SOFIA Program SE&I Lessons Learned

NASA PM Challenge

9 February 2011

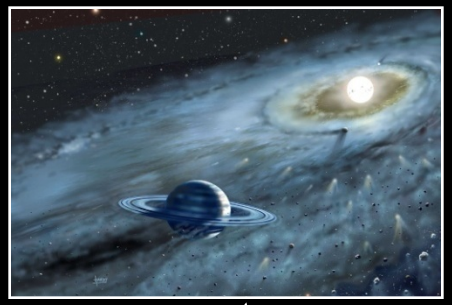
Presented by: **Ron Ray** - SOFIA Program SE&I Lead
Laura Fobel - SOFIA Program CM & IT Lead
Mike Brignola - Platform Project SE&I Lead

SOFIA
Stratospheric Observatory for Infrared Astronomy

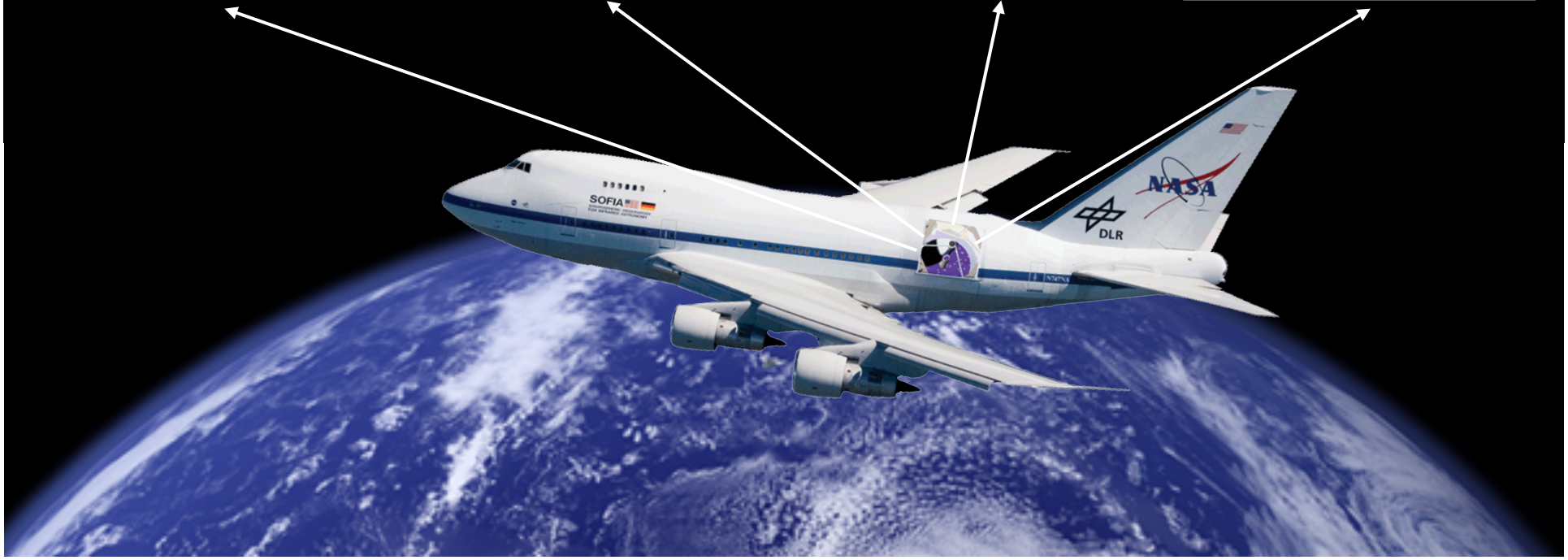
Interstellar Medium

Planetary Science

Formation of Stars and Planets



Galaxies and the Galactic Center



The purpose of this presentation is to describe the Systems Engineering solutions applied in the middle of the "troubled" SOFIA Program that helped it become successful

Table of Contents

Background

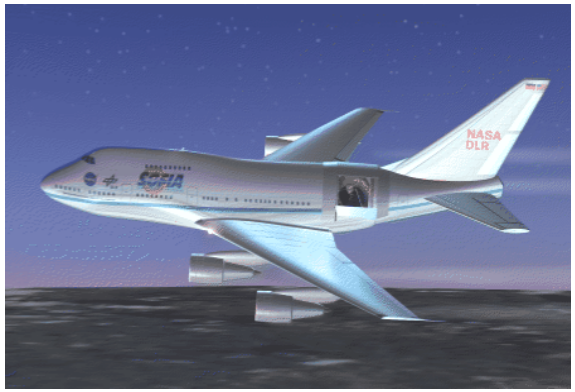
Ron Ray

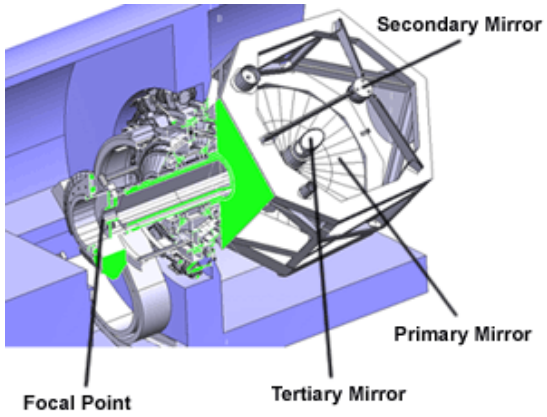
Why SOFIA?

- SOFIA is the largest portable telescope in the world
  - 2.5-meter (100-inch) telescope in a Boeing 747SP
- SOFIA is reconfigurable and highly flexible
  - Every SOFIA flight series is comparable to a Hubble reservicing mission
    - Science instruments can be routinely changed and upgraded
  - Able to quickly respond to all astronomical events
- SOFIA will exceed the performance of ground-based Infrared Telescopes
  - Flies above 99.9% of the water vapor
- SOFIA is designed to be productive
  - 140 eight-hour research flights per year; 20 year lifetime
- SOFIA cost much less than space-based observatories

