When Failure Means Success: Accepting Risk in Aerospace Projects
NASA Project Management Challenge 2009

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Agenda

• Evolving from Saturn, to Shuttle, to Ares
• Expanding Frontiers for 50 Years and Counting
• Harnessing Risk Management Techniques and Tools
• Applying Human Space Flight Testing Philosophy
• Learning Lessons from the 1990s: Delta-Clipper Experimental Advanced Demonstrator
• Learning Lessons from the 1990s: X-33 Single-Stage-to-Orbit Flight Demonstrator
• Transitioning from Shuttle to Ares: Hard-Won Lessons
• Reducing Shuttle Risk: HD Cameras Visualize ET Foam Loss
• Reducing Shuttle Risk: Main Engine Cutoff (ECO) Sensor
• Reducing Technical Risk for Ares I Crew and Ares V Cargo Launch Vehicles
• Systems Engineering Throughout the Project Lifecycle
• Testing for Knowledge versus Testing for Success
• Ares I Project Milestones
• Ares I-X Development Flight Test: Breaking the Systems Engineering Model
• Generating and Analyzing Data to Reduce Risk: Main Propulsion Test and Integrated Ground Vibration Test
• Adopting Other Risk Reduction Methods: Project Lifecycle Management
• Engineering Knowledge Management System
• Conclusion: Reducing the Risk Inherent in the Human Exploration of Space
Expanding Frontiers for 50 Years and Counting

**Saturn V**
- Command/Service Module
- Lunar Lander
- S-IVB (One J-2 engine)
- S-II (Five J-2 engines)
- S-IC (Five F-1 engines)

**Space Shuttle**
- External Tank
- Solid Rocket Boosters (SRBs)
- Orbiter
- Main Engines

**Ares I**
- Orion Crew Exploration Vehicle
- Upper Stage (One J-2X engine)
- Core Stage (Six RS-68 Engines)

**Ares V**
- Altair Lunar Lander
- Earth Departure Stage (EDS) (One J-2X engine)
- Two 5.5-Segment Reusable Solid Rocket Booster (RSRBs)

**Saturn V**
- Overall Vehicle Height: 122 m (400 ft)
- Payload Capability: 44.9 metric tons (99,000 lbs) to TLI
  118.8 metric tons (262,000 lbs) to LEO

**Space Shuttle**
- Height: 91 m (300 ft)
- Payload Capability: 25.0 mT (55,000 lbs) to LEO

**Ares I**
- Height: 61 m (200 ft)
- Payload Capability: 25.0 mT (55,000 lbs) to LEO

**Ares V**
- Height: 30 m (100 ft)
- Payload Capability: 187.7 mT (413,800 lbs) to LEO
  71.1 mT (156,700 lbs) to TLI with Ares I
  62.8 mT (138,500 lbs) direct to TLI

**Timeline**
- 1967–1972
- 1981–Present
- First Flight 2015
- First Flight 2020

3/2/2009
Harnessing Risk Management Techniques and Tools

**Likelihood Plus Consequence Equals Risk Level**

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<th>Title</th>
<th>Owning Team</th>
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<th>PERFORMANCE</th>
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**Legend**
- Decreasing (Improving)
- Increasing (Worsening)
- Unchanged
- Cost Threat (Level 1, 2, 3)
- Top Program Risk (TPR)
- Top Project Risk (TProjR)
Applying Human Space Flight Testing Philosophy

Considering the Crew Drives Levels of Analyses
Learning Lessons from the 1990s:
Delta-Clipper Experimental Advanced Demonstrator

Defining Hardware Limits through
Technology Development Flight Testing
Learning Lessons from the 1990s:
X-33 Single-Stage-to-Orbit Flight Demonstrator

Pushing the Limits of Technology
Transitioning from Shuttle to Ares: Hard-Won Lessons

“The great liability of the engineer compared to men of other professions is that his works are out in the open where all can see them. His acts, step by step, are in hard substance. He cannot bury his mistakes in the grave like the doctors. He cannot argue them into thin air or blame the judge like the lawyers. He cannot, like the architects, cover his failures with trees and vines. He cannot, like the politicians, screen his short-comings by blaming his opponents and hope the people will forget. The engineer simply cannot deny he did it. If his works do not work, he is damned.”

— Herbert Hoover
U.S. Mining Engineer & Politician (1874 – 1964)

Applying 30 Years of Lessons Lived
Reducing Shuttle Risk:
HD Cameras Visualize ET Foam Loss

Regularly Scrubbing Requirements to Reflect Reality
Reducing Shuttle Risk: Low-level Main Engine Cutoff (ECO) Sensor

Solving Potentially Critical Anomalies
Reducing Technical Risk for Ares I Crew and Ares V Cargo Launch Vehicles

In House Upper Stage Design and Vehicle Stack Integration

Designing for Life-Cycle Considerations: Safety, Reliability, Affordability
Systems Engineering Throughout the Project Lifecycle

Testing Philosophy Drives Failures
Testing for Knowledge Versus Testing for Success

Technology Readiness Levels Drive Testing Objectives
## Ares I Project Milestones

### Ares I Flight Dates

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### Upper Stage

- HW Delivery
- 1yr 9mo Build Time
- Prior to Delivery

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### Flight & Integration Test

- Ares I-X HW to KSC
- Ares I-X HW

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### System-Level Tests Inform Major Engineering Milestones & Validate Readiness
Ares I-X Development Flight Test: Breaking the Systems Engineering Model

Validates Modeling and Simulation, and Tests Operations Concepts
Generating & Analyzing Data to Reduce Risk: Main Propulsion Test & Integrated Vehicle Ground Vibration Test

Testing the Edges and Margins on the Ground
Verifies Design Performance & Validates Computer Models
Project Lifecycle Management Model: Reducing Undefined, but Known, Risks

Designing with the End in Mind

Manufacturing Engineering

Product Engineering

Concept Engineering

People

Information Platform

Technology

Processes

Requirements

Decommissioning

Manufacturing

Operation
Engineering Knowledge Management System

Broad Range of Data Resources/Types Across the Enterprise

Engineering Communities (IPTs)

Agency SharePoint 2007 Portal Platform
FAST Enterprise class search Engine
Search/custom Integrated web parts

Web based User Interface

Network Infrastructure & SOA IT Solution

ICE
Program Structured File System
Project Planning, Scheduling/EVM
Requirements Management
Risk Management

Legacy Data
MSFC Repository
Shuttle/Apollo
technical
Lasse/CASSI/RSI/C...

IEC/DDMS
Product Data Structure
Configuration/Document Management
Hardware/CAD/Environment
Evaluation/Approval Workflow/Routing

MSFC KM

Workflow and Graphics
drill down Tools
Voice/Audio
Video
Internet/Web Pages

3/2/2009
Conclusion: Reducing the Risk Inherent in the Human Exploration of Space

Engineering is a great profession. There is the satisfaction of watching a figment of the imagination emerge through the aid of science to a plan on paper. Then it moves to realization in stone or metal or energy. Then it brings homes to men or women. Then it elevates the standard of living and adds to the comforts of life. This is the engineer's high privilege.

— Herbert Hoover
U.S. Mining Engineer & Politician (1874 – 1964)

One Good Failure Is Worth a Thousand Successes