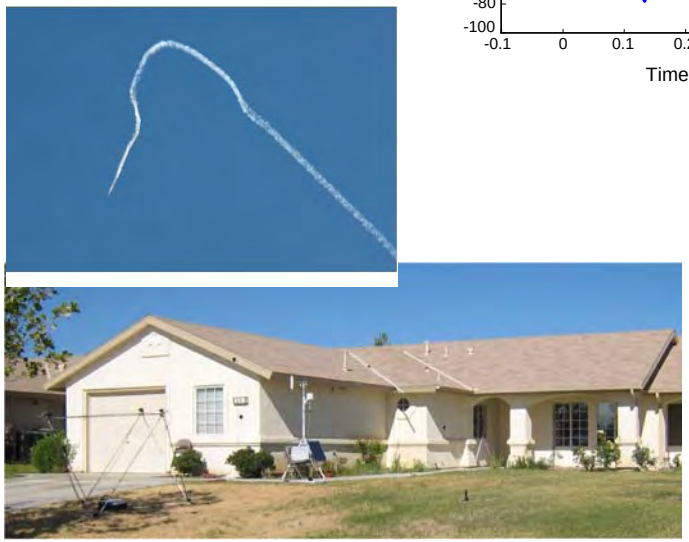


Photomicrograph of IM7/ PETI-298 panel fabricated by high temperature VARTM

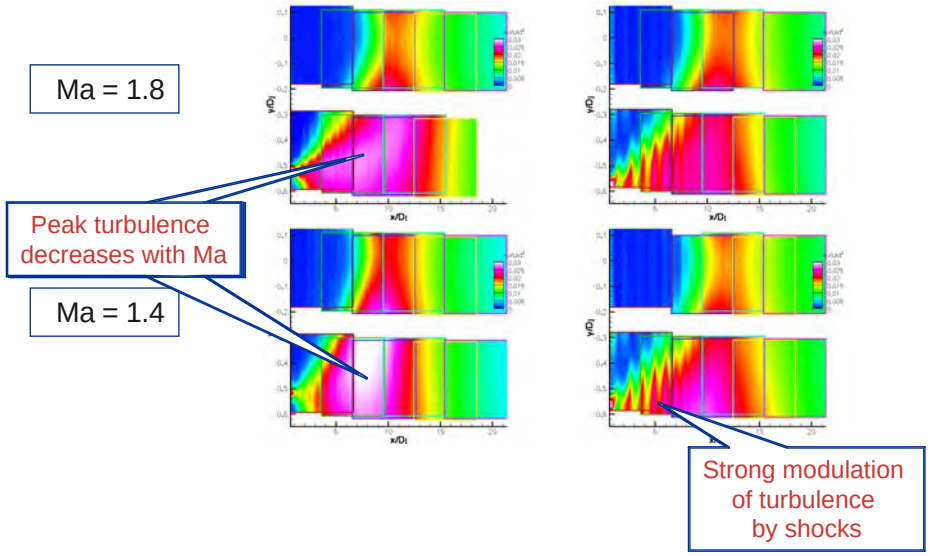
Investigated improved VARTM processes for out of autoclave manufacturing of high temperature composites

Highlights: Environment Technical Challenge





Completed extensive field test studying sonic boom propagation and structural response



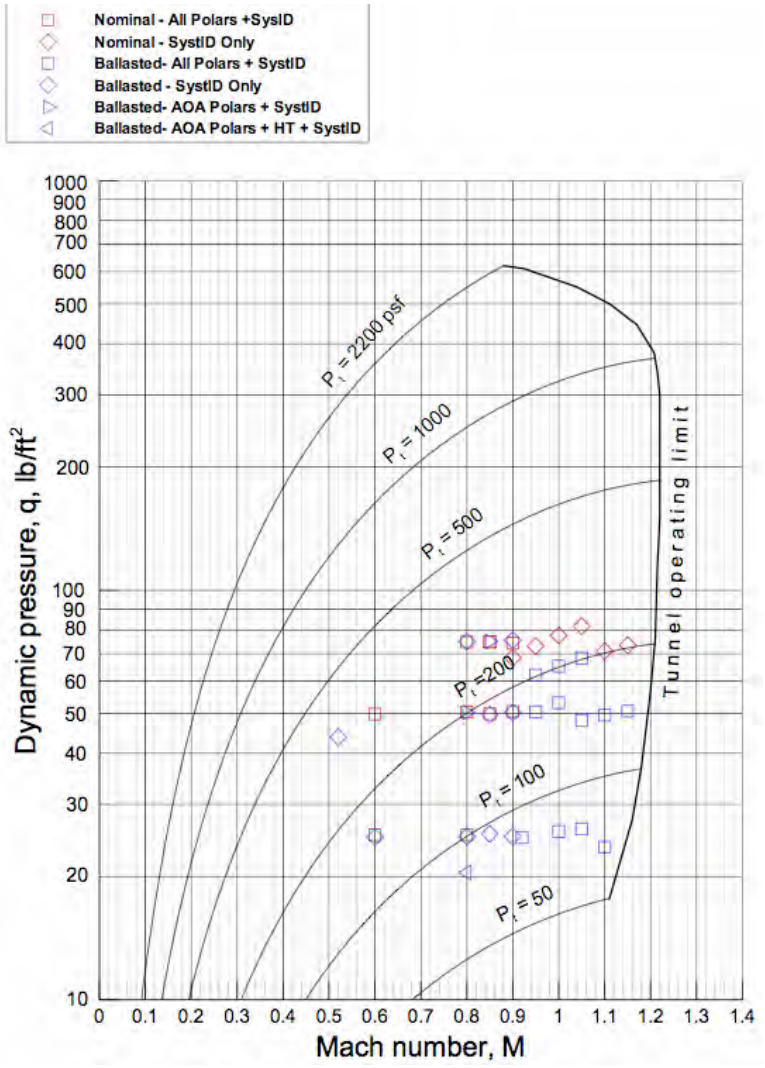
Completed study of the application of time resolved PIV to supersonic hot jet noise diagnostic measurements