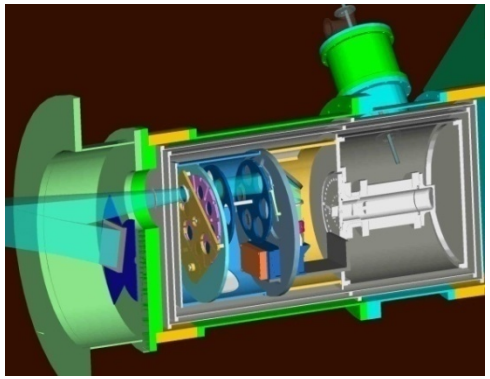
Major Components of SOFIA

Observatory

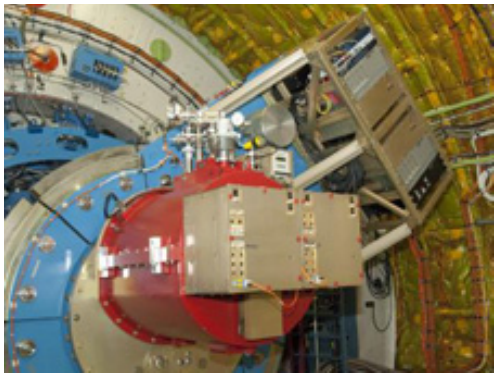




Telescope Assembly



Science Instruments



Science and Mission Operations Center

Aircraft Operations Center

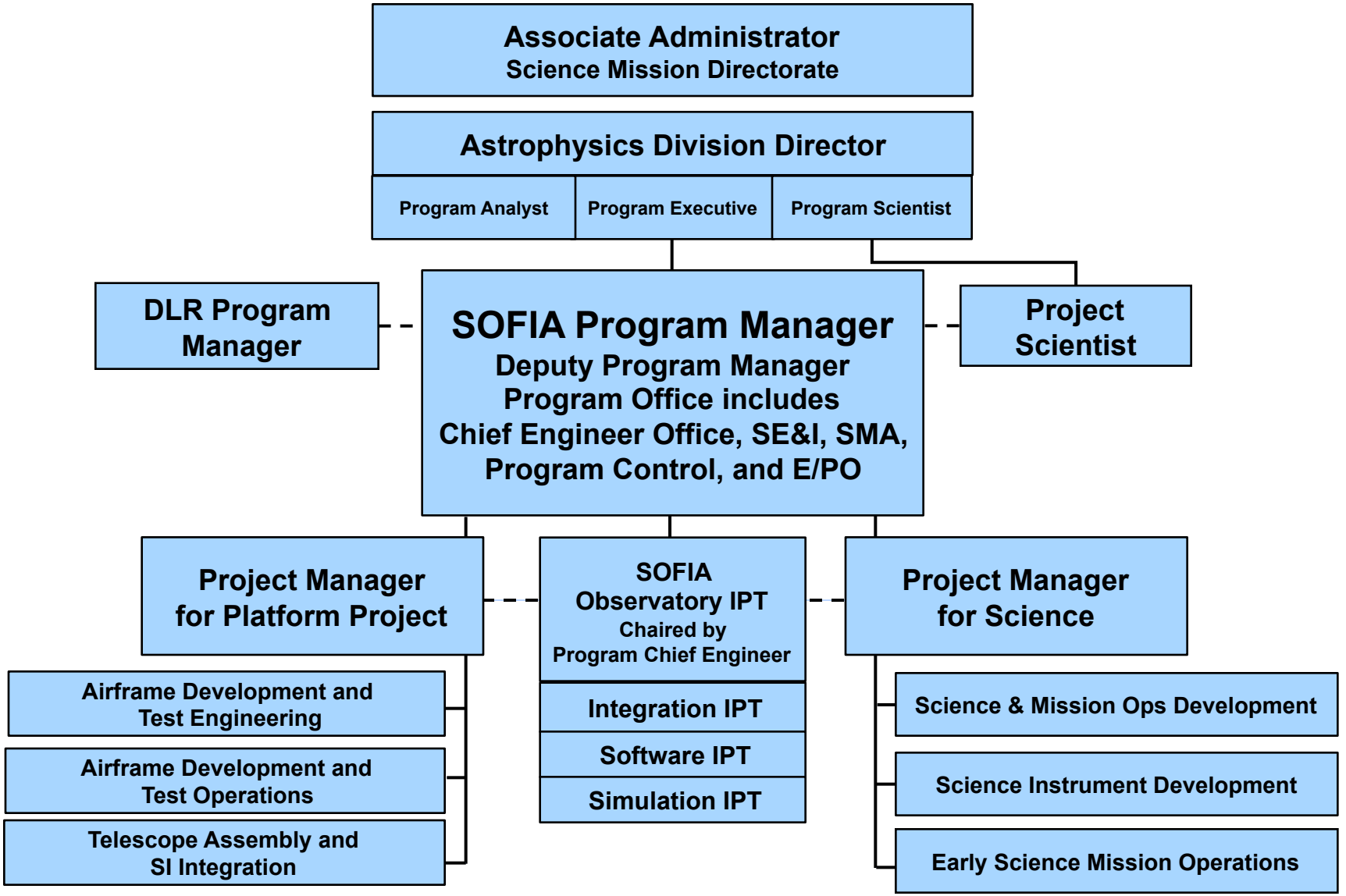
Background

- SOFIA was established as a 80/20 partnership between the U.S. (NASA) and Germany (DLR)
  - Original NASA/DLR MOU signed 1996
  - Germany supplied telescope assembly and other significant contributions
  - NASA supplied modified aircraft and Science Operations Center
  - NASA receives 80% of available science time, DLR 20%
- Initial program model was contractor led with NASA oversight (privatized)
- Overtime, a series of schedule slips, cost increases, contract issues and mishaps occurred

Background

- NASA withheld funding and the Program was slated for cancellation in the spring of 2006
  - Members of Congress, Germans and the Science Community “pressured” NASA to continue Program
  - NASA commissioned an independent review team to consider options
- The Agency approved the Program for continued funding in the fall 2006
  - The Program was restructured:
    - Government led, contractor supported
    - Program management moved to Dryden
    - Two projects; Science and Platform

SOFIA Program Organization During Development



SOFIA SE&I Approach

Ron Ray

SOFIA Systems Engineering Transition

- The new Program Office initiated an independent review of SOFIA Systems Engineering (Summer 2006)
- The SE&I Lead position was transferred to Dryden (Sept. 2006)
  - Reviewed SOFIA SE&I history & existing processes
  - Reviewed the SE&I independent assessment and recommendations
  - Completed additional assessments
- Several significant issues with SE&I were identified (See following pages)

SOFIA SE&I Assessment

- System Requirements were lacking and fragmented
  - Needed government ownership and greater priority
  - Only a small percentage of Specifications had been baselined
  - The Interface Control Documents (ICDs) were not centrally managed (not clear who owned what)
- Program CM process was dysfunctional (over 100 documents were tied up in the old process)
  - A small group made all of the decisions creating a bottleneck
  - Hardware was being built to unapproved documents

SOFIA SE&I Assessment (Cont.)

- Program had an immediate need for a formal Risk Management Process
  - New PM was working this informally because the previous system was unmanageable
- The amount of information already assembled for SOFIA was vast and users had difficultly finding things on the central Data Management System
  - Over 100,000 data records existed in hard and soft copy
  - Over 50,000 Telescope Assembly (TA) documents existed in the Data center only in hard copy and filed chronologically
  - Many documents were owned and managed by the Contractors using various document control processes

It is never too late to fix Systems Engineering (SE) deficiencies

SOFIA Program Systems Engineering Dilemma

- The new Program Management faced a major dilemma with Systems Engineering:
  - Either stop and "fix" the Systems Engineering and Integration (SE&I) problems identified at the time of transition

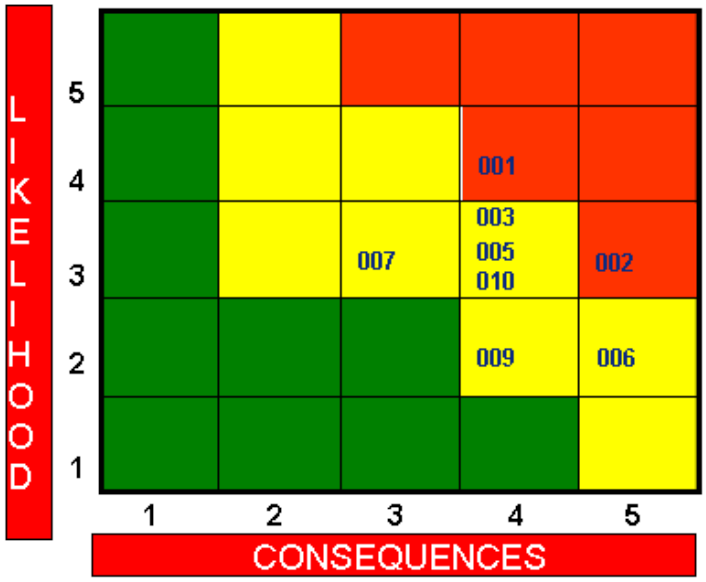
  or
  - Continue at risk and try to "rebuild" SE&I along the way
- Some consideration factors
  - Priority was to get the aircraft from Waco to Dryden and demonstrate progress after the threat of cancellation
  - The near-term challenges were not considered as difficult as the long-term challenges
  - The new Dryden team members were still coming up to speed on the SOFIA systems

New Implementation Strategy for SE&I

- The Program made the decision to continue at risk and "rebuild" SE&I as we go
- Risk mitigation decisions/activities
  - Phase the remaining development into increments which would give key SE activities a chance to catch-up
    - Add an "Early Science" Milestone to recapture schedule
    - Conduct both near-term and long-term SE activities simultaneously
  - Work more collaboratively between the stakeholders and developers to compensate for requirement gaps
    - Conduct a series of "delta" System Requirements Reviews focusing on near-term needs and requirements
    - Implement cross-Project Integrated Product Teams (IPTs)
  - Establish a new set of SE&I priorities and provide a dedicated staff to facilitate the rebuilding process

The Use of Risk Management on SOFIA

- SOFIA distributed Program and Project level risks and made Risk Management an integrated but delegated management tool
- The SOFIA Program focused on the "top priority" risks and tracked a larger set of "threats" (potential risks)



Rank & Trend	LxC	Risk ID	Approach	Risk Title
⇨	1 (4x4)	SOF-RSK-001	M	MCCS Development
⇧	2 (3x5)	SOF-RSK-002	M	Loss of Science Community and DLR Support, Due to Late Science
⇨	3 (3x4)	SOF-RSK-003	M	Cavity Door System Failure (Loss of Science / TA Damage)
⇨	4 (3x4)	SOF-RSK-005	M	Lack of Requirements Definition (Systems Engineering)
⇨	5 (2x4)	SOF-RSK-010	W	Unacceptable Cavity Acoustics
⇨	6 (2x5)	SOF-RSK-006	M	Handling Damage to Primary Mirror
⇨	7 (3x3)	SOF-RSK-007	M	Schedule and Cost Growth, Due to Schedule Uncertainty
⇨	8 (2x4)	SOF-RSK-009	W	Limited Flight Envelope, Due to Technical Issues

Risk List from March 28, 2008

SOFIA identified the lack of Requirements Definition as a risk

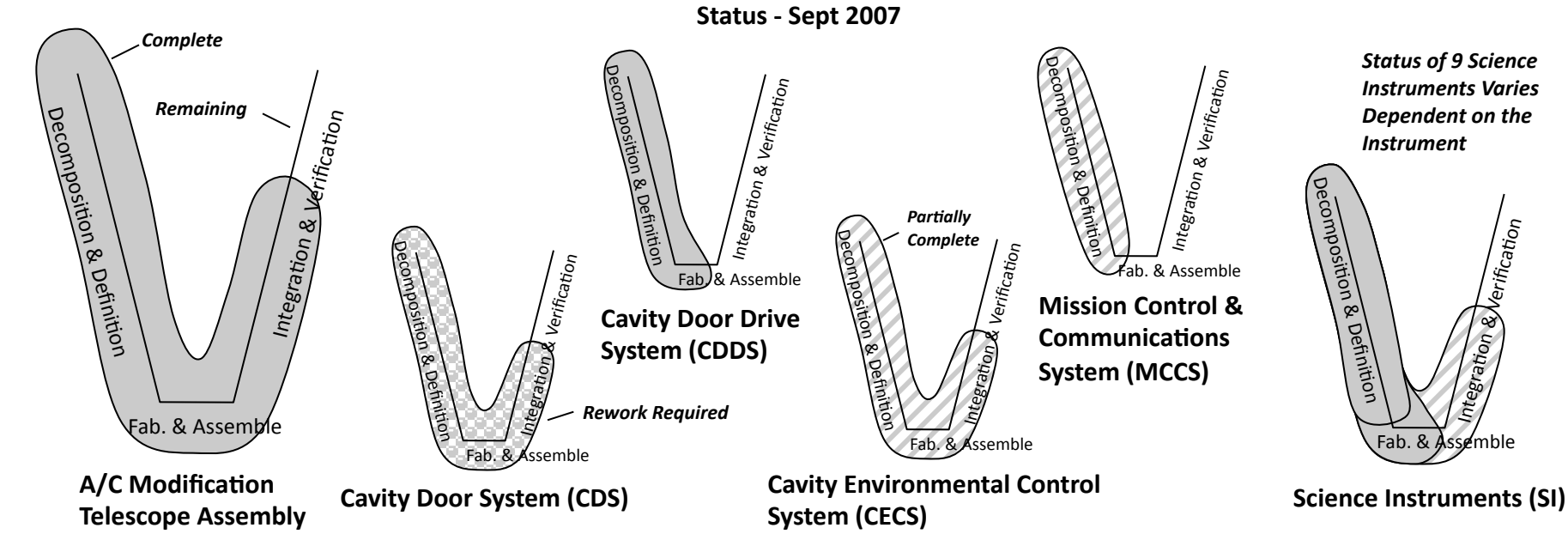
Criticality	L x C Trend	Approach
High	⇩ Decreasing (Improving)	M - Mitigate
Med	⇧ Increasing (Worsening)	W - Watch
Low	⇨ Unchanged	A - Accept
	□ New Since Last Period	R - Research

