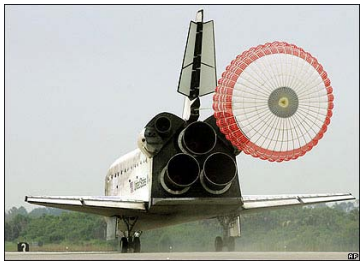
National Aeronautics and Space Administration

JSC Commercial Human Space Flight Symposium
October 13-14, 2010

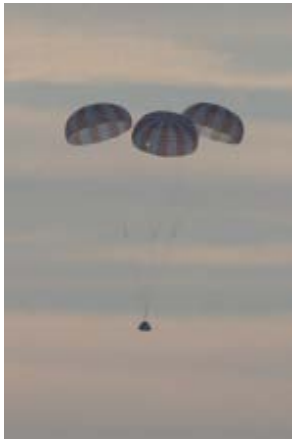
Government Furnished Equipment and Parachutes

- JSC has unique skills and experience in simulation, design, integration, and testing of Aerodynamic Decelerator Systems.
  - Our experience is based on the past 15 years of working with both guided and ballistic parachute systems for recovered masses ranging from 7,000 to 25,000 lbs.
- We have collaborated with both major parachute vendors (Airborne Systems and Pioneer Aerospace) in the United States.
- We have also worked with and conducted tests at the three major parachute centers of excellence within the US Armed Forces (US Army Yuma Proving Grounds, US Navy China Lake, Edwards Air Force Base).



Shuttle landing at KSC

X-38 landing on Rogers

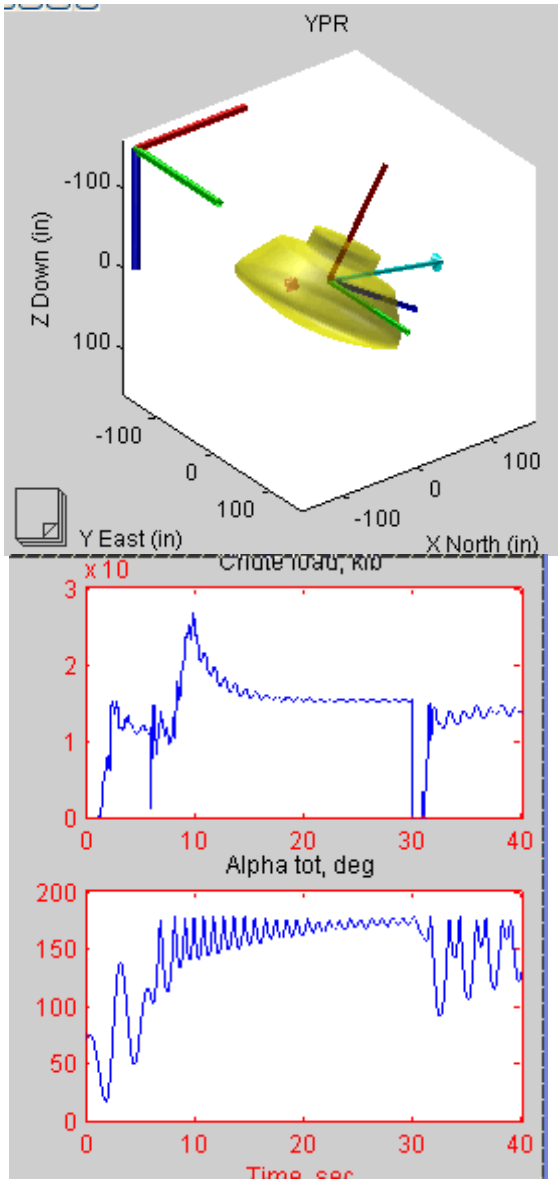


Orion Pad Abort 1 at White Sands

Pad Abort Demonstrator at YPG

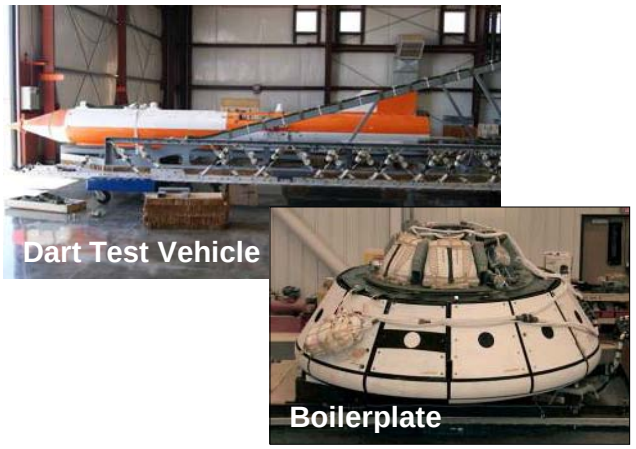
JSC Unique Tools in Aerodynamic Decelerators

