Juggling Act: Re-planning & Building an Observatory Simultaneously!!!
Purpose

This presentation discusses how the SOFIA Program, in the midst of a re-plan and system development phase, executed multiple simultaneous planning and business initiatives/requirements and integrated them into improved project management processes without impacting technical progress.
Overview

• The SOFIA Mission

• Before the Re-plan

• The Juggling Act

• Managing the Chaos

• Engage Existing and New Jugglers

• The Results

• **KEY BREAKTHROUGHS**

• Conclusion
The SOFIA Mission...
Stratospheric Observatory For Infrared Astronomy (SOFIA)
Layout of Personnel and Accomodations

(Mission Control & Science Operations Section

Education & Public Outreach Section

Science Instrument

Pressure Bulkhead

Open Port Telescope Cavity

Cavity Environmental Control System

Telescope, 2.5 meter

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Why SOFIA?

• Infrared information is important to gather astronomy science data
  – IR can see through dust
  – IR can detect cold gases and dust, other cool stars, and planetary objects
    –! Forming stars have their light intensity peaks in the IR
  – IR can detect the content of the early universe through red shift of distant objects
• Infrared is filtered by moisture in atmosphere
• At 41,000 ft, above more than 99% of the water vapor
• Spacecraft consume infrared required cryogens’ in 3 to 4 years
• Mobility: anywhere, anytime
• Long lifetime
• A near-space observatory that comes home after every flight

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The Orion Constellation

In Visible Light

In Infrared Light
Before the re-plan...
Program Background

-! The predecessor to SOFIA, the Kupier Airborne Observatory (KAO), was decommissioned in 1995 to start SOFIA

-! SOFIA established as a 80/20 partnership between US and Germany (NASA and DLR)
  •! NASA receives 80% of available science time, DLR 20%

-! Initial program model, was contractor led with NASA oversight (privatized)

-! Program slated for cancellation in the spring of 2006

-! Agency approves program for continued funding in the fall of 2006
  •! Program restructured
    -! Government led contractor supported
    -! Two projects, Science and Platform
      »! Science at Ames Research Center
      »! Platform at Dryden Flight Research Center
Program Restructure

Shift From Contractor Run / Government Oversight
To Government Lead / Subcontractor Relationship

Previous Organization

Restructured Organization

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Incremental / Phased Development Approach

- A/C Modification Telescope Assembly
- Cavity Door System (CDS)
- Cavity Environmental Control System (CECS)
- Science Instruments (SI)

<table>
<thead>
<tr>
<th>User Need</th>
<th>Functional/Ferry</th>
<th>Closed Door</th>
<th>Open Door</th>
<th>Early Science</th>
<th>TA Characterization &amp; Shared Purpose</th>
<th>Full Operational Capability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original Requirements Baseline</td>
<td>SRR</td>
<td>SAR, Data Review</td>
<td>FRR, Flt Test</td>
<td>ΔSAR, Data Review, Re-Base</td>
<td>ΔSAR, Data Review</td>
<td>ΔSAR, Data Review</td>
</tr>
<tr>
<td>PDR</td>
<td>FRR</td>
<td>Ground Test</td>
<td>ΔSRR, ORD</td>
<td>FRR, Ground Test</td>
<td>ΔPDR, ΔORD</td>
<td>ΔPDR, ORR</td>
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<td>SAR, Data Review</td>
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<td>Ground Test</td>
<td>ΔCDR</td>
<td>ΔCDR, Ground Test</td>
</tr>
</tbody>
</table>

- A/C Modification TA/CECS
- Instrumentation CECS Improvements
- CDS/CDDS/CECS MCCS Build #1
- MCCS for Early Science Early Science Instruments
- Final MCCS/CECS-LN2 Science Instruments
- Final Upgrades

Segment 0 | Segment 1 | Segment 2 | Segment 3 | Segment 4
Approximate Aircraft Configuration at Program Restructure, 2006
Introducing the Juggler...

Program Restructure

Incremental Observatory Development

System Engineering & Integration

The SOFIA Program Office

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Build a World-Class Observatory

Implementing the New Program Structure

Inter-leaving Development and Early Science (phased development approach)

Systems Engineering & Integration

Integrating the New Team

Science Community Expectations

Deploy working observatory capabilities and services

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New Challenges

• Can you handle a few more balls in the air?
• Subsystem development schedule delays

MCCS Development for Early Science

CDDS Technology Development Issues
Working harder, but it’s all under control
The Impossible Act...
The “fun” begins…

- GAO Large Program Assessment/Audit
- Technical Re-plan
- Clear the flight envelope
- Standing Review Board (SRB)
- Get to the Initiation of Science Flights

(but don’t drop any of the other balls!!)
And the fun keeps coming…

- IG Pre Audit, Formal Audit, Recommendations
- Earned Value Implementation
- Joint Cost & Schedule Confidence Level (JCL)

(but don’t drop any of the other balls!!)

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Something's gotta give!!!!
Managing the Chaos...
Take a timeout....

What’s important?

What’s urgent?

What don’t we know?

What’s feasible?

How are we going to get this done?!

What added value can we get from these new requirements?
Managing the Chaos...

• Strategize....before you add more jugglers to the team, or even accept the balls

• Sequence the balls...don’t try to accept them all at once

• Leverage skill and experience of existing jugglers...

