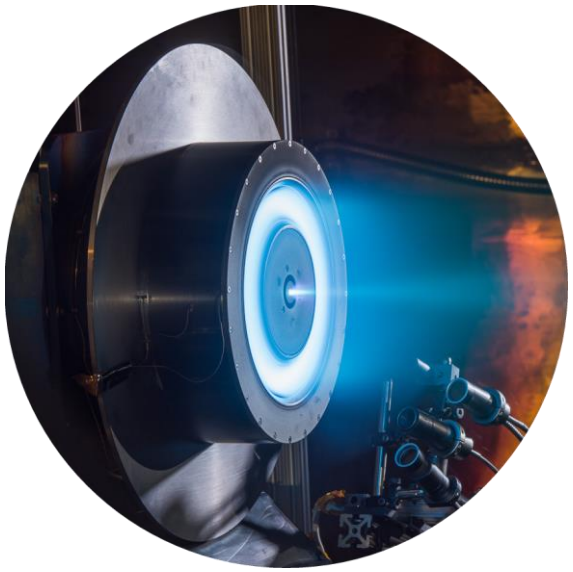
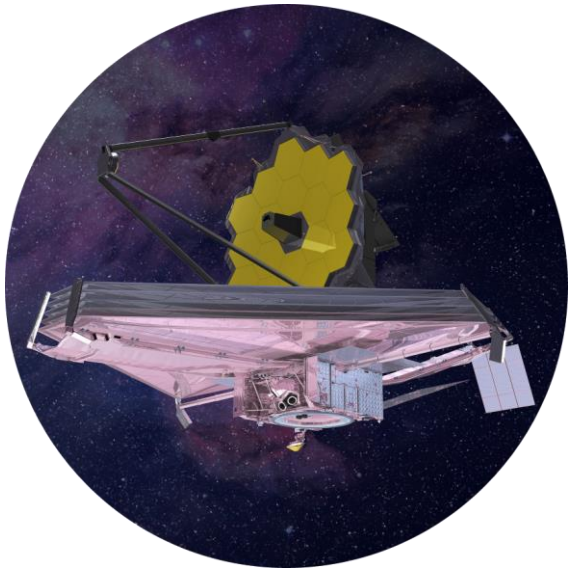
Two Decades of Aerospace Vehicle Analysis with HyperSizer and HyperX

National Aeronautics and Space Administration





Lloyd B. Eldred

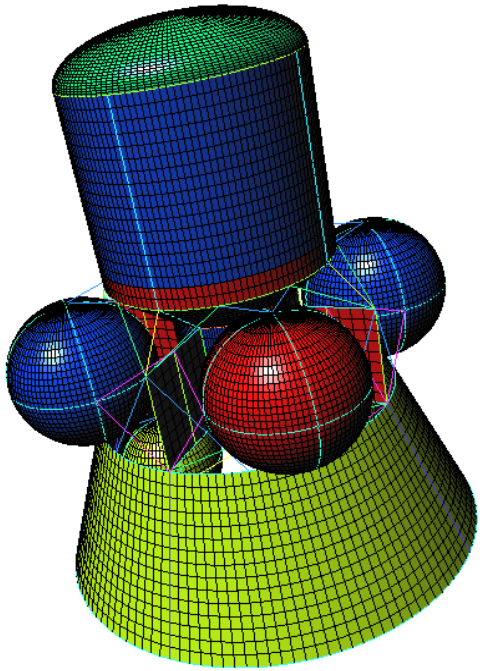
Vehicle Analysis Branch

NASA, Langley Research Center

Outline

National Aeronautics and
Space Administration

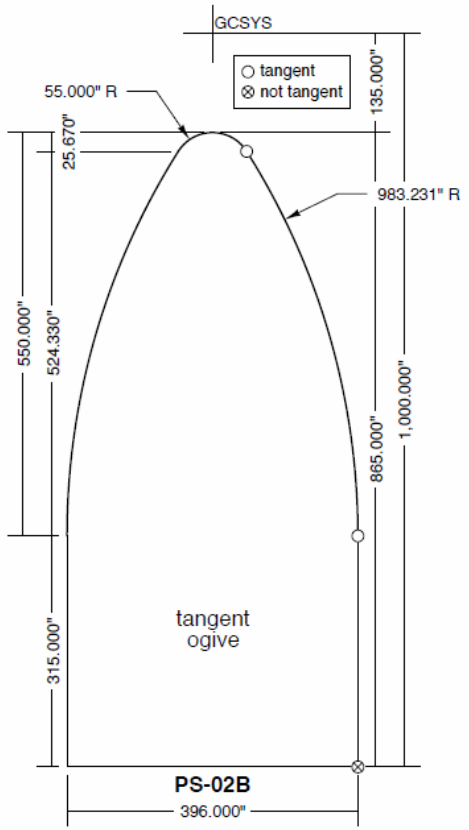
- Multidisciplinary preliminary analysis process
- Twenty+ years of design
- Automation & Related Tools
- Conclusion

