



CUSTOMER:  
**Lockheed Martin Space Systems**

INDUSTRY:  
**Aerospace**

PROJECT NAME:  
**Independent Verification and Validation (IV&V) of Titan Centaur**

CUSTOMER LOCATION:  
**Littleton, Colorado**

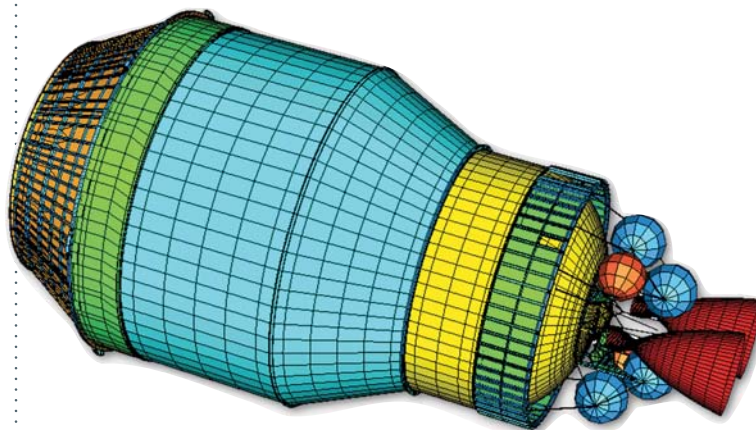
**OVERVIEW**

The Titan Centaur is a high-performance upper stage for the Titan IV launch vehicle developed by Lockheed Martin Space Systems (LMSS) and used primarily to launch Air Force payloads. Titan IV is the nation's largest, most powerful expendable space launch vehicle. It provides primary access to space for critical national security and civil payloads and is launched from the East and West Coasts.

ATA Engineering, Inc. (ATA) has worked with LMSS since approximately 1990 to provide independent verification and validation (IV&V) of all Titan Centaur, Centaur phase-of-flight loads.

**ATA SUPPORT INCLUDED:**

- ▷ Developed an independent finite element model (FEM) of the Titan Centaur.
- ▷ Supported modal tests of the Titan Centaur.
- ▷ Modified FEM to better correlate with modal-test data.
- ▷ Worked with LMSS to develop a "common model" representation.
- ▷ Developed a methodology for representing fluid sloshing in tanks in Nastran.
- ▷ Developed a methodology for representing the effect of pressure stiffening on tank walls using Nastran.
- ▷ Independently verified numerous forcing functions including buffet, ignition overpressure, and longitudinal thrust oscillations.
- ▷ Verified the control-system models used to analyze autopilot.
- ▷ Assembled system models for every Titan Centaur mission and independently verified all dynamic loads.



*“During the Titan IV B-35 project some unforeseen work developed which would have hindered a launch. ATA staff sacrificed much personal time to support analyses and develop a methodology which allowed for better understanding of the issues. The work by ATA was recognized and appreciated by Lockheed Martin and the Air Force customer.”*

**Sandra Mossman**  
 Titan IV Technical Lead  
 Lockheed Martin Corporation