- Decelerator Systems Simulation (DSS)
  - A coupled multi-body 6-dof simulation based on the analysis code that was used to design the SRB recovery system.
  - Modified extensively during X-38, Pad Abort Demonstrator, and Orion programs.
  - Broad range of applications:
    - Design of flight tests (predicting not only the parachute loads but the dynamics of the coupled system)
    - Flight test data reduction
    - Monte Carlo analysis to aid in designing the parachutes and spacecraft attach structure and concept of operations
    - Identifying riser re-contact with crew module
    - Trade studies for space craft design
    - Response to atmospheric perturbations such as gusts

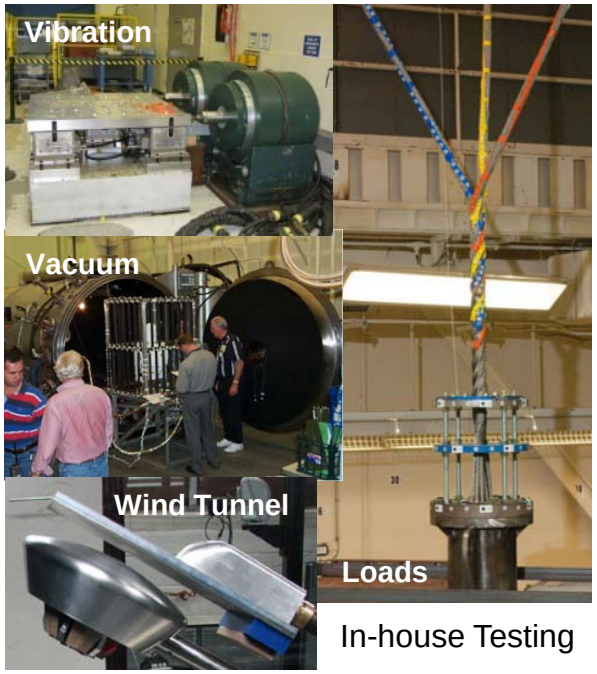


JSC Unique Skills in Aerodynamic Decelerators

- Core team with decades experience simulating, designing, integrating, and testing large parachute systems.
  - Parachute system design and analysis
    - Includes both ballistic and steerable ram air parachutes with modeling databases and guidance algorithms.
  - Parachute system integration
    - From defining achievable requirements, to working with the spacecraft designers to solve integrated spacecraft level problems.
  - Parachute system performance testing
    - Encompasses test configuration, design and manufacture of the test vehicles, instrumentation, pyrotechnics and avionics, integration and procedures, execution of the test, data reduction and analysis validation.
  - In-house resource utilization
    - Access to vibration test facilities, pyrotechnic test facilities, structures test lab, vacuum chambers, and photogrammetric analysis, as well as other Agency assets.



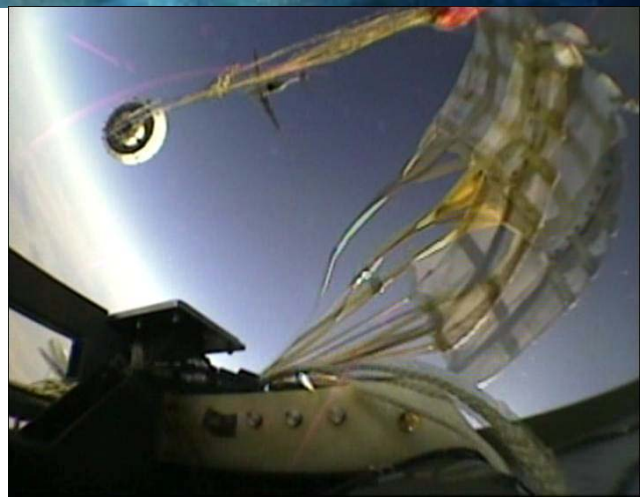
Parachute Test Vehicles



In-house Testing

GFE Parachutes on Orion

- The Crew Exploration Vehicle (CEV) Parachute Assembly System (CPAS) project is responsible for:
  - the design, development, fabrication, qualification, and delivery of the flight CEV parachute system to support the pad/ascent abort tests and the first three orbital flight tests (including the first human flight).
- Our role has evolved from supplying a certified parachute system into supporting design trades within the Orion architecture related to the Landing and Recovery System
  - Forward Bay Cover jettison, landing orientation, definition of interfaces and operational restrictions, independent design of the parachute attach structure and assembly concepts, evolution of integrated testing capabilities beyond just the parachute recovery system, integrated LRS reliability assessment.



Benefits and Challenges

- Never has it been truer than with parachutes that simple is better
  - Early analysis and trading of integrated performance risks will decrease development time and costs.
- Depth of institutional capability
  - From inventing instrumentation, to quantifying and bounding the physics associated with a given risk, JSC Engineering has demonstrated success.
- Our role can be molded to fit the need
  - EA has led parachute development within a government designed spacecraft, provided a system as GFE to a contractor designed spacecraft, and used our expertise to help guide design and implementation of parachute systems.
- We are team players interested in the safe advancement of human spaceflight!

Point of Contact

- Parachute Landing and Recovery Systems
  - Design, Simulation, Delivery, Integration, and Certification

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