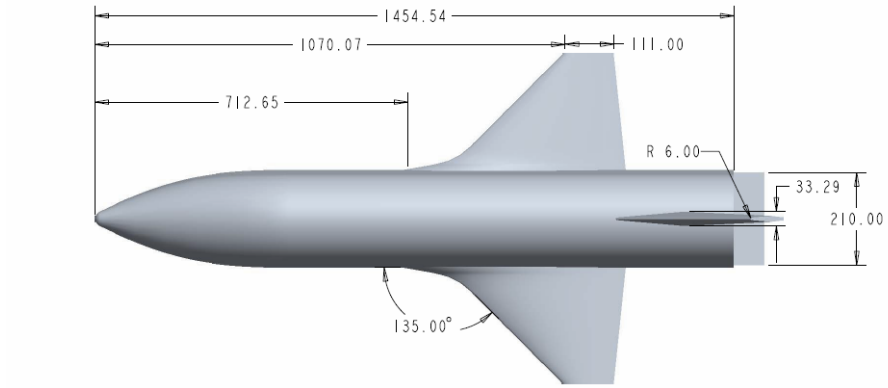


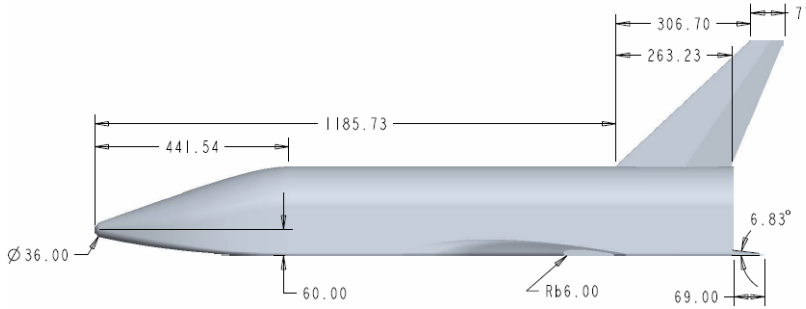
EXPLORE VAB

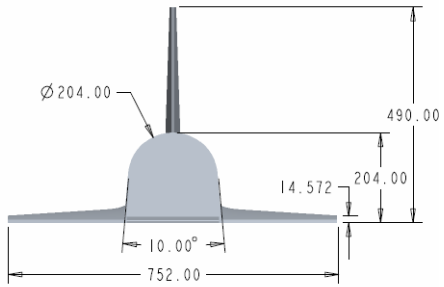
Preliminary Design: Sketch

National Aeronautics and Space Administration









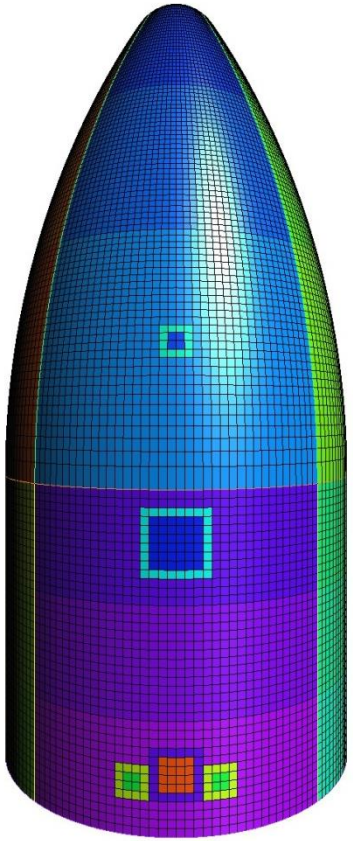
TSTO-2009-2B_OML

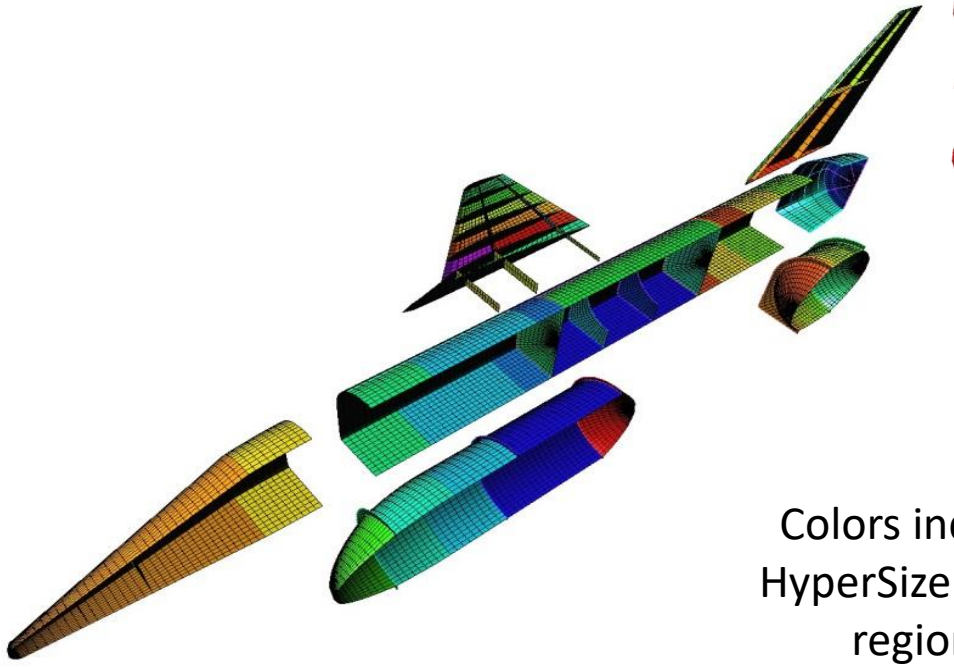
SEF_09/24/2009

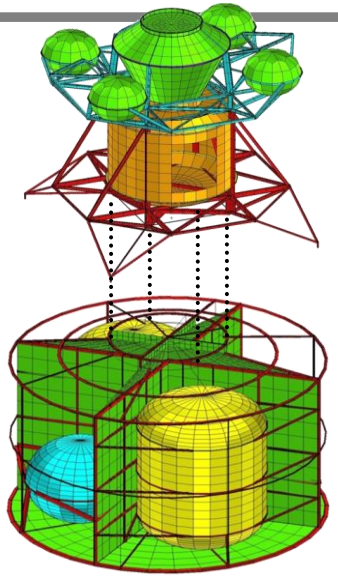
EXPLORE VAB

Preliminary Design: FEA Model

National Aeronautics and Space Administration







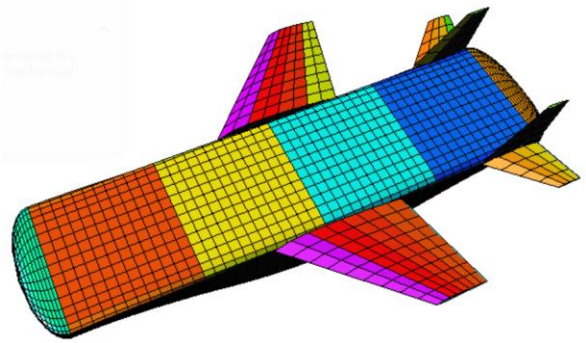
Colors indicate HyperSizer sizing regions