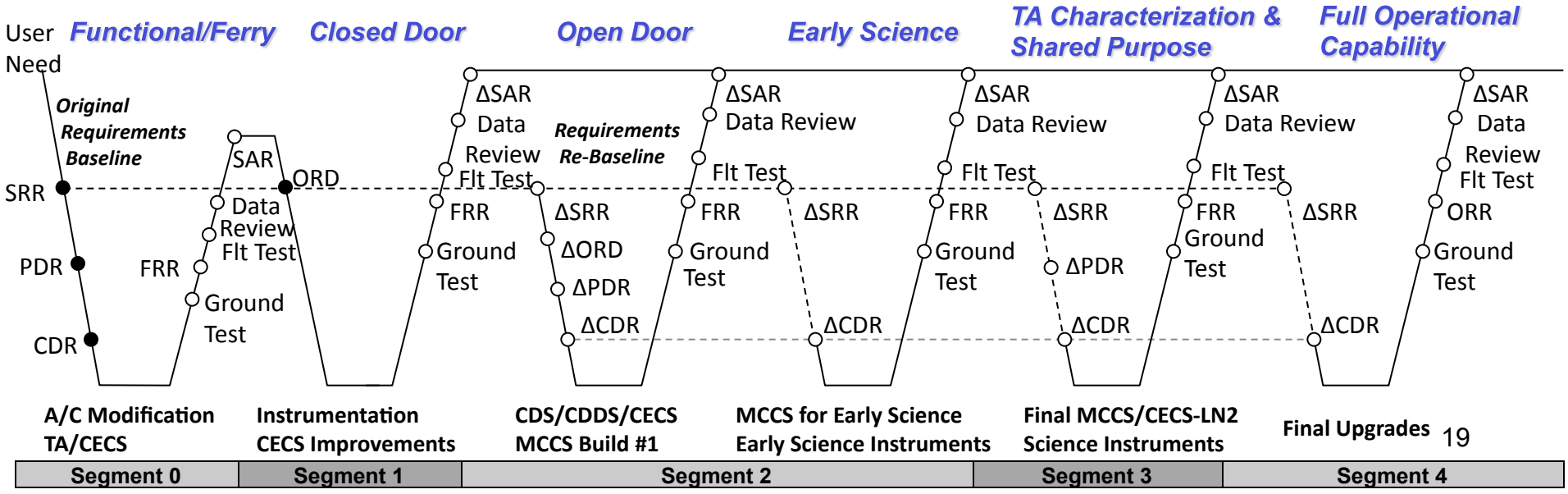
SOFIA SE Lessons Learned

Breaking complex development activities into increments can improve the overall chance of success

"Sometimes the questions are complicated and the answers are simple."
Dr. Seuss

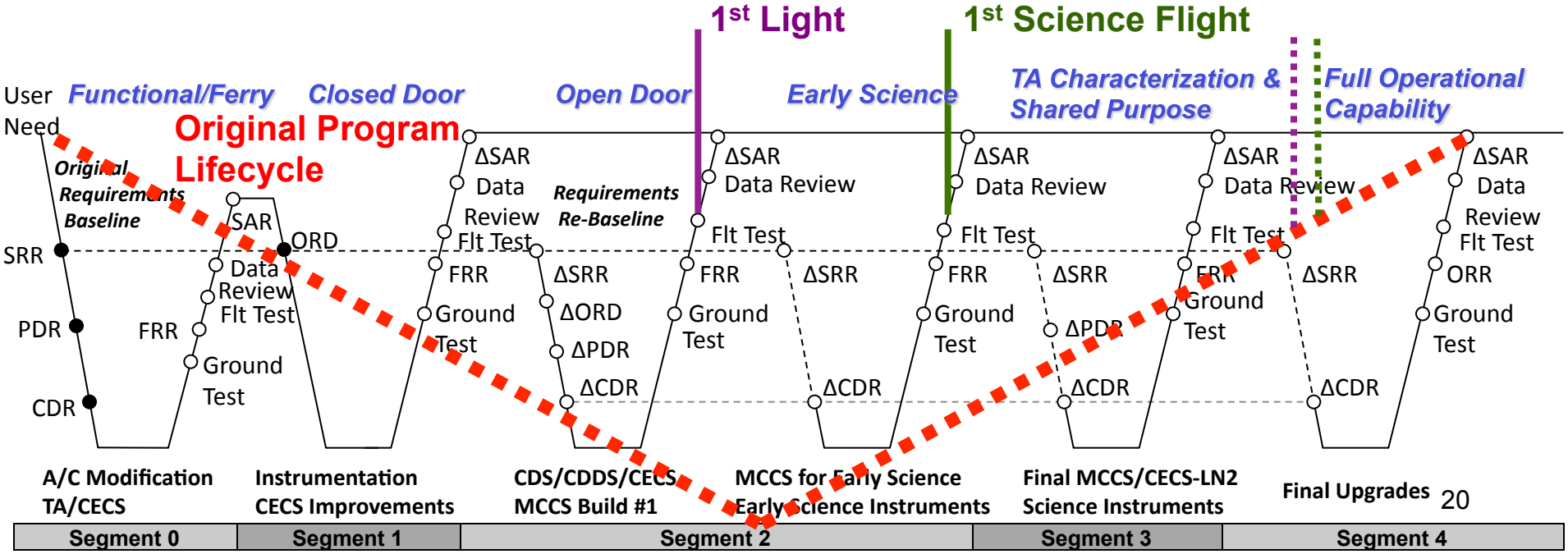
New SOFIA Life Cycle: Incremental Development





Advantages of the Incremental Development Life Cycle for SOFIA

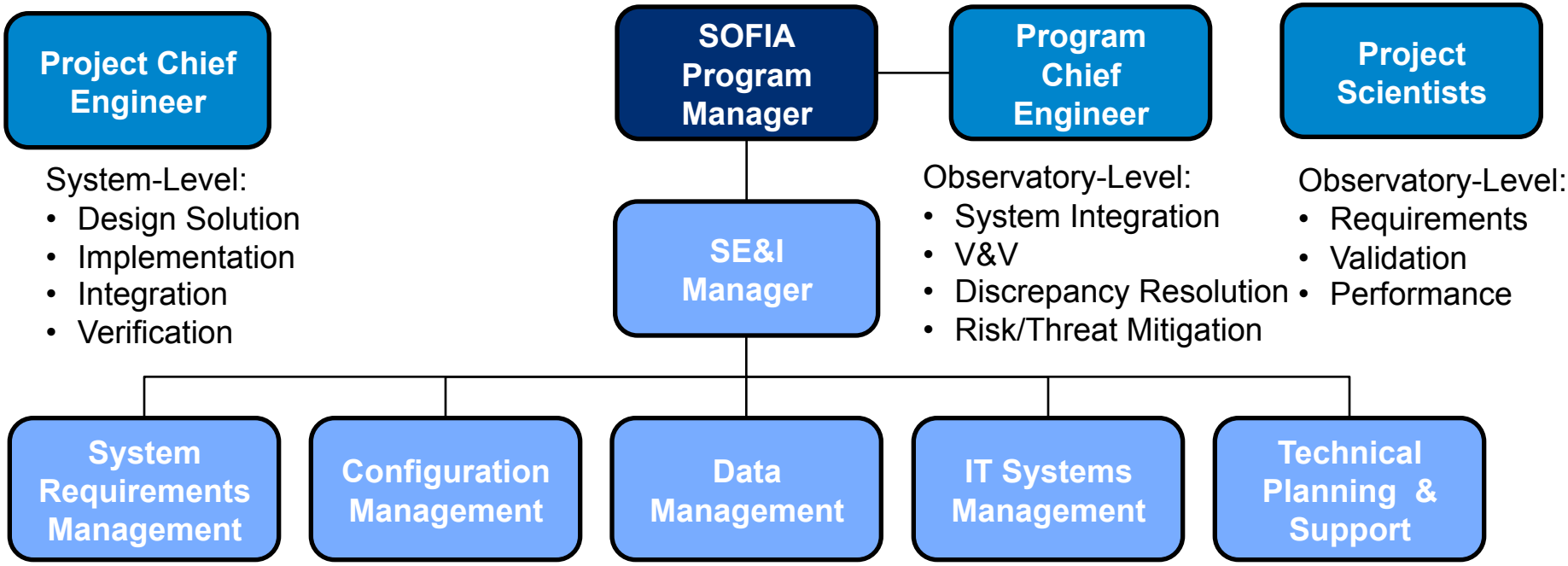
- Allowed science data to be obtained significantly sooner helping retain science community support
- Allowed requirements time to catch-up over the long term
- Allowed integration issues to be identified and better isolated as system complexity grew
- Allowed for Observatory performance to be assessed earlier
  - Early 1st Light gave initial indication we have no major performance deficiencies



