MIT January Operational Internship Experience 2011

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Agenda

• Background and Introduction
• Systems Engineering
• NASA Organization
• Workforce Core Values
• Human Factors
• Safety
• Lean Engineering
• NASA Now
• Press, Media, and Outreach
• Future of Spaceflight
JOIE Program

- 3 week program at KSC
- Allows students to study
  - Operational aspects of spaceflight
  - How design affects operations
  - Systems engineering in practice
- Organized by the Massachusetts Space Grant Consortium, NASA, and ESMD
The Team

- 7 MIT aerospace engineers, 1 Olin College mechanical engineer
- 4 seniors, 3 juniors, 1 freshman
- Previous internship experiences include JPL, JSC, SpaceX, and Orbital Sciences
- Interest in human factors, design, lean engineering, materials, propulsion, controls and analysis
Our Experiences
Systems Engineering

- Big Picture Approach
  - Integration of diverse systems
  - Optimization through trade-offs
- Iterative
  - Multiple rounds of development and review
"... to ensure safety and mission success, increase performance, and reduce cost."

~ NPR 7123.1

Product Hierarchy & Division of Labor

Effectiveness / Cost Envelope

Project Phases & Approval Mechanisms
Method: SE Engine
Method: SE Engine

Formulation

1. Stakeholder Expectations Definition
2. Technical Requirements Definition
3. Logical Decomposition
4. Design Solution Definition

Requirements process flow down to level below:
System design process applied to each work breakdown structure model down and across system structure

Requirements flow down from level above:

Technical Solution Definition Processes

Technical Planning Process
10. Technical Planning

Technical Control Processes
Requirements Management
Interface Management
Technical Risk Management
Configuration Management
Technical Data Management

Technical Assessment Process
14. Technical Assessment

Technical Decision Analysis Process
17. Decision Analysis

Realized products to level above

Realized products from level below

Product realization processes applied to each product up and across system structure

Product Transition Process
9. Product Transition

Evaluation Processes
7. Product Verification
8. Product Validation

Design Realization Processes
5. Product Implementation
6. Product Integration

January Operation Internship Experience
Constellation

- **Phase A: Concept & Technology Development**
  - Fire & Rescue working with Orion capsule designers

- **Phase B: Preliminary Design & Technology Completion**
  - Orion capsule mock-ups
  - Constellation Mobile Launcher
Implementation

Shuttle Operations
• Phase C: Final Design & Fabrication
  – Manufacturing of Shuttle tiles
• Phase D: System Assembly, Integration & Test, Launch
  – Preparing Atlantis in OPF
• Phase E: Operations & Sustainment
  – ET stringer repairs
• Phase F: Closeout
  – USA Logistics team
Logistics: Resources and Schedule

• Changes over a project's life-cycle
  – Manufacturers
  – Product demand

• Integration
  – Verification of product
  – Validation of system
Observations

- Within each system, designs must be balanced and forward-looking
  - Practicality & safety
  - Saving space vs. maintenance
- Integration of systems facilitated by required interactions between teams
  - Agreements between KSC and other centers
  - Chain of command for different tasks
NASA Organization

- Bureaucracy
  - Constellation
  - Continuing Resolution
- Procedures
  - Documentation
  - Work Approval Process

Credit: CBC News

1/25/11
January Operation Internship Experience
KSC Organizational Chart

Credit: www.nasa.gov
# KSC Contractors

<table>
<thead>
<tr>
<th>Contractor</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analex</td>
<td>Expendable Launch Vehicle (ELV) Integrated Support.</td>
</tr>
<tr>
<td>ASRC Aerospace</td>
<td>Arctic Slope Research Corporation (ASRC) Aerospace provides research and engineering services and technical support to KSC.</td>
</tr>
<tr>
<td>Boeing</td>
<td>Supports payload processing for the Space Station, Space Shuttle, Expendable Launch Vehicles, and other payload programs.</td>
</tr>
<tr>
<td>EG&amp;G Technical Services</td>
<td>Services for the operation and management of complex government installations, and military bases.</td>
</tr>
<tr>
<td>Pratt &amp; Whitney Rocketdyne</td>
<td>Powers the Space Shuttle and supplies boosters for Delta II, Atlas V &amp; Delta IV.</td>
</tr>
<tr>
<td>Science Applications International Corporation (SAIC)</td>
<td>Innovative applications of technology and expertise.</td>
</tr>
<tr>
<td>United Space Alliance (USA)</td>
<td>Prime contractor for NASA’s Space Shuttle Program, responsible for the day-to-day operation and management of the U.S. Space Shuttle fleet.</td>
</tr>
<tr>
<td>Space Gateway Support (SGS)</td>
<td>Delivers fire and rescue support services for both the Kennedy Space Center and Cape Canaveral Air Force Station</td>
</tr>
</tbody>
</table>