• Learn new “juggling skills”
  – “Jugglers” and “juggling skills” equate to process improvement, functional groups, NOT additional staff
Sequence the Balls

• The timing of when new balls get thrown in the mix is critical to keeping everything in the air

Flight Test

Technical Re-plan

Standing Review Board (SRB)

• Technical re-plan required

• Same team preparing for initial flight test of the observatory

• SRB required...but urgent?
Sequence the Balls

Technical Re-plan  Flight Test

- **KEY DECISION**: Prioritize Flight Test over the SRB
  - Provided a pre-brief to the SRB to give them time to get familiar with the program, but minimize impact to the project teams
  - Top priority – Conduct Flight Test so that we can start science missions
  - Reschedule formal SRB after initial flight test phase complete

- **KEY DECISION**: Index the program to an interim baseline pending SRB recommendations
Engage Existing / New Jugglers...
Engage Existing Jugglers...

- Leverage existing team members and groups instead of adding to the confusion with new players

- Introducing...
The Observatory IPT

Owns the key skills to keep the act going...developing the observatory

- Technical Coordination
- Requirements Management
- System Engineering & Integration
- Mission Preparedness & Execution
- Technical Risk Management
CRM has a new key skill...the THREAT DATABASE

- Makes it easier for team to identify threats “on the fly”
- “any issue that keeps you up at night”
- Threats linked to milestones with quantified cost / schedule impacts
- Improved Program risk identification
The Threat Database...
Communication of Concerns

Traceability of concerns maintained from top to bottom

“Significant” Risks tracked at Program Level

Threats “roll up” into formal Risks

Concerns are collected at the team level...

SOFIA Team Concerns

Threats

Platform

Science

Program
The threat database is used to populate the JCL risk register and the Risk Action Matrix at the Project and Program Level.

The threat database proved to be a good predictor of likely schedule impacts and helped focus mitigations.
Two Coordinated Jugglers

Synchronized by tossing the Threat Database ball back and forth

Observatory
IPT

Continuous Risk Management
Integrated Schedule & Budget

- Tune up **key juggling skills** to manage more balls in the air at one time
- By teaming with other Jugglers, tossing balls back and forth, sharing the load...
- Leverage threat database for cost/risk integration (toss ball back and forth with **CRM** & **Observatory IPT**)
- Leverage existing budget data for schedule/cost integration (coordinating with **SPO**)
- Acquiring JCL implementation knowledge
- Integrated technical and reserve management strategy
Reserves Management Strategy

![Chart showing reserves management strategy from FY08 to FY15 with categories: Distributed, Unapproved, Approved, Threats, Unknowns.](image)
Three Coordinated Jugglers

- Observatory IPT
- Schedule
- Threat Database (DB)
- Continuous Risk Management
- Integrated Schedule / Budget

Synchronized by tossing the Threat Database and Schedule balls back and forth
Bring the New Juggler#5....

Integrates cross-functional knowledge to create a new skill

- Integrated Master Schedule with:
  - Tie to Threat Database via JCL Risk Registry
  - Resource Loaded Tasks
  - JCL plug-in
  - Leverage JCL for EVM Implementation
  - Institutionalize value-added processes and analyses
  - Ensure continual improvement and sustaining processes through coordination with other jugglers

Schedule IPT

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39
Program-wide Coordination

Observatory IPT

Schedule IPT

SOFIA Program Office

IMS

Threat DB

Continuous Risk Management

Integrated Schedule / Budget

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Accomplishments

•! Can really work together and perform tricks!!!

✓! Completed technical re-plan
✓! Successful First Flight with 100% open door
✓! Successful First Light through telescope in the air
✓! Completed Envelope Expansion
✓! Completed JCL
✓! Successful SRB
✓! Completed Re-plan with APMC
✓! Completed EVM Implementation
✓! Completed Observatory testing with Integrated MCCS/CDDS for Early Science.

✓! Initiation of Science Flights on Nov 30 / Dec 1, 2010!!!
Key Breakthroughs

• Key decisions made to set down balls...not drop them
  - Leveraged the results of technical re-plan
  - Re-sequenced SRB appropriately
  - Program indexed with an interim baseline
• Enhanced CRM processes
  - Threat database construct
  - Linking threats to specific activities, identify cost and schedule impact
  - Use threat database as primary source for JCL inputs
  - Feeder to traditional risk management - augment, don’t replace
• Integrated Master Schedule
  - Resources, threats, JCL/EVM enabled
• Finding a way to dissolve traditional stovepipes
  - Key relationships (Business Manager, CE, SPO, PMs...)
  - Integrated products that allow for cross-functional use and enabled new teams to implement new requirements
Conclusion
The SOFIA Program found ways to leverage existing roles in new ways to meet the requirements without creating unmanageable overhead. The team developed strategies and value added processes - such as improved risk identification, structured reserves management, cost/risk integration - so that the effort expended resulted in a positive return to the program.
The Improved Operating Model

Resource Loaded IMS

- EVM
- JCL
- Schedule IPT
- Integrated Budget
- PPBE
- GAO Audits
- Reserves Mgt

Threat Database

- CRM
- Program Risks / RAM
- Observatory IPT
- SPO
- SRB
- SE&I
- FOC
- ISF

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Questions?
Successful 100% Door Open Landing; April 14, 2010
Telescope in Aft Cavity
SOFIA First Light Image - Jupiter
May 26, 2010

SOFIA infrared image
(5.4, 24.2, and 37.1 µm)

Visible light image
SOFIA First Light Image - M82

SOFIA infrared image (19.7, 31.5, and 37.1 μm)

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Initiation of Science Flights
Nov 1 - Dec 1, 2010

[Image of scientific equipment]