SOFIA SE Technical Priorities

- Organize and establish Systems Engineering leads and support teams for key SE tasks
  - Established a dedicated Requirements Manager (High Priority)
- Revise Program SE&I documents and processes
  - Risk Management
  - Configuration Management
  - IT Management
  - Data Management
- Develop a new Systems Engineering Management Plan (SEMP) to define technical process and requirements
  - Complies with NPR7123.1
- Establish Program Management Control Boards
  - PMB: Programmatic Control
  - OCCB: Observatory Control
- Establish a SOFIA Observatory-Level IPT (SOLIPT)
  - Addresses Observatory and “cross project” technical issues
- Establish a process to manage and track the status critical Program and technical documents

SOFIA Program
SE&I Organization



Management needs clear insight on the status of SE products

SOFIA Program SE&I Documentation Tracking Tool

Status on 12/01/2007

	General Program/Project Documentation	Science Project	Platform Project	SOFIA Program
1	Program/Project Plan	In Review	In Review	Baseline
2	Systems Eng. Management Plan (SEMP)			In Review
3	Configuration Management Plan (CMP)	In Development	Rev A	In Review
4	Risk Management Plan (RMP)			Baseline
5	Data Management Plan (DMP)			Outline
6	Safety and Mission Assurance Plan (SMA)	In Review		Baseline
7	Reliability & Maintainability Plan (R&M)			In Development
8	Software Management Plan	?	In Development	
9	Software Development Plan	?	?	
10	Software Assurance Plan	?	In Development	
11	IT Security Plan			In Development
12	Concept of Operations			In Development
13	Supplier Statement of Requirements (SSOR)		In Review	
14	Integrated Master Schedule (IMS)	Detailed Seg 2	Detailed Seg 2	Baseline w/HQ
15	Level 1 & 2 Milestones	Updating	Updating	Baseline
16	Flight Test Segment Definitions (Revision)			Segment 2 Rev A
17	Product Owners List			In Development
	Legend	Complete	Open, On-going	Impacts Schedule

- Illustrates a summary chart presented to SOFIA Management to track documentation progress

See conclusion chart for more recent status

SE must account for and tailor to various Center and cultural differences

"Scientists investigate that which already is; engineers create that which has never been."

Albert Einstein

The Relationship Between Engineers and Scientists

- Engineers and Scientists must have clear and distinct roles and responsibilities
- On SOFIA (during the development phase) the Scientist is the "customer" and the Engineer is the "implementer"
  - SE&I is often the interface

Scientists:
- Specify needs and requirements
- Develop the Concept of Operations
- Participate in technical reviews
- Accept verification
- Provide validation

Engineers:
- Interpret and decompose requirements
- Conduct trade studies
- Develop design & implementation strategies
- Provide verification
- Participate in validation

Systems Engineer:
- Manages requirements
- Implements supporting processes
- Establishes entrance/exit criteria for technical reviews
- Maintains the V&V Matrix

SOFIA SE Lessons Learned

"Better is the enemy of good enough"

- Engineers want to know what are the minimum requirements so they can meet them
- Scientists want the best they can get with no constraints: "*Good enough is the enemy of the great*"

Systems Engineering is an Optimization Process

- Too little or too much SE causes problems
  - SE must be “value added”
- When addressing SE&I in the middle of a Program, there is never enough time, resources, and budget to complete all processes
  - SE priorities must be developed and documented but also must fit within the overall Program/Project priorities
- SOFIA used the Risk Management process to understand and accept the risks of “deliberately” leaving some things out due to schedule and budget realities

Requirements Management

Mike Brignola

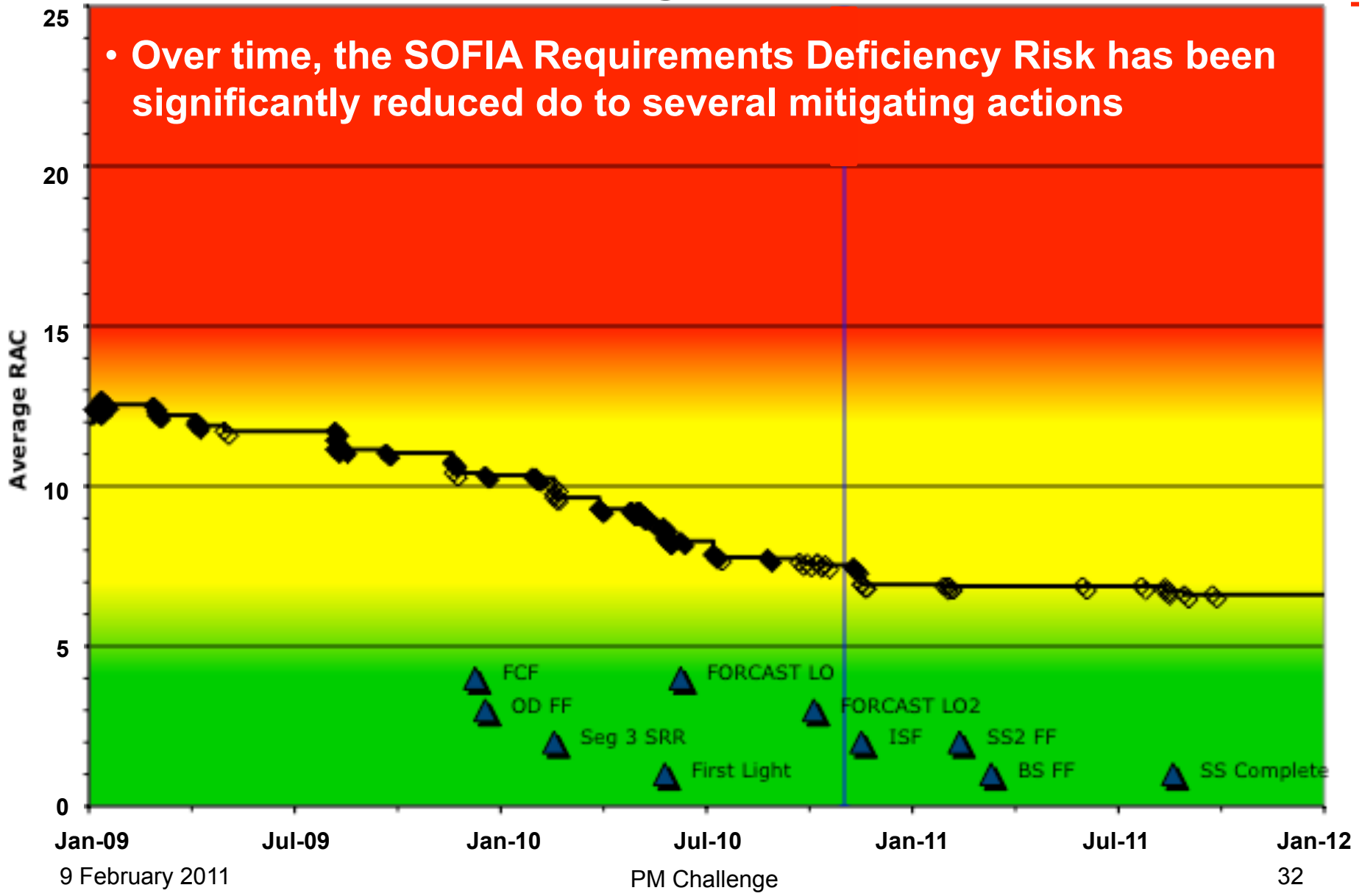
Making the "Lack of Requirements Definition" a Program risk, is an effective way to highlight and address the problem

- This allowed the Program Management to establish a long-term mitigation strategy to drive down the risk
- SOFIA Management made a long-term commitment to correcting requirements deficiencies

Requirements Deficiency Risk Mitigating Actions

1. Develop **SE plan and process** to audit, develop, and manage requirements. Implement early with adequate staff
   - Utilize Product/Specification Tree to facilitate communication
   - Utilize RM Database tool to manage 4000 requirements, trace and allocate
2. Establishing a NASA **Requirements Manager** with broad systems knowledge to bridge stovepipes
   - NASA is now managing and controlling the requirements
   - Keep management informed, elevate issues, status reporting
3. Establish frequent **technical interchange meetings** to ensure requirements definition and coordination
4. Prioritize and baseline **near-term requirements** for "Early Science"
5. Establish an Observatory **Integration IPT** to coordinate V&V planning and execution between the two projects, the science instrument teams, and the international partner
6. Complete Early Science Observatory **V&V Plan**
7. Complete **long-term requirements** for final SOFIA configuration (including ICDs, Specs, and Verification/Validation plans) **(On-going)**

Requirements Deficiency Risk Mitigation Waterfall



SOFIA SE Lessons Learned

Phasing system development has bought time to establish a significantly improved set of "final" requirements

- Valuable experience was gained accomplishing the "Early Science" Phase that will greatly benefit the final SOFIA system design

Benefits of Phasing Development on SOFIA Requirements

- The “final” SOFIA system requirements will benefit from the knowledge gained during Early Science
  - The “near-term” requirements for meeting the “Early Science” goals were less stringent but still challenging
  - Several issues with requirements definitions had to be resolved for Early Science
    - Identified gaps and misunderstandings in requirements
  - SOFIA employed an “Agile Development” process (frequent iterations with collaborative feedback) to deal with these issues
    - Some degree of product rework was tolerated or procedural “work arounds” were employed to meet Customer expectations
  - The development team gained valuable experience
- Phasing allowed valuable time to refine the Product Tree and systematically review “final” requirements