Highlights: Performance Technical Challenge

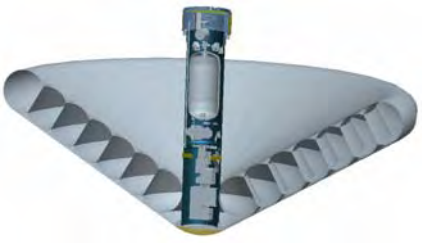
ASE Open Loop Test Completed

- Test successfully performed in TDT from May 14 - June 14
- Acquired more than 2K data tab points across several Mach numbers (0.6 - 1.15) and several dynamic pressures
- Tested two different configurations (nominal engine weight and heavy engine/ballasted weight)
- Acquired data used to project possible flutter boundary
- For this first test, did not push to the edge of flutter boundary
- Need to get additional data - 2nd open-loop test being planned

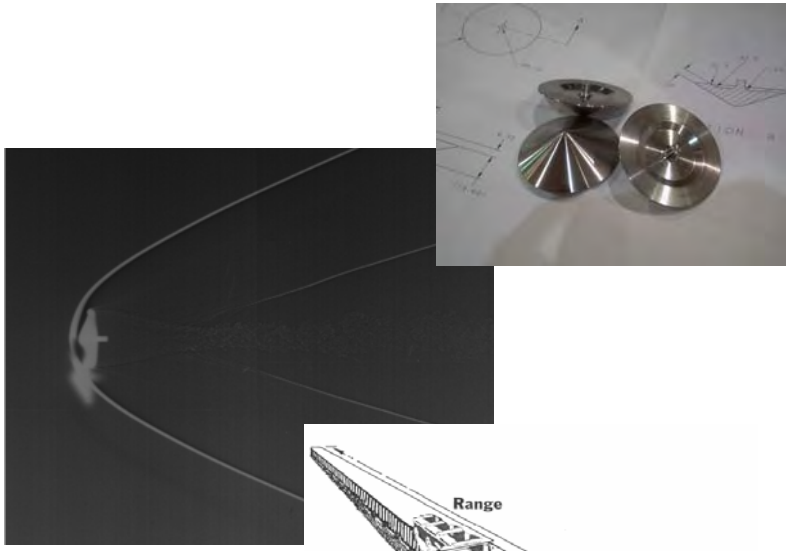
S^{4}T Model in TDT

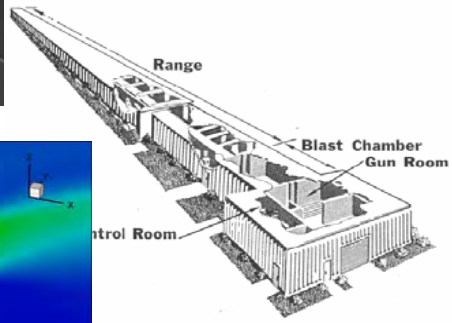


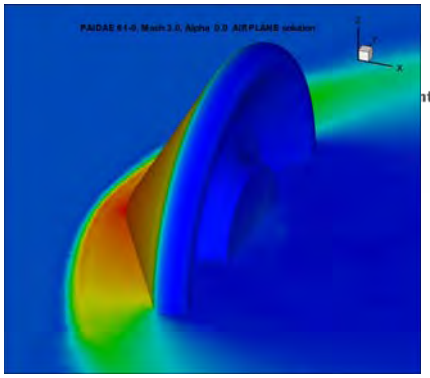
Highlights: EDL Technical Challenge



Full Scale Aeroshell Testing







Separate RV from TM, 80s

Separate T/M, RV assembly from Payload Shroud, 70s

Separate Payload from Booster, 60s

Coast to 72 km, (60s),

2nd stage burnout, 40 seconds
2nd stage ignition, 15 seconds

Launch on Terrier-Orion From Wallops Island

T=0s

WFF provides launch operations, telemetry acquisition, and radar track of flight

RV begins broadcast of data after separation of Payload Shroud

Inflation begins at 200s

RV completes inflation prior to Reentry Phase (T=315s)