EXPLORE VAB

Preliminary Analysis

National Aeronautics and Space Administration

- Generate finite element model
- Identify critical load cases
  - Launch vehicles: MaxG, MaxQα, etc.
  - Flight vehicles: 2g runway bump, Max pullup, etc.
- Create or approximate aero, thermal, propulsion, hydrostatic, etc. loads
- Solve in NASTRAN
- Size in HyperSizer/HyperX
- Iterate to converged mass
- Perform design trade studies

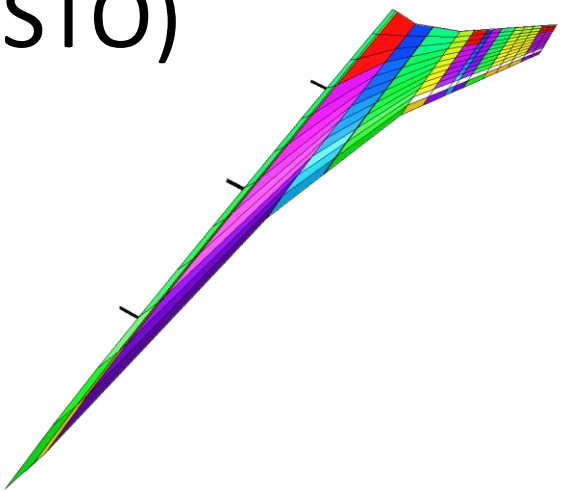


EXPLORE VAB

Twenty+ Years of Design

National Aeronautics and Space Administration

- Wingbox calibration
- Next Generation Launch Technology (NGLT) wing optimization
- Unusual tank concepts
- Lunar lander concepts
- Single and Two Stage to Orbit (SSTO and TSTO) hypersonic concepts
- Launch vehicle fairings
- Low boom supersonic aircraft

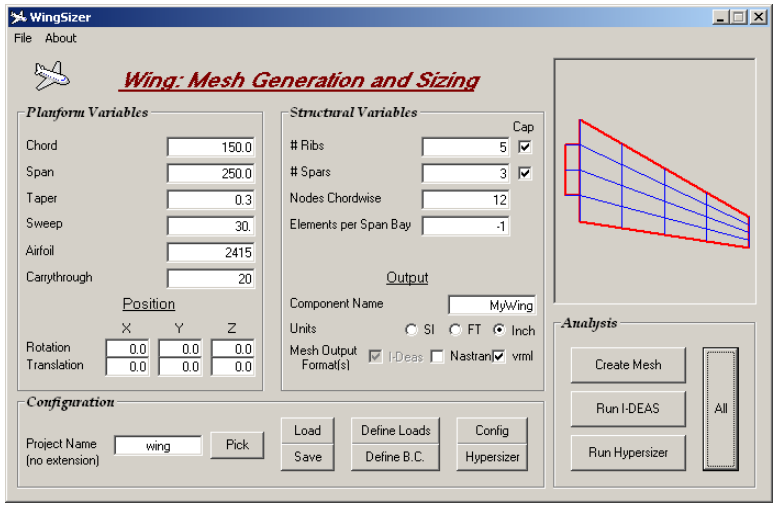


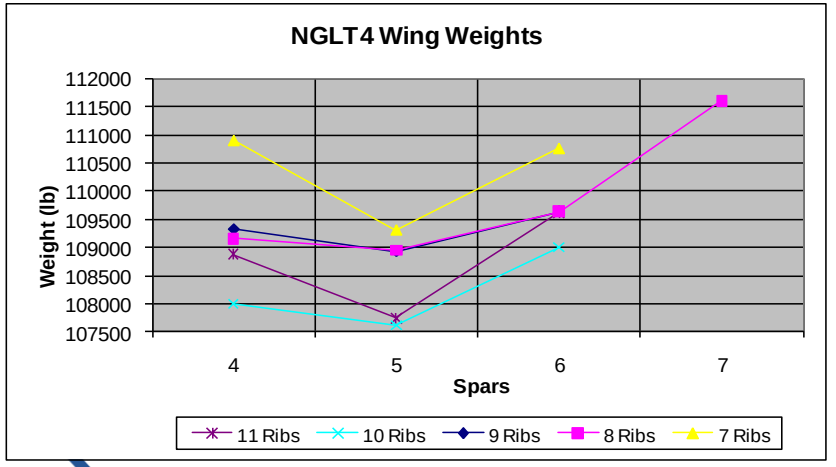
EXPLORE VAB

Wingbox & NGLT Wing

National Aeronautics and Space Administration

- Initial HyperSizer use (1999) predicted weight of NASA wingbox test article
  - As built weight was 1.5 times predicted weight
- Early 2000s automated study of Next Generation Launch Technology (NGLT) wing