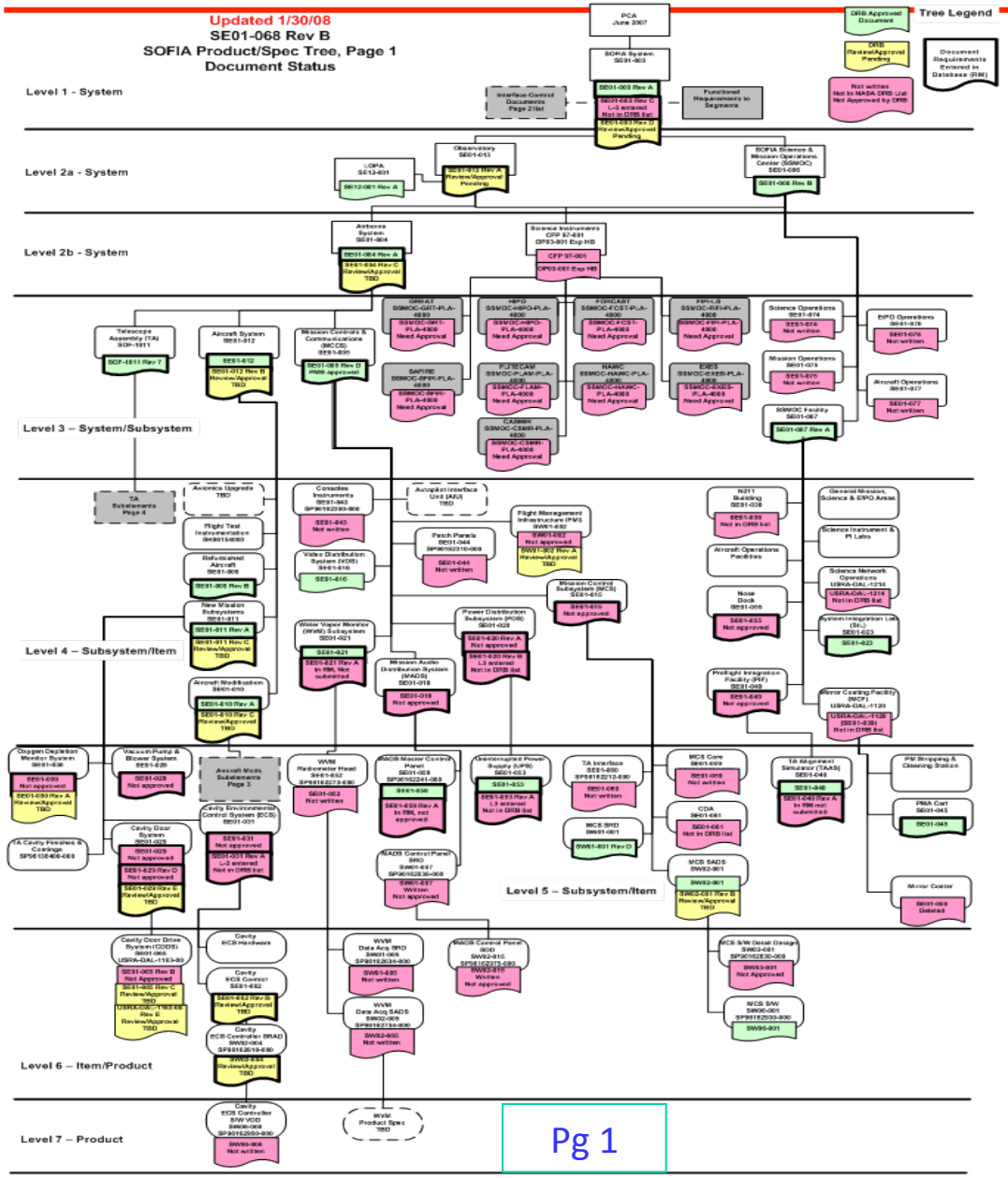
It takes time to become knowledgeable enough of complex systems to effectively develop "good" requirements

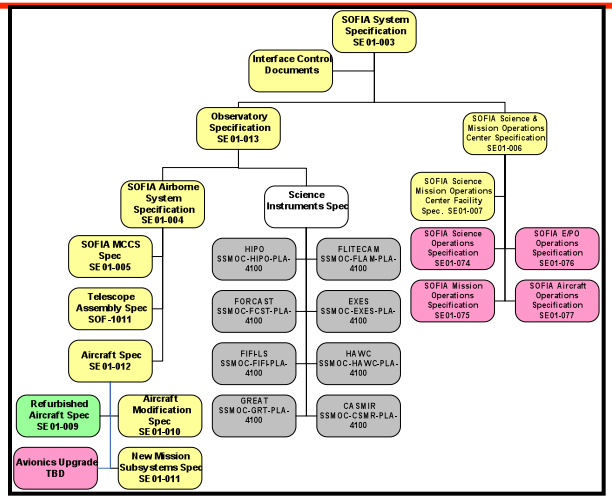
- It took the new Program team a significant period of time to become proficient with the complex SOFIA systems
  - This knowledge is critical to being effective at requirement decomposing and establishing good traceability

Having a comprehensive specification/product tree (and ICD list) is critical to system integration

- At transition, SOFIA had to deal with new “observatory-level” requirements that were inserted to address missing overall system performance values

SOFIA Spec Tree
Rev B 2008 Baseline





Compare to May 2007
Original Spec Tree Rev A

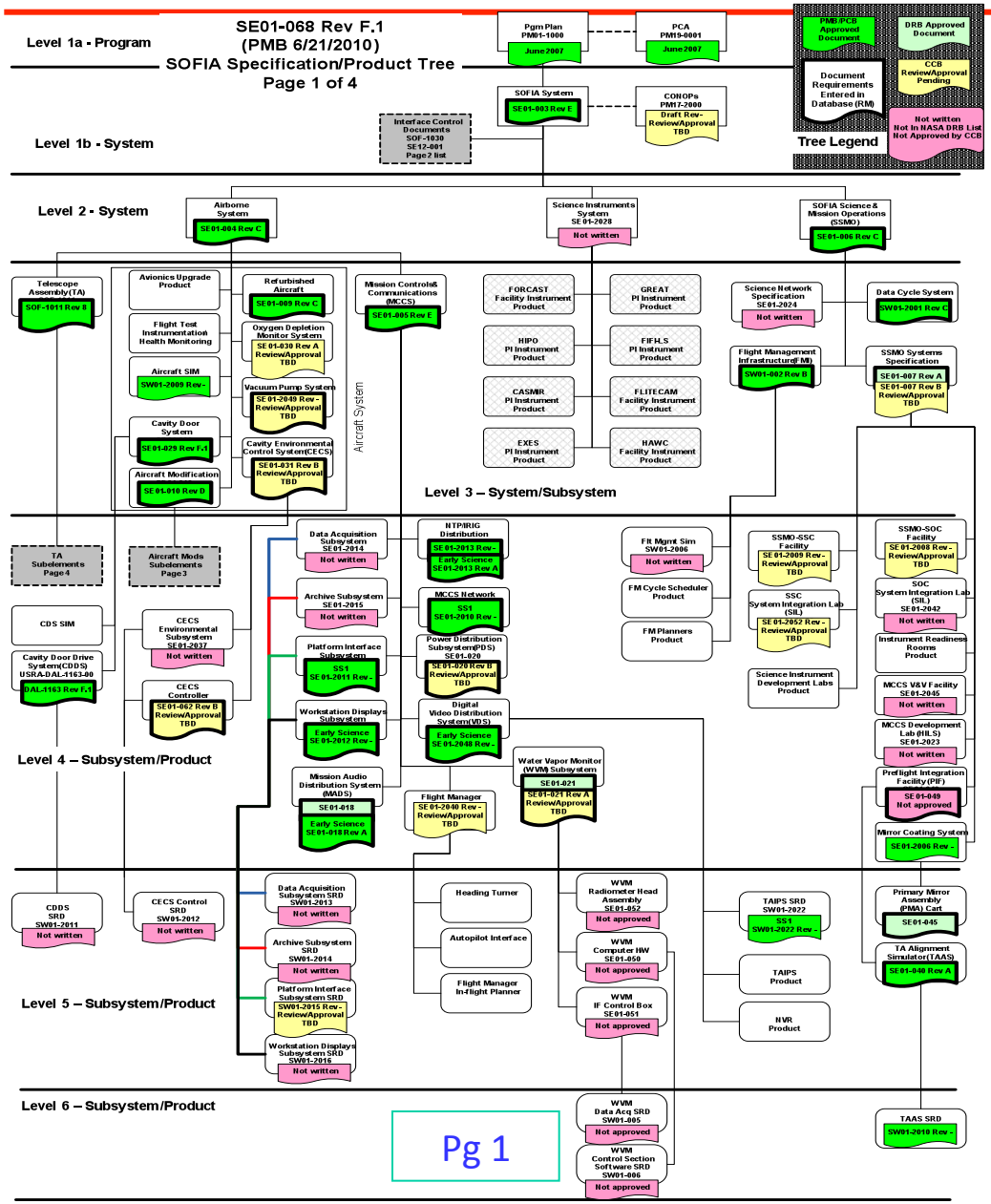
Summer 2007 goal - top 4 specs approval

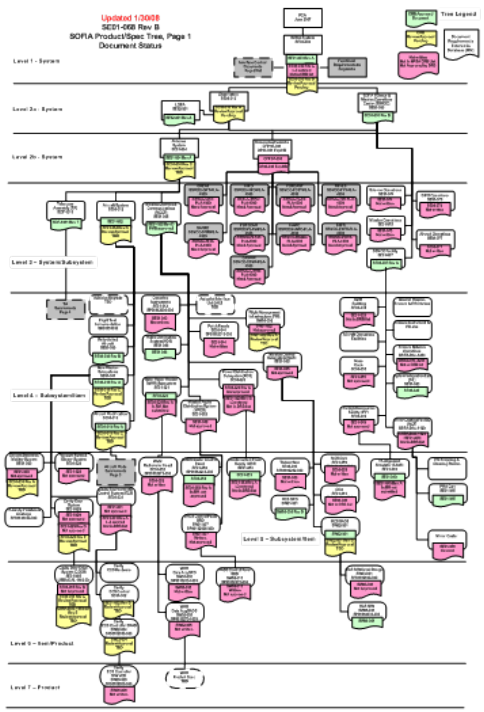
SE01-003 (SOFIA), SE01-013 (Observatory), SE01-004 (Aircraft), SE01-005 (MCCS)