*Credit: [www.nasa.gov](http://www.nasa.gov)*
United Space Alliance

- Established in 1995 by Boeing and Lockheed Martin
- Sought to reduce Space Shuttle program contractors into one primary contractor
- Space Program Operations Contract (SPOC) in 2006
- Over 70% of repairs and spares for the shuttle fleet go through USA
- NASA Shuttle Logistics Depot
ASRC Aerospace

- Launch Equipment Test Facility (LETF)
- Quality Assurance
- Rapid Prototyping
- Vehicle Motion Simulator
- Umbilical Testing
- Cryogenics

Credit: www.nasa.gov

January Operation Internship Experience
Space Gateway Support

- **Shuttle Program**
  - Pad rescue for shuttle
  - M113 armored personnel carriers

- **Constellation**
  - Orion capsule configuration for rescue
  - Liquid air SCBAs
  - Train Air Force Pararescue
Pratt & Whitney Rocketdyne

- Space Shuttle Main Engine (SSME) Processing
- SSMEs designed in the late 1970s
• Provides engineering expertise in
  – Systems engineering
  – Logistics
  – Integration
  – Operation
• Focuses on
  – Expendable launch vehicles
  – Consulting for Constellation program
PEOPLE & CULTURE
Systems and People

- Constraints and interests for a design have all been set by people
- People working together form as important a group as the technical portions
- Workforce, culture, and values are parts of that system
Types of People

- The Passionate One
- The Traditionalist
- The Energetic One
- The Rookie

- The Practical One
- The One-Track Mind
- The Wise One
Values

Safety
- Crew safety
- Personal safety

Responsibility
- Doing the job right
- Quality
- The process
- We’re putting people in space

Accomplishment
- Mission success
- Experience
- Getting the job done

The Work
- The job
- Shuttle program
- Space program
HUMAN FACTORS
Human Factors

- Human factors design rules:
  - Safety
  - Ergonomics
  - Work space design
  - Human/robot interaction: supervisory control
Human Factors: ORION

- Visual access
- Reach
- Work space
- Technical: ground system to Ares I opening and first stage to upper stage opening
KSC layout

Credit: Google Maps

1/25/11

January Operation Internship Experience
KSC layout


January Operation Internship Experience
Safety

• Prevention, protection, and handling of hazardous elements
  – Human safety
  – Service equipment
• Communication is key
Human Safety

- Astronauts
  - Most important payload
  - Familiarize crew with logistics
- Ground/Crew Support
  - Fire Rescue Team
  - Protective equipment
Service Equipment

- HAZMAT
- End User Friendly
  - Intuitive
  - Redundancy
- Inspection/Testing
- Maintenance
• Safety motivated research
  – Corrosion Lab
  – Electrostatic and Surface Physics Lab
  – Regolith and Granular Lab

Credit: www.nasa.gov
ACCIDENTS
Accidents

- Type and severity range
- Always should be a learning experience
- NASA accidents can be very public and high profile

Credit: Synthstuff.com
25 years ago today

Result of known SRB joint O-ring issue that was not properly addressed

NASA management restructured to encourage engineers to speak up about issues

Many lessons learned

Credit: http://loftyambitions.wordpress.com/
Columbia

- Known ET issues
- Impact of these issues not properly addressed
- Cultural issues similar to those encountered with Challenger contributed to lack of data about wing damage

Credit: www.nasa.gov
Lessons Learned

- RATS cards
- Modifications to shuttle before each return to flight fixed hardware issues
- Safety is a priority
Lessons Learned

• Accident Investigation Board Recommendations
  – Fixed Technical Issues
  – Patched organizational issues
• Attrition of recommendations to old ways

"Perhaps most striking is the fact that management – including Shuttle Program Mission Management Team, Mission Evaluation Room, and Flight Director and Mission Control – displayed no interest in understanding a problem and its implications."