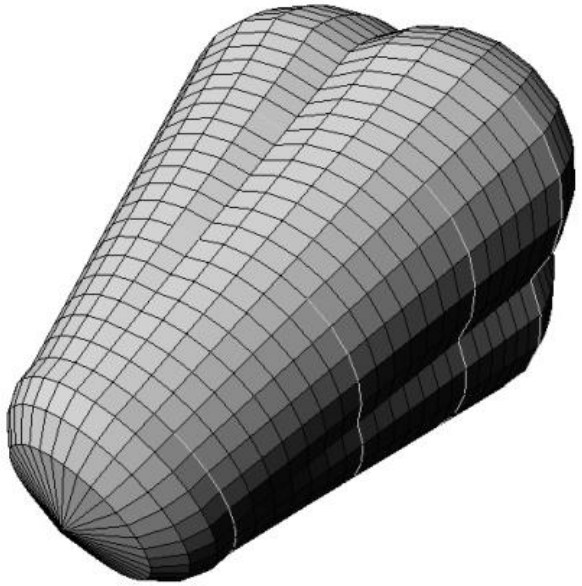


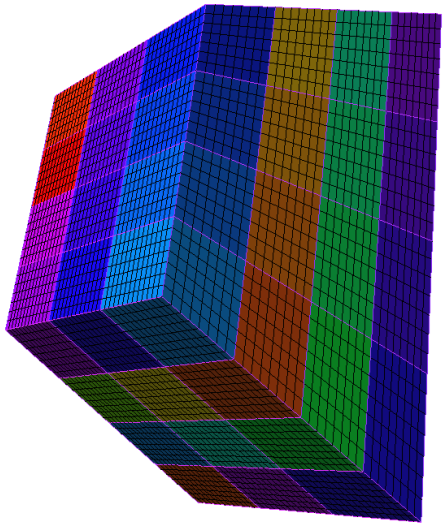
EXPLORE VAB

Unusual Vehicle Components

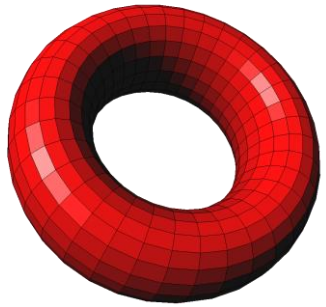
National Aeronautics and Space Administration

