The Importance of Thermostructural Testing Hypersonic Structures

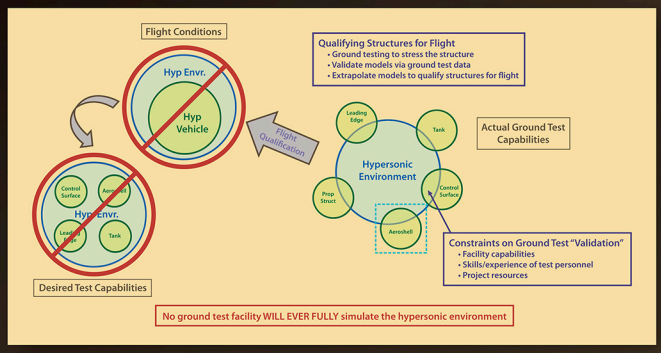
"All models are wrong, but some are useful" - George Box

The Contextualization of Hypersonic Ground Tests

No model does it all, and neither can any test

Primary Testing Goals:

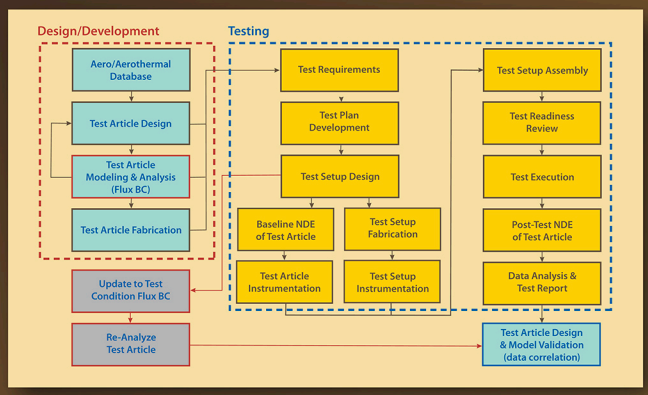
A. Validate workmanship of hypersonic structures
B. Ensure successful flight
C. Validate models



Testing Is Required to Ground Analyses

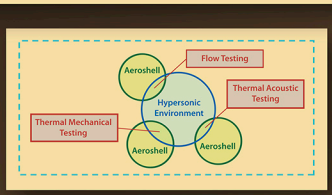
Hypersonic flight is characterized by coupled physics, therefore coupled multiphysics models are a necessity. Validating these models analytically can only be done at the simplest level, therefore to have confidence in the predicted response to complex flight environment requires evaluation of response to combined loading in ground tests.

Test Design Methodology

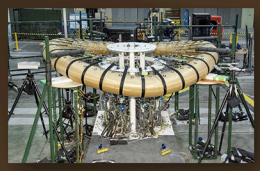


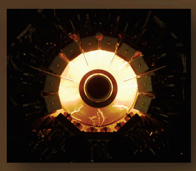
Testing Methods:

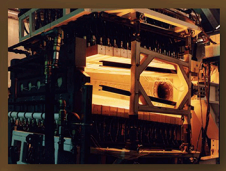
Thermal
Structural
Thermal-Structural
Structural Dynamic
Thermal-Structural Dynamic

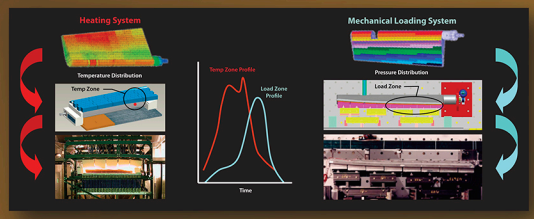


Ground testing requires compromises in test environment simulation and load introduction methodology





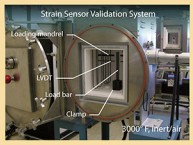


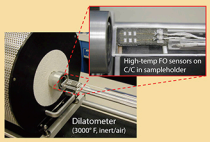


Data Collection

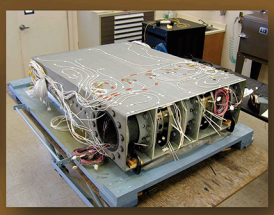
External temperatures
Internal temperatures
Boundary condition temperatures
Strains
Deflections

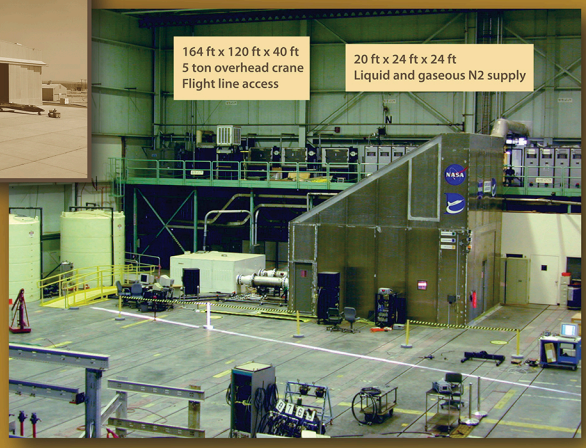
All sensors and instruments need to remain attached, function accurately in dynamic, ET environment





Typical Systems for Sensor Development





Current Capabilities

Coupon – Component – Vehicle
264 channels of thermal control
84 channels of hydraulic load control
> 2,000 channels of DAQ
Large nitrogen atmosphere test chamber
Thermal or structural testing in ambient conditions or purged atmosphere
Temperatures -320°F - >3,000°F, Temperature rise rate ≤ 150 °F/sec, Heating Rate ≈100 BTU/ft2-s
Combined thermostructural loading, multiple hours
Instrumentation attachment methods for metallic, C/C, C/SiC, oxide-oxide
Point strain measurement to 1,800°F using fiber optics
Point temperature measurement >3,000°F (bonded & optical)
Classified testing

Armstrong Flight Research Center

Andrew Holguin Larry Hudson Chris Kostyk Anthony "Nino" Piazza Tim Risch Craig Stephens