-Columbia Accident Investigation Board
• Reduced Costs
• More Added Value
• Manufacturing Driven
• Reduced Waste
  – 7 Types:
  Over production, inventory, waiting, motion, transportation, rework, over processing

Credit: http://lsspmp.com
Places we saw LEAN

- 5S Workplaces:
  - Sorting
  - Straightening
  - Shining
  - Standardizing
  - Sustaining

- Many offices, labs and contractors use this already

Credit: Beyondlean.wordpress.com
Places we saw LEAN
Shuttle Operations and Sustainment

- Spares and refurbishment for reusable parts
- Orbiter tiles require replacement/refurbishment
- SRBs require cleaning and refueling
- Parachutes require cleaning and repacking
KSC Shuttle Operations

Shuttle Landing

OPF (3-4 months)

VAB (3-7 days)

Roll Out (12 hours)

Launch

Pad (30-60 days)

JSC Control
Closeout of the Shuttle Program

- Plan final flights
- Dispose of hazardous materials, determine the future for ground facilities, etc.
- Top to bottom analyses of program elements
- Data/information requires analysis and archiving
- Workforce reduction
- Rehire issues
EDUCATION
Education Programs

- K-8
  - EarthKam
  - Fly your face in space
  - Send your name to Mars
  - Pluto Pals

- High School
  - FIRST Robotics
  - Space Settlement Design Contest
  - MyNASA
  - NASA Facebook

- Undergraduate
  - Internships (SURF, Space Grant, etc)
  - Future of Flight competition
  - Lunabotics Mining Competition
  - NASA Academy

- Graduate
  - Graduate Student Research Program
  - UARC STI Graduate Student Summer Internship Project
  - PhD mentors
Beyond

- NASA TV
- Launches
- Astronaut Tweets
- NASA iPod applications

Credit: www.nasa.gov
Press

- NASA TV
- Mobile satellite uplink trucks
- Manned flights have most attention
- Historically has not approached networks
  - Missed opportunity to educate public
- Challenges in advertising

Credit: Wunderground.com
• Convey NASA to public
• Translate policy and policy implications
• Promotions beyond Florida area
  – Extend NASA speakers program
  – Creative marketing
NASA Spinoffs

- Light-emitting diodes (LEDs)
- Infrared ear thermometers
- Ventricular assist device
- Artificial limbs
- Transportation
- Aircraft anti-icing systems
- Highway safety
- Improved radial tires
- Chemical detection
- Public safety
- Video enhancing and analysis systems
- Fire-resistant reinforcement
- Firefighting equipment
- Consumer, home, and recreation
- Tempur foam
- Enriched baby food
- Portable cordless vacuums
- Environmental and agricultural resources
- Water purification
- Solar energy
- Pollution remediation
- Computer technology
- Structural analysis software
- Remotely controlled ovens
- Industrial productivity
- Powdered lubricants
- Improved mine safety
- Athletic shoe design
- Athletic shoe manufacture
- Freeze-dried food
- Insulation (mylar)
- Water purification technology
- Surface enhancement coatings
- Digital signal-processing for CAT scans & MRIs
- Vacuum metallizing techniques
- Cordless power tools
- Cool suits

January Operation Internship Experience
Future of NASA

- Space Shuttle retirement
- Constellation
- ISS requires resupply and maintenance: Foreign and commercial options
  - Soyuz: $56 million per seat
  - SpaceX
  - Orbital Sciences

Credit: www.nasa.gov
- Use commercial industry to service the ISS in a more profitable and efficient manner
- Cargo and crew transportation capabilities
- Funding once reach milestones (performance objectives) with ISS
- Access to all NASA archives, experts, and experience
Orbital Sciences

- 150 major space and rocket missions in 7 years
- Focus on satellites and space systems, launch vehicles, and advanced space programs
- Clear market focus, product line breadth, technical excellence and cost efficiency
- Moderate use of contractors
Taurus II & Cygnus

- Taurus II is medium class launch vehicle
- Cygnus is advanced maneuvering spacecraft
- COTS demo in the second half of 2011
- 8 pressurized cargo missions from late 2011 or early 2012 through 2015
- $40-45 million

Credit: www.nasa.gov
SpaceX

- Reduce the cost and increase the reliability of space access by a factor of ten
- Simplicity, low cost, and reliability can go hand in hand
- Eliminate traditional layers of management internally and sub-contractors externally
- Design for reuse
- Limited use of contractors
Falcon 9 & Dragon

- Falcon 9 - launch vehicle
- Dragon - pressurized capsule with unpressurized trunk
- COTS Demo 1 success
- Next steps: integrated launch abort system and crew accommodations
- COTS Demo 2 and 3
- $50 million

Credit: www.nasa.gov
SE in the Commercial Industry

• Contracts and the make/buy dilemma (capability and budget considerations)
• Budget, risk, and performance optimization
• CDIO execution must emphasize the connection between design and operation
• Few failures to learn from thus far
NASA and Commercial Industry

- Man-rating (i.e.: LETF)
- Facilities available with the end of the Shuttle program
  - space vehicle processing and launch facilities
  - off-line processing facilities
  - payload processing facilities
- Advantages and disadvantages of using NASA facilities
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