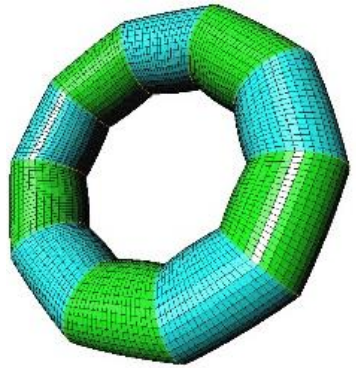
Multi-lobe tanks





Stiffened Mattress tanks



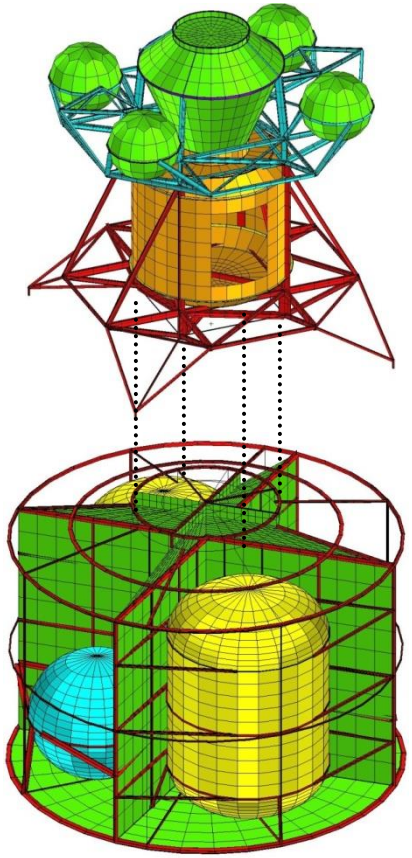


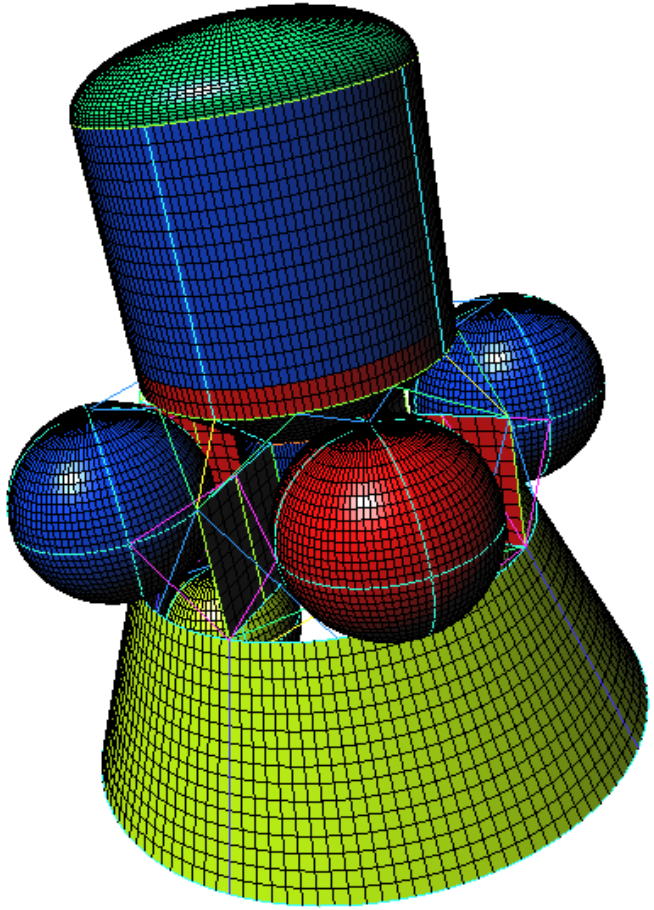
Toroidal and segmented toroidal tanks

EXPLORE VAB

Lunar Landers

National Aeronautics and Space Administration





Dash Lander Concept

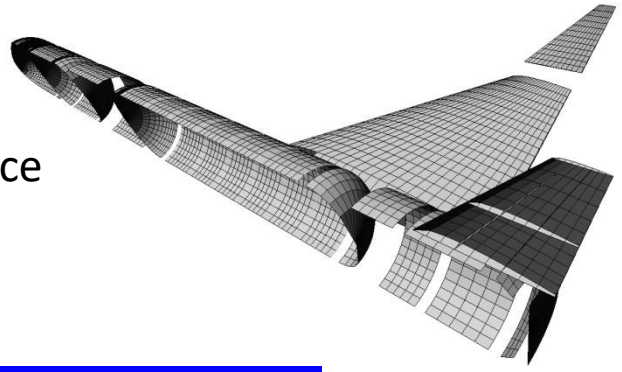
NASA HLS Reference

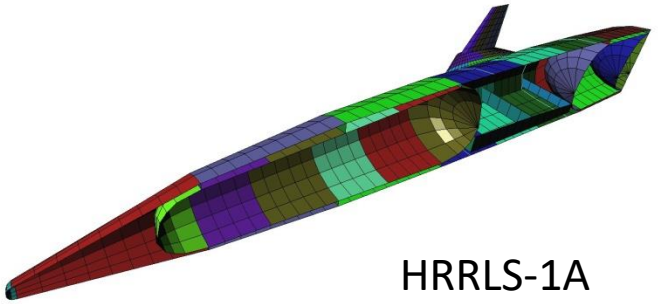
EXPLORE VAB

Hypersonic Orbiters

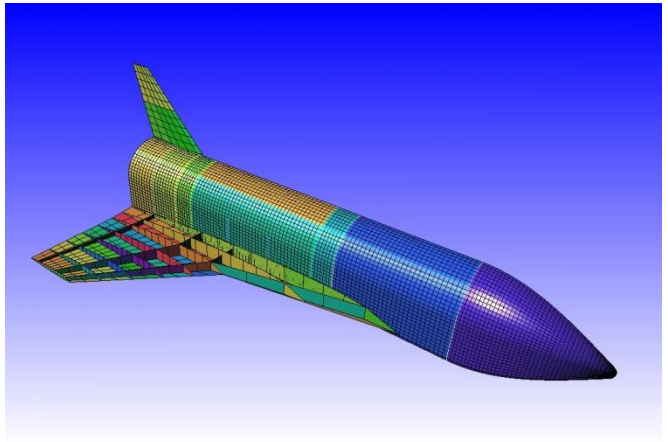
National Aeronautics and Space Administration