✓ *Top 4 specs have been program reviewed through delta SRR, MCCS Redesign, SOLIPT, SE&I and Program assessments*

Yellow – Revision in work
Red – Not written or not approved
Green - Approved

Current Rev F Spec Tree 2010





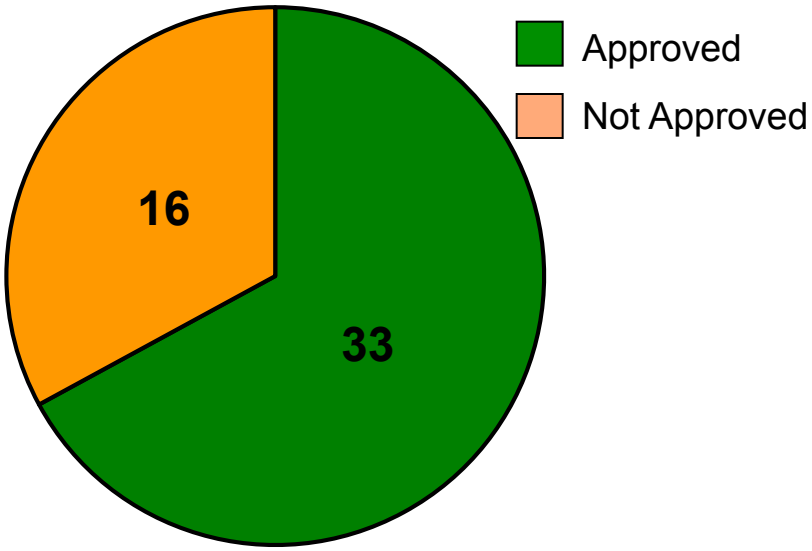
Compare to 2008 Baselined Spec Tree

Between Jul 2007 & Dec 2010:
Program + SE&I reviewed 30 Specification Documents, containing over 3000 requirements

Forums: Delta SRRs, Design Reviews, IPTs, SE&I, and system assessments

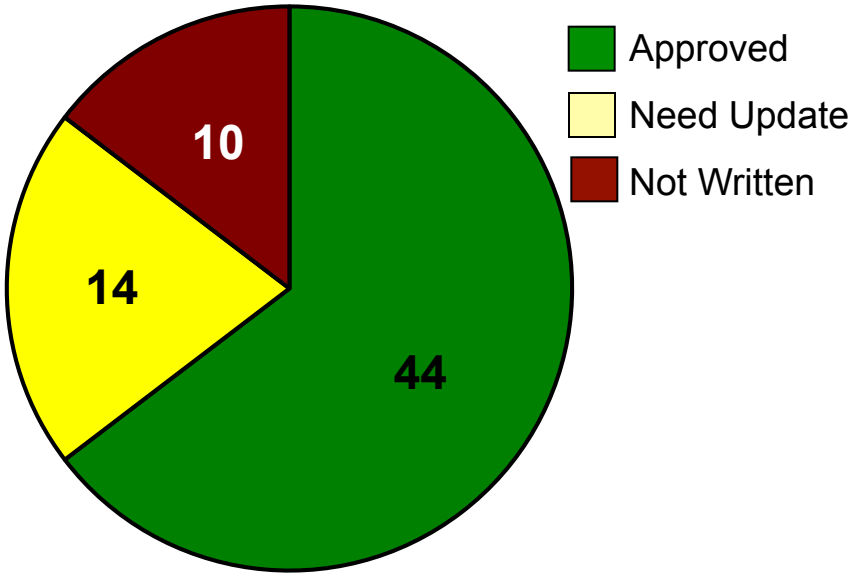
SOFIA Interface Control Document Status History

ICDs July 2007



49 Total ICD's

ICDs Dec 2010



68 Total ICD's

Summer 2007 goal:

- Identify and list all SOFIA ICDs
- Establish initial status and ownership

Between Jul 2007 & Dec 2010:

- Several new ICDs identified
- Several key ICDs completed or updated

Requirements Management Challenges

- Availability of key personnel and conflicting priorities
  - Planners = owners = implementers = testers (all the same person)
- Requirements creep due to lack of complete/baselined requirements or well defined interfaces
- Traceability of design requirements completion status to V&V test plans/results
  - Lack of overarching program guidance and integrated test plans (No program integration office)
- Although SOFIA has made a significant amount of progress, a lot remains to get done
  - Delta system level SRRs are on-going
  - Striving for more formality in Segment 3 (final build)

Configuration Management, Data Management and Related Topics

Laura Fobel

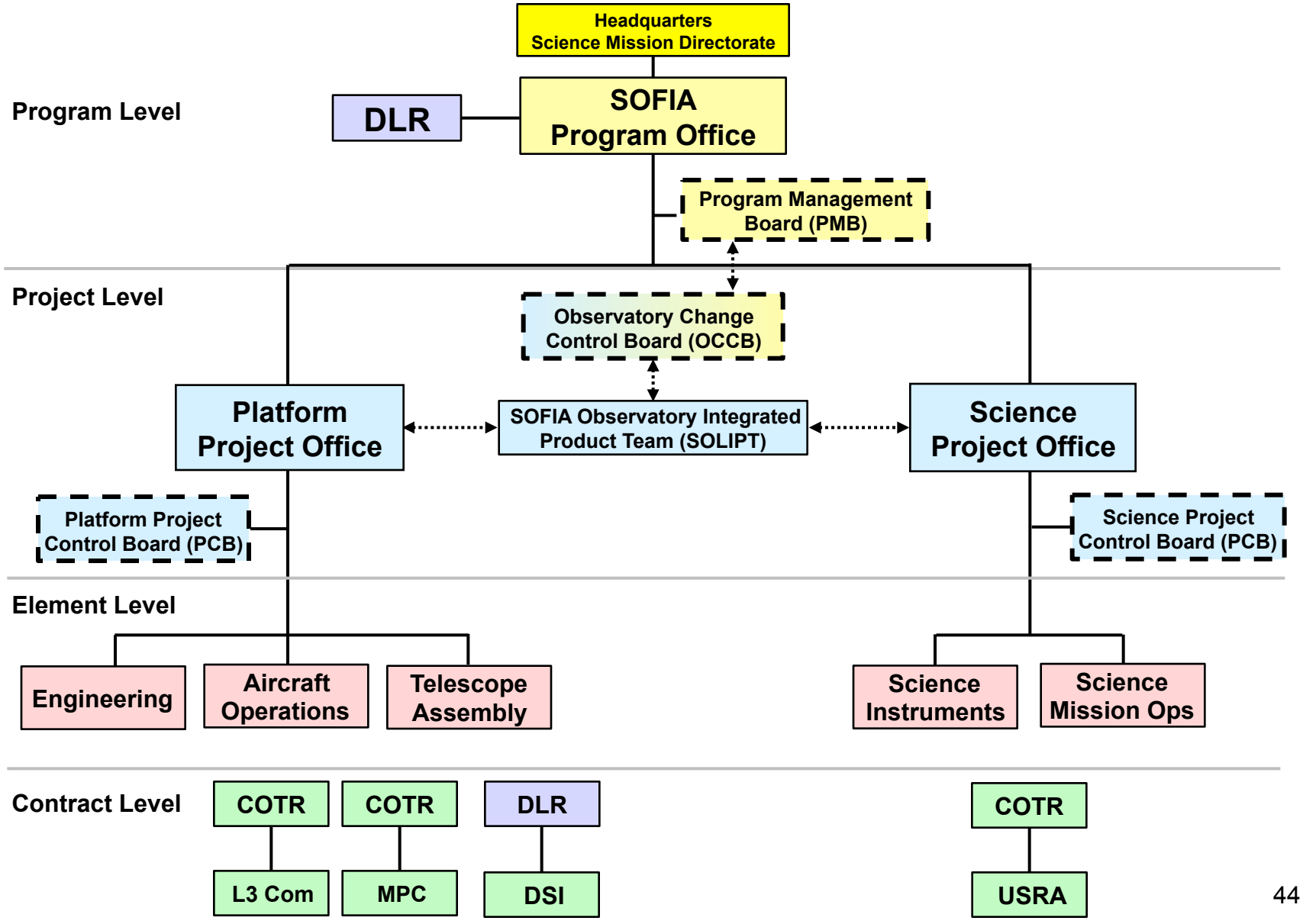
SOFIA SE Lessons Learned

To improve CM process efficiency, delegate CM responsibilities to the lowest level possible