T=335s **80 kilometers**

Reentry Phase

RV passes through peak pressure ~47.6 kilometers. T=364s

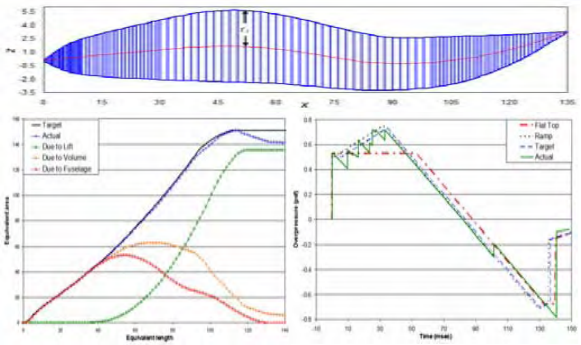
Flight Experiment concluded after vehicle has passed 40km

T=373s or Alt < 40 km

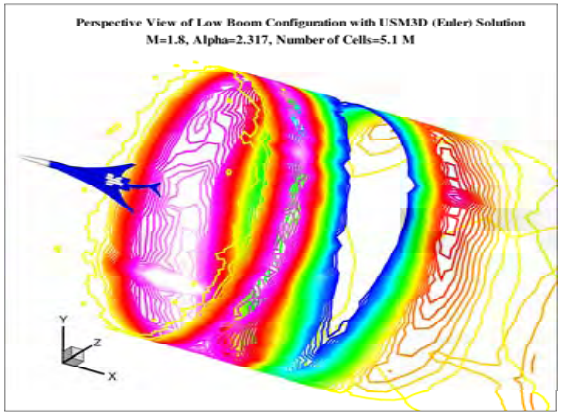
IRVE flight test experiment

Supersonic Decelerator Experimental and Computational Studies

Highlights: Systems Integration & MDAO



Fuselage Shape Optimization



Automatic Euler Solution

Developed process for rapid CFD validated conceptual design of low boom aircraft

Completed initial development of “N+2” Challenge Concept Aircraft

NRA Awards

- Round 1
  - Cruise Efficiency, Light Weight and Durability at High Temp, Airport Noise, High Altitude Emissions,
  - 23 awards: 21 Educational Institutions, 2 Commercial Entities
- Round 2
  - Sonic Boom Modeling, APSE
  - 7 awards: 2 Educational Institutions, 5 Commercial Entities
- Fixed Wing Round 2
  - MDAO Tools and Techniques
  - 2 awards: 1 Educational Institution, 1 Commercial Entity
- Round 3
  - Cruise Efficiency, Light Weight and Durability at High Temp, Airport Noise, Systems Integration, Assessment and Validation, Experimental Capabilities
  - 18 selected for negotiation: 7 Educational Institutions, 11 Commercial Entities
- Round 4
  - EDL (Jointly with Hypersonics Project)
  - 19 selected for negotiation: 11 Educational Institutions, 8 Commercial Entities
- Round 5 - Jan 08

Key Partnerships

- Gulfstream Aerospace
  - Tool development and validation for integrated low boom/low drag aircraft design
  - External Vision System requirements validation
- Lockheed Martin Corporation
  - Tool development and validation for integrated low boom/low drag aircraft design
- Aerion Corporation
  - Supersonic Boundary layer transition prediction and validation using the CLIP test fixture on F15B
- USAF ADVENT Program
  - Agreement in principal established
  - Propulsion cycle study and optimization for mixed mission variable cycle engines
  - Other areas under discussion
- USAF CESTA (Control Effectors for Supersonic Tailless Aircraft)
  - Completed specified activities for design, analysis and validation of innovative control effectors
- DARPA Supersonic Oblique Flying Wing
  - Technical analysis and guidance as members of Government Team
  - Actively participating in development of flight testing concept and plans
- General Electric
  - Low emissions combustor Testing
- Rolls Royce North America
  - Ceramic propulsion components

Others in Development

Supersonic Technical Sessions

- Tuesday PM
  - Supersonic Cruise Efficiency (Propulsion & Airframe)
- Wednesday AM
  - Light Weight and Durable (Airframes & Engines)
  - Entry Descent and Landing (parallel with Hypersonics)
- Wednesday PM
  - Airport Noise
  - Sonic Boom Modeling
  - Systems Integration, Assessment and Validation
- Thursday AM
  - High Altitude Emissions
  - Aero-Propulso-Servo-Elasticity
  - Experimental Capabilities
- Thursday PM
  - Feedback Session (Open forum 1 hour, Individual 15 minute face-to-face)