ISAT reference design

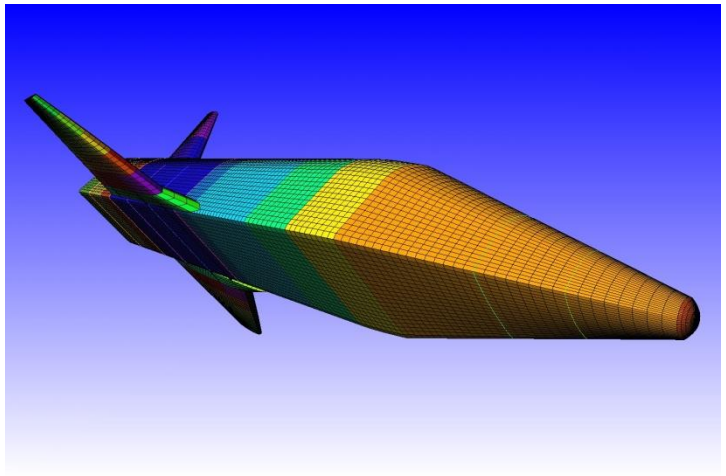




HRRLS-1A



RALV-A

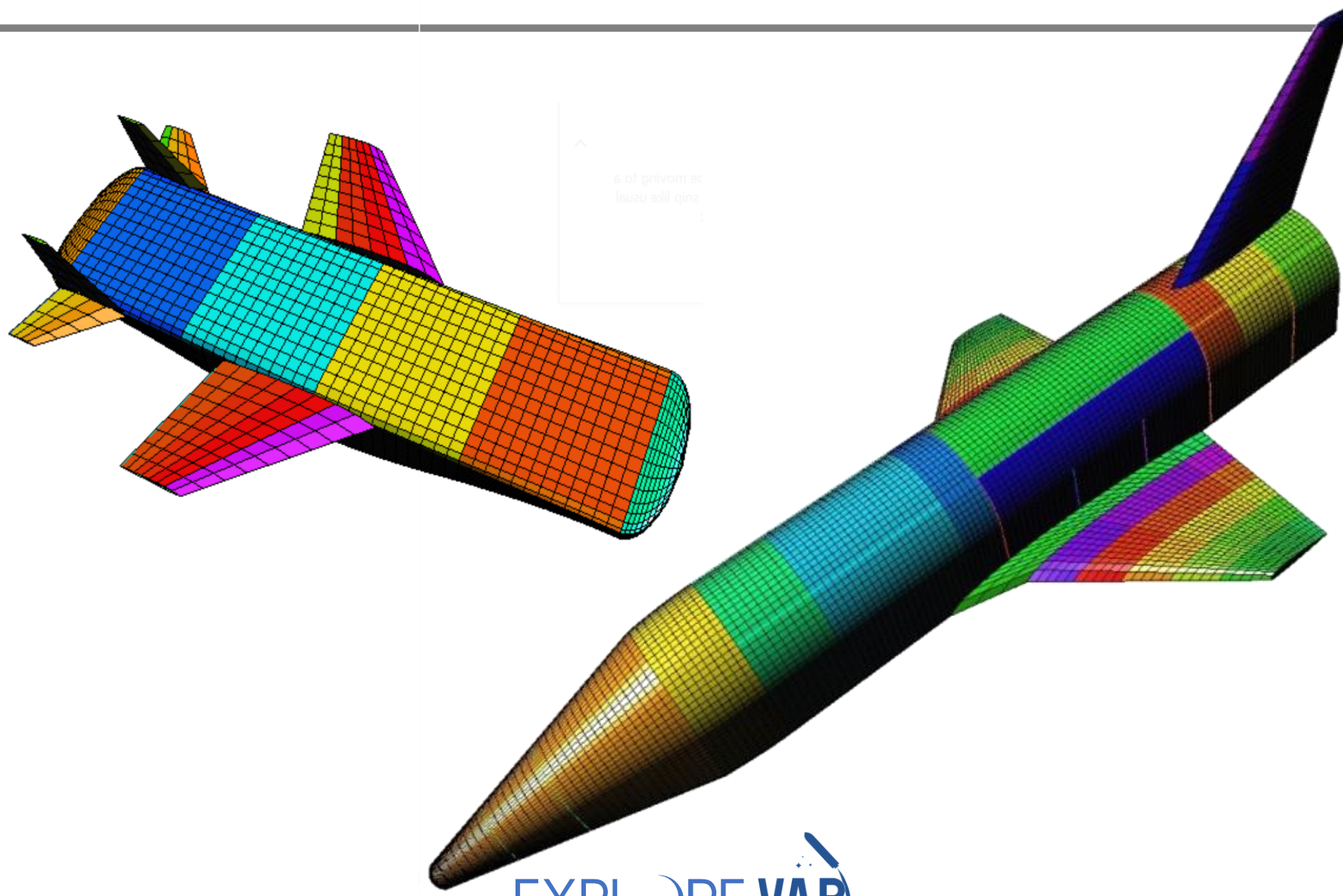


RALV-B

EXPLORE VAB

Airbreather & TSTO Orbiter

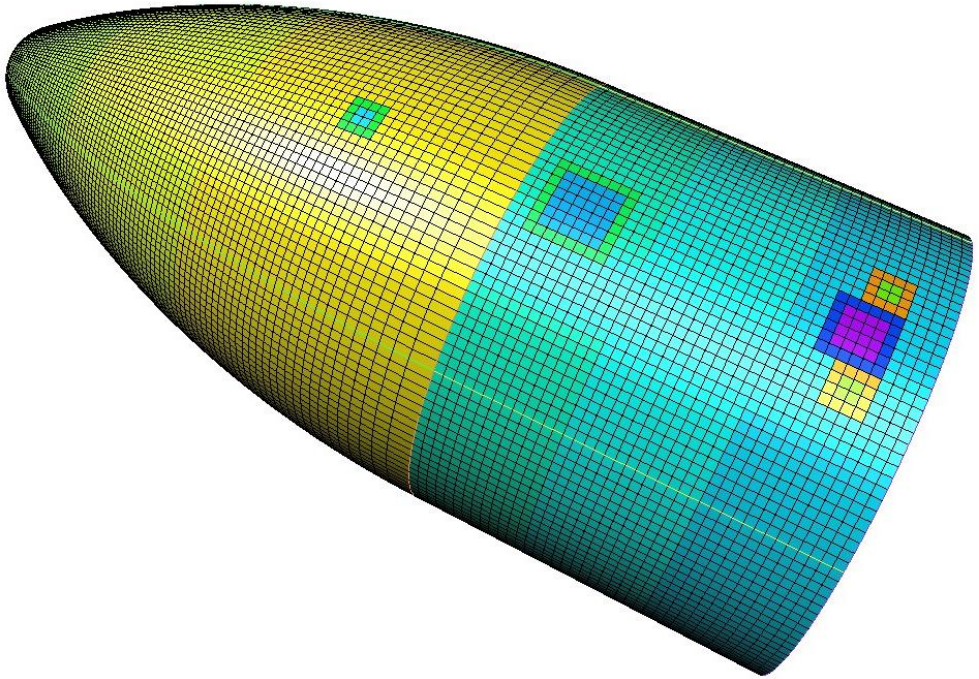
National Aeronautics and Space Administration