The Delegation of Configuration Management (CM) Authority

- SOFIA developed a hierarchy of CM Boards to drive CM authority down to the lowest appropriate level
  - Improves efficiency by distributing the work load
  - CM hierarchy parallels the product hierarchy
- Over time SOFIA's CM needs changed
  - Initially a single CM Board may have made sense on SOFIA
  - As development work expanded and system complexity grew, a more distributed CM process was needed
- SOFIA established a separate Control Board to manage the "Observatory" configuration
  - Includes Program, Platform and Science Project members
  - Focuses on configuration management of the "integrated system" and related discrepancies

The Delegation of CM Authority on SOFIA

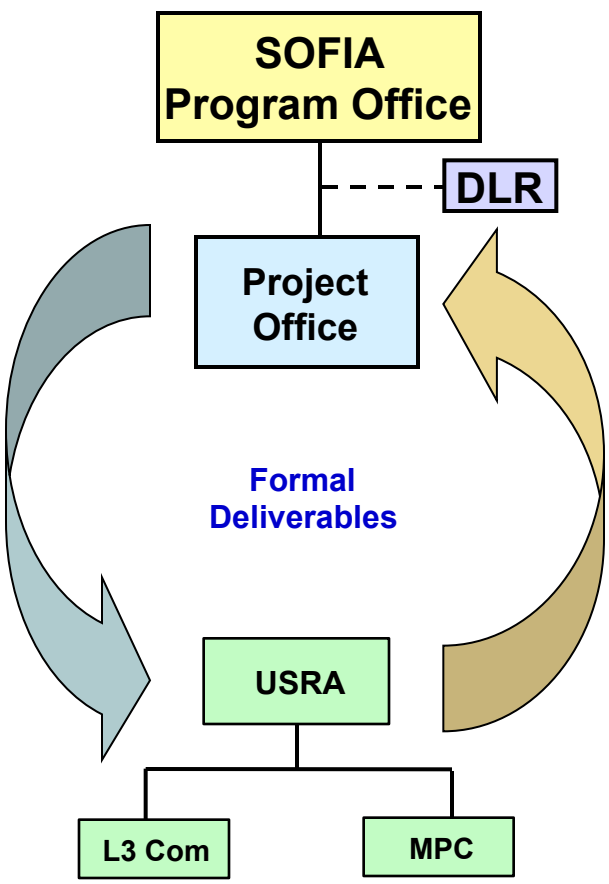


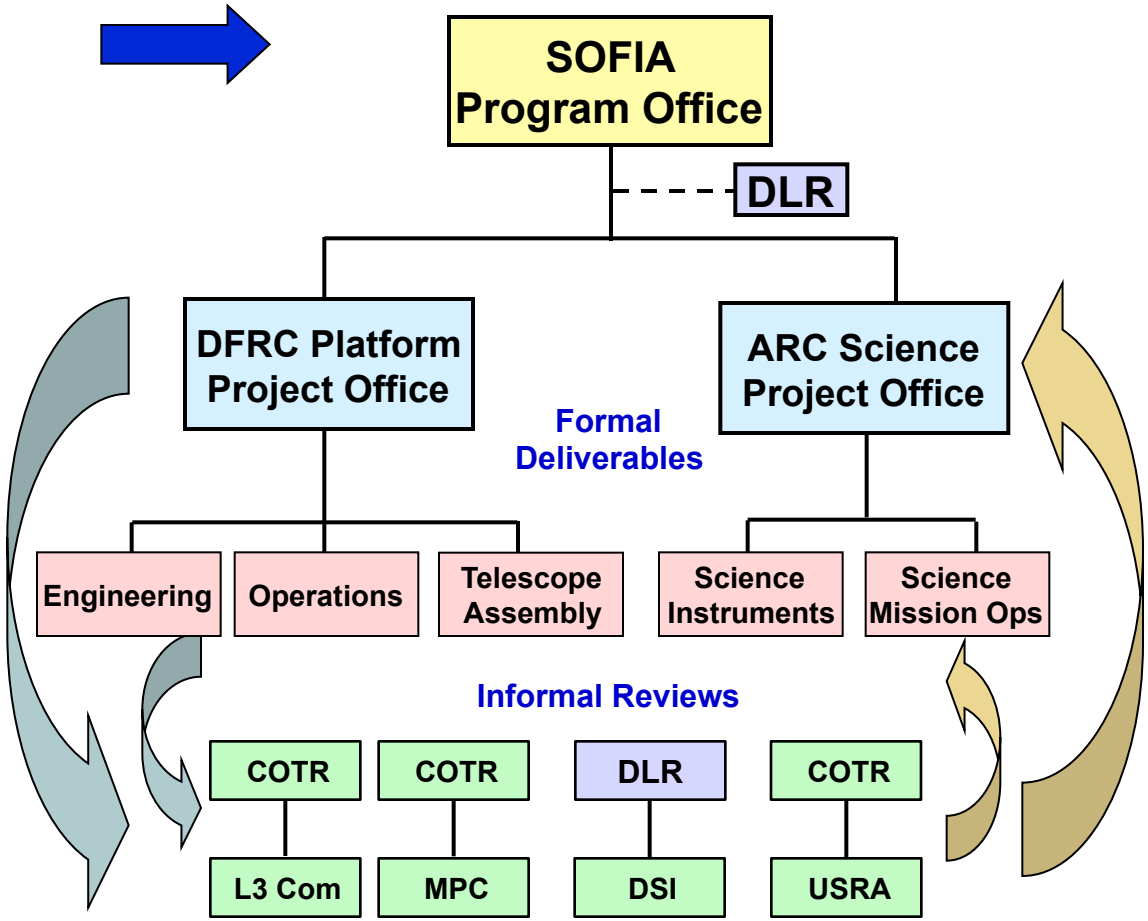
Informal collaboration with contractors improves the probability of success of formal deliverables

- The distributed CM process facilitated more collaboration with contractors

Informal Collaboration Improves Probability of Success

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





Previous Organization

Restructured Organization

The Value of Informal Collaboration

- Too much back-and-forth over the fence is inefficient
  - A significant amount of rework occurred when not enough informal collaboration occurred with the contractors
- It's important to establish a cooperative environment with contractors
  - SOFIA applied an "agile development" process by allowing informal software builds to be delivered early in the development process to flush-out problems prior to formal deliveries
    - Collaboration occurred at the lower levels and included stakeholders
    - Deliverables still went through the formal acceptance process to be baselined

SOFIA SE Lessons Learned

On SOFIA it was beneficial to have a problem reporting process that spanned informal development activities and formal acceptance testing

The Value of Problem Reporting and Discrepancy Resolution

- By establishing a Problem Reporting system early (during informal software testing) issues were identified and resolved sooner (prior to formal delivery)
  - Allowed customers to capture issues and collaborate with developers to understand and refine formal requirements
  - Supported the “Agile Development” process
- The Observatory-level control board allowed cross-Project issues to be identified and resolved jointly
  - Chaired by the Program Chief Engineer
    - Provided independent authority
  - Established priorities and assignments to Projects for resolving integration issues
  - Facilitated communication of issues and their resolution

SOFIA SE Lessons Learned

The lack of a carefully designed Data Management systems hinders effective communication and collaboration

- SOFIA team members had a difficult time finding the information they needed
  - Old and obsolete data mixed with relevant data contributed to the problem