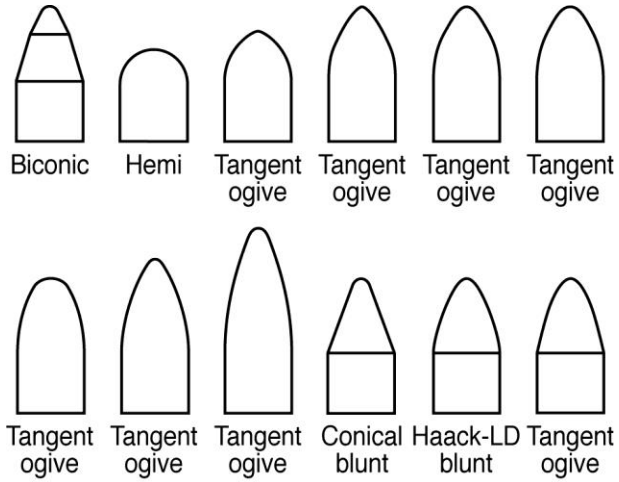


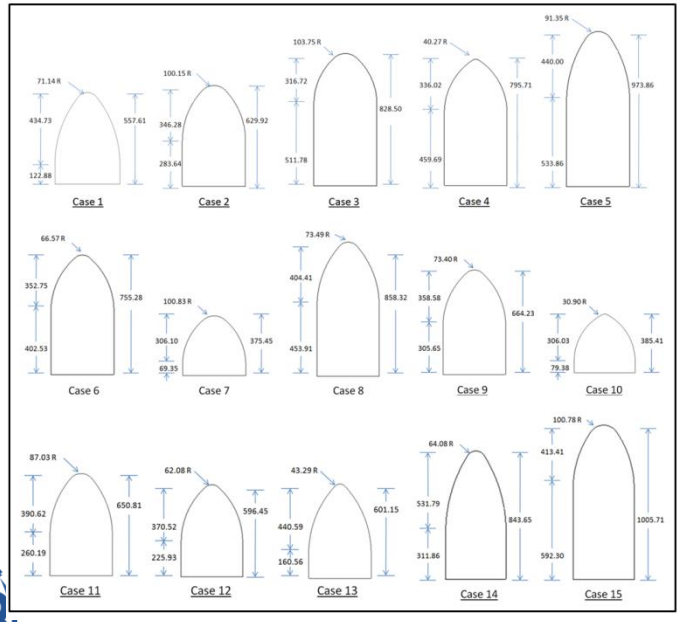
EXPLORE VAB

NASA Ares V/SLS Payload Fairing

National Aeronautics and Space Administration







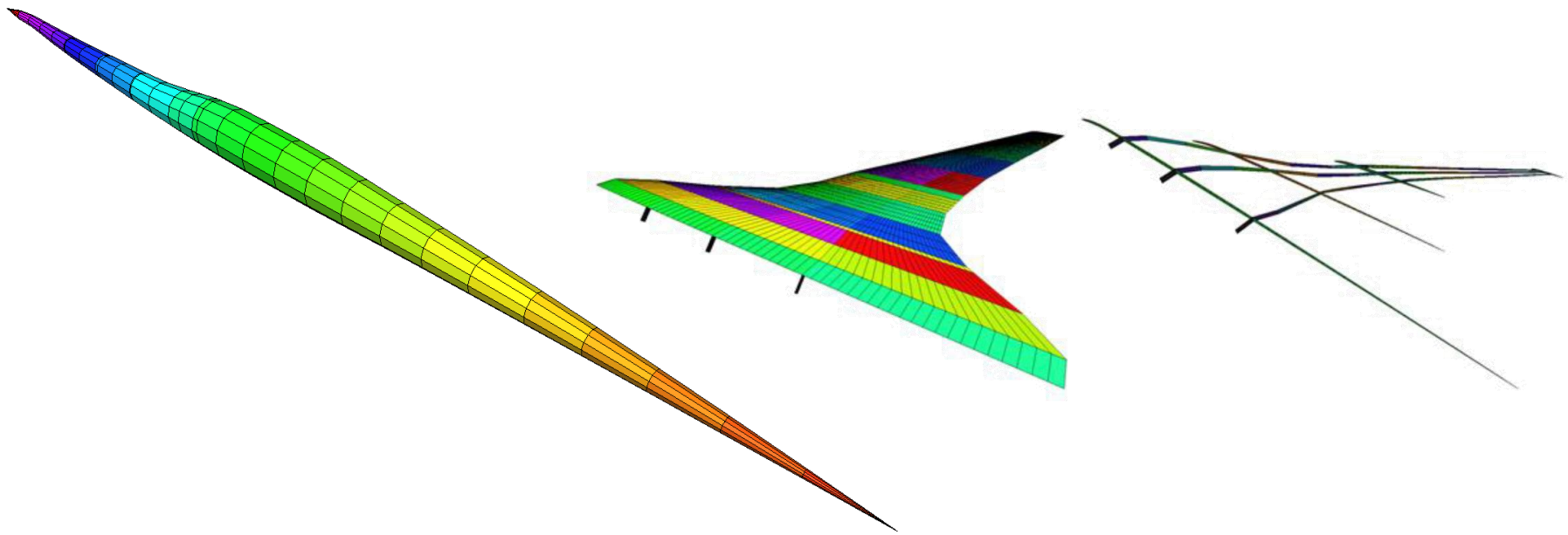
- Created and sized dozens of different shaped shroud FEA models for the shroud team over 5.5 years
- Drove NASA change to composite fairing baseline

EXPLORE VAB

Low Boom Supersonics

National Aeronautics and Space Administration

- Simple fuselage and piecewise trapezoidal wings meshes generated automatically, glued in NASTRAN, and sized in HyperSizer

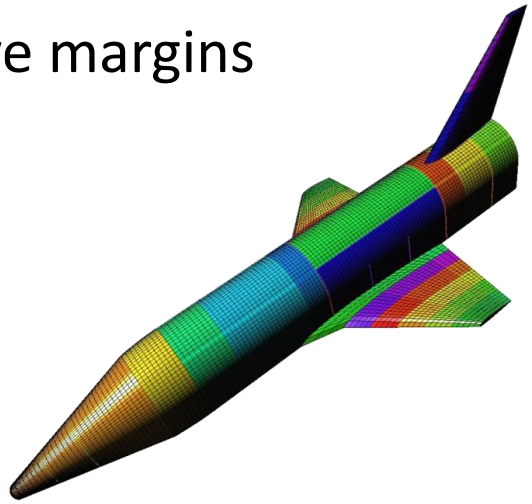


EXPLORE VAB

Batch Integration Tools

National Aeronautics and Space Administration

- *HSLoad:* tool that reads a text input file for instructions to drive HyperSizer's API
  - Opens database, loads model
  - Creates components and assemblies
  - Applies templates
  - Sizes
  - Post processes: final mass, list of components with negative margins
- *HXLoad*: HyperX update of HSLoad in work

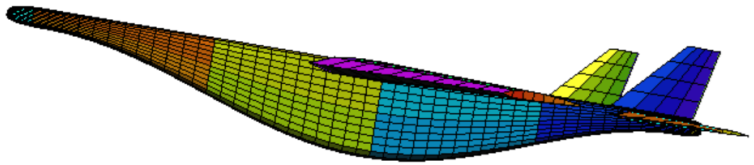


EXPLORE VAB

Batch Mesh Generation: *Loft*

National Aeronautics and Space Administration

- Every mesh in this presentation was generated by Loft
- Built for easy HyperSizer/HyperX import
  - User specified object names create meaningful properties & components in HyperSizer
  - Easy setup and post processing
  - Consistent normal and material directions
- Text file input
- Outputs NASTRAN, Abaqus, Tecplot, VRML, STL
- Ideal for rapid mesh generation, parametric studies, and batch integration
- Approved for general public release by NASA

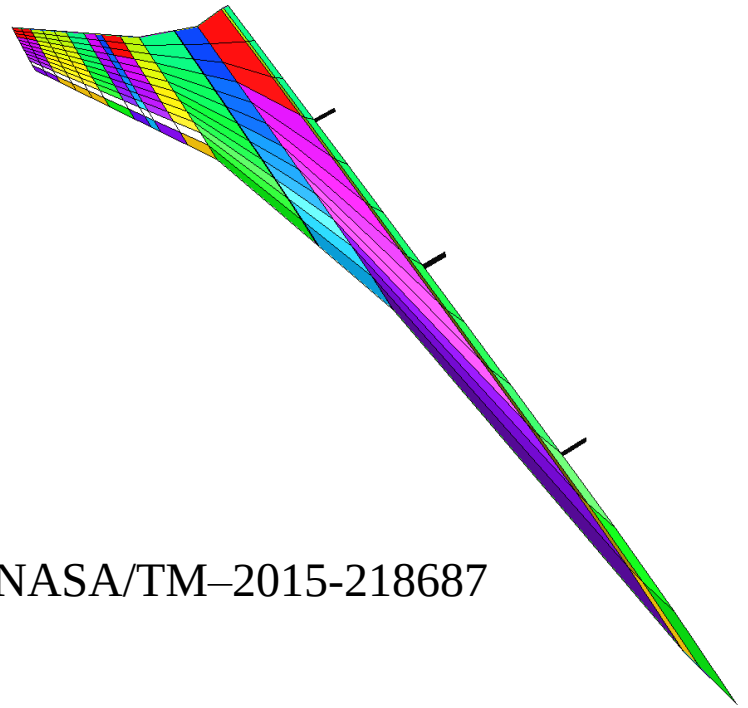


EXPLORE VAB

Batch Integration: Supersonics

National Aeronautics and Space Administration

- Design of Experiments study for low-boom supersonic design using HSLoad, Loft, NASTRAN, and HyperSizer



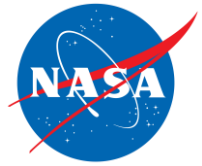
Ref: NASA/TM–2015-218687

EXPLORE VAB

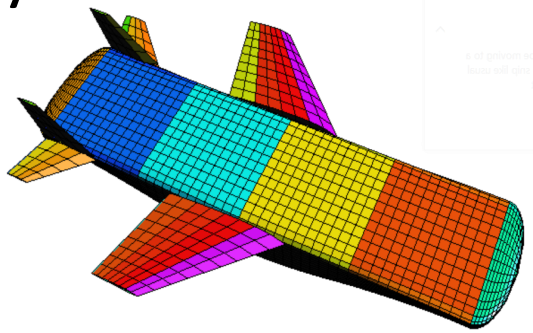
Batch Applications: SPARC

Structural Preliminary Analysis for aeRospaCe vehicles

National Aeronautics and Space Administration



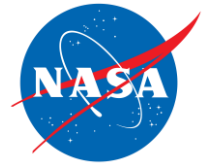
- Current effort to build a low-maturity design environment where non-structural inputs are approximated and mapped to a *Loft* generated FEA model
- Uses our high fidelity analysis tools: NASTRAN and HyperX with simpler models and loads
- Application to aircraft, rockets, landers, and components like wings and tanks
- Allows for structural design insight and input in a system before detailed aero, thermal, propulsion, and trajectory analyses are available



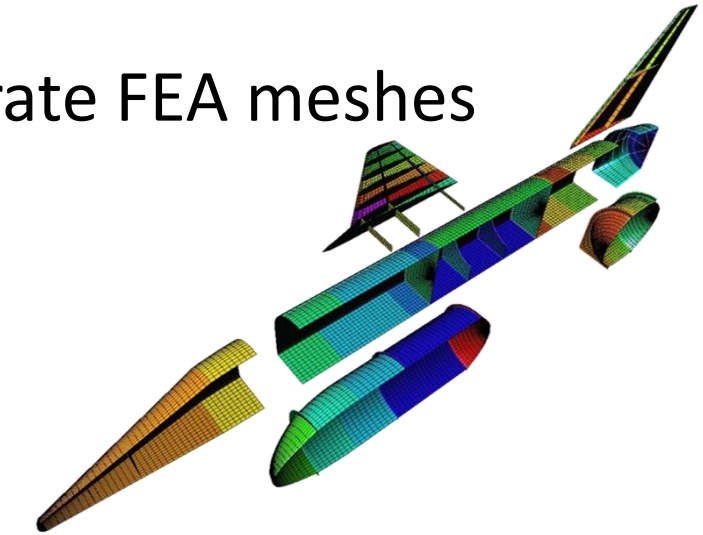
EXPLORE VAB

Twenty+ Years of Sizing

National Aeronautics and Space Administration



- Multidisciplinary vehicle design has been performed for
  - Vehicle components: wings and tanks
  - Lunar landers
  - Payload fairings
  - Supersonic aircraft
  - Hypersonic vehicles
- Utilities were created to drive HyperSizer and generate FEA meshes



EXPLORE VAB