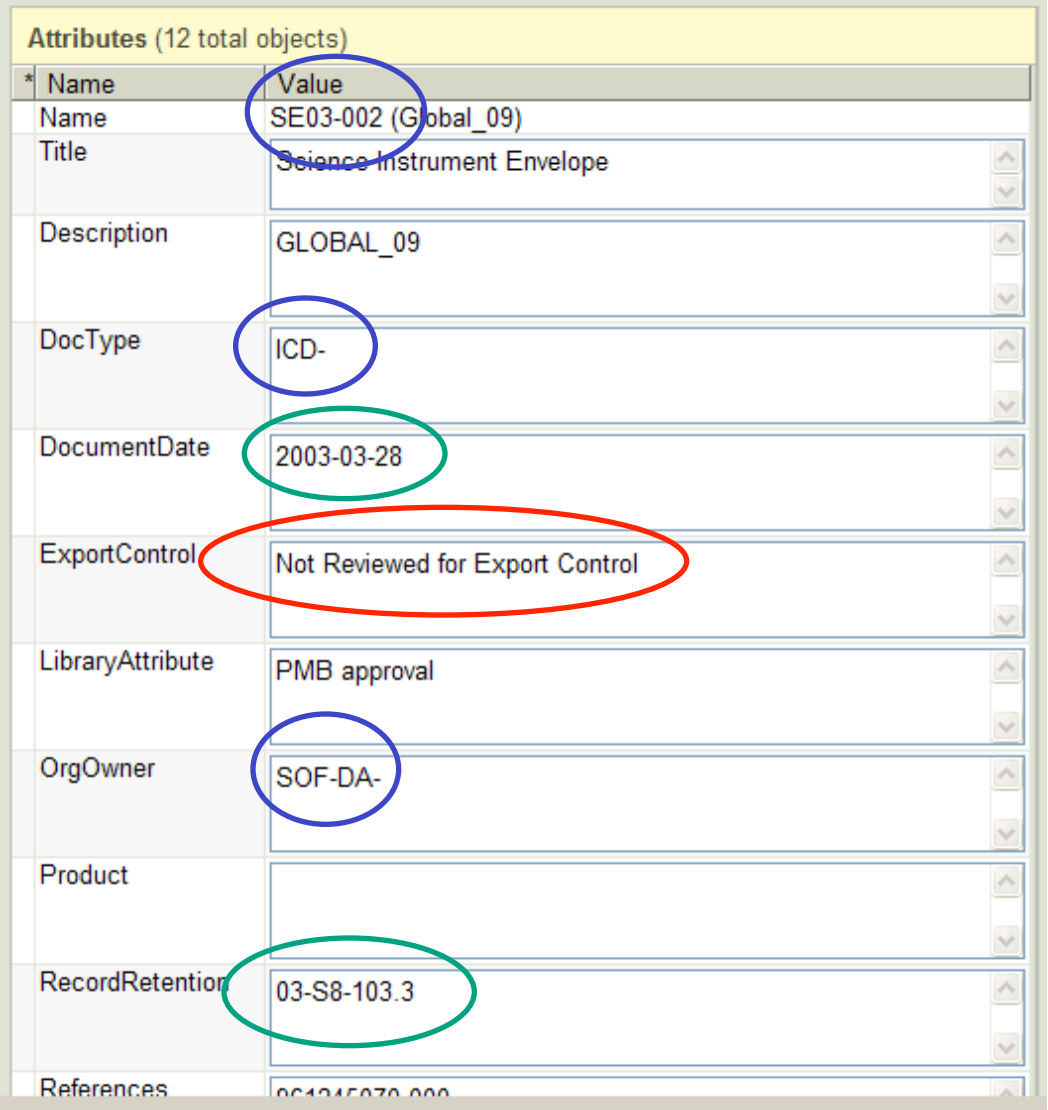
SOFIA Data Management Improvements

- Established a central repository to improve control and management of the data originating from various sources
  - Reorganized the data and archived obsolete documents
- Defined data attributes for each document
  - Product ID
  - Data retention
  - Owner
  - Descriptive search keywords
  - Document number
  - Export control
  - CM authority
- Considered Configuration Management, Data Management, Export Control, Records Retention, and Data Access as part of one integrated process

SOFIA Sample Records Retention Schedule

(SOF-1017 Category) Record Type	NPR 1441.D Schedule - Item Number	Windchill - Record Retention Number	Records (NPR 1441.1D defined or SOFIA defined)	Records Location	Retention Authority
<01> Program and Project Management (PM)					
Management Plans	Sch.8 - 101	01-S8-101.1	Program Plan; Project Plan; Systems Engineering Management Plan (SEMP); Configuration Management Plan; Manufacturing and Assembly Plans; Parameter Control; Electromagnetic Interference and Compatibility Control; Fracture Control/Damage Tolerance; Support Equipment; Education and Public Outreach; Continuous Improvement/Preplanned Product Improvement; Observatory Certification; SOFIA Observatory Integration Plan; System and Subsystem Integration Plans; Aircraft System Flight Test; SOFIA Observatory Ground Test; SOFIA Observatory Flight Test; SOFIA Science and Mission Operations; SOFIA Science and Mission Operations; New Technology Reporting; Training Plans; Software Management Plans; Software Development Plans; Safety, Reliability and Mission Assurance Plans; Environmental, Safety and Health Plan, Integrated Logistics Support Plans; Data Management Plan; Mission Statements; Operations Concept	Held at office of record (ARC: N211-Room 320)	101 - Permanent Record. 3-year blocks cutoff for long term programs. Can transfer to National Archives 7 years after cutoff.
Agreements, Understandings and Approvals	Sch.8 - 101	01-S8-101.2	Partnering Agreements; Memorandums of Understanding; Memorandums of Agreements; Program Commitments; Authorization/Approval Documents		
Schedules	Sch.8 - 101	01-S8-101.3	Program Milestones; Project Milestones; Schedules; Integrated Master Schedule		
Budget and Finance	Sch.8 - 101	01-S8-101.4	Work Breakdown Structure and Dictionary; Budget and Cost Data; Estimates of budget and schedule options		
Configuration Management	Sch.8 - 101	01-S8-101.5	Configuration Management Board (CCB) Agendas, Minutes and Review Material; Configuration Change Requests; Discrepancy Reports; System Test Reports; Waivers		
Risk Management	Sch.8 - 103	01-S8-103.6	Risk Management Board (RMB) Agendas. Minutes and Review Material; Risk Lists		

Sample SOFIA Document Attributes



Attributes (12 total objects)

* Name	Value
Name	SE03-002 (Global_09)
Title	Science Instrument Envelope
Description	GLOBAL_09
DocType	ICD-
DocumentDate	2003-03-28
ExportControl	Not Reviewed for Export Control
LibraryAttribute	PMB approval
OrgOwner	SOF-DA-
Product	
RecordRetention	03-S8-103.3
References	

File attributes facilitate Data Management, Export Control, Access Control and Records Retention processes.

- Data Management (Document Name): SOF-DA-ICD-SE03-002
- Export Control/Access Control: "Not Reviewed for Export Control"
- Records Retention: Date (2003-03-28) and Records Retention Schedule reference (03-S8-103.3)

SOFIA CM and DM Remaining Challenges

- Establishing ownership and control of all SOFIA documents and drawings
  - Contractors still own important information like “models”
- Shortcomings of the Data Management System
  - Search engine and user interface complexity
  - User familiarity
  - Data access by Foreign Nationals
- Catching up with Export Control and Records Retention attribute labeling

SOFIA SE&I Summary

Ron Ray

Management must set the cultural tone for the importance of SE on a Program/Project

- The commitment the SOFIA Management Team has made to SE has helped turn around the once “troubled” Program

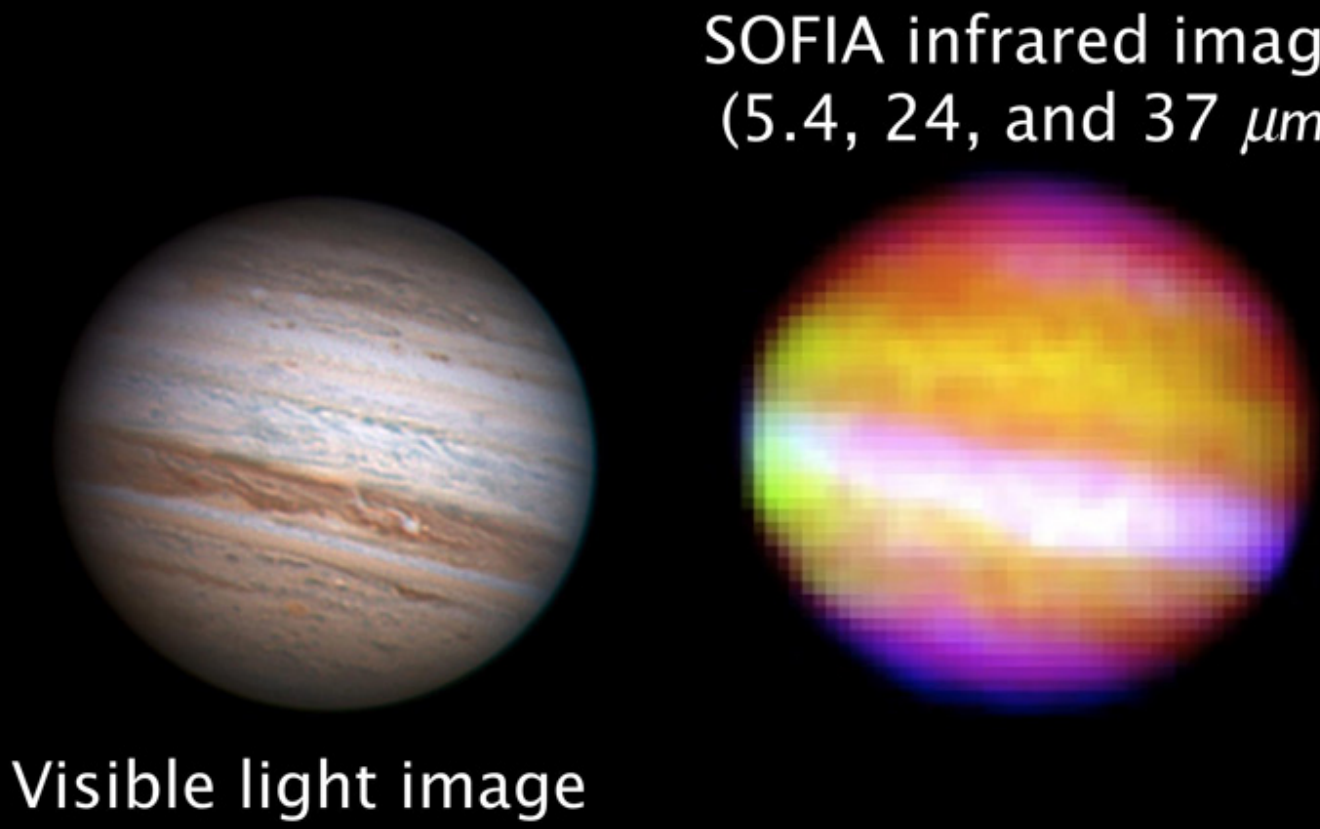
SOFIA Program Documentation
Status as of: 12/03/2010

	General Program/Project Documentation	Science Project	Platform Project	SOFIA Program
1	Program/Project Plan	Baseline	Baseline	Baseline/Rev
2	Systems Eng. Management Plan (SEMP)			Rev A
3	Configuration Management Plan (CMP)	Baseline	Rev A/Updating	Rev 3/Rev
4	Risk Management Plan (RMP)			Rev B
5	IT Management Plan			In Review
6	Data Management Plan (DMP)	Baseline		Baseline
7	Export Control Plan			85%/Dec
8	Safety and Mission Assurance Plan (SMA)	Rev B		Baseline
9	System Safety Plan		Baseline	Baseline
10	Reliability & Maintainability Plan (R&M)			In Review
11	Mishap Response Plan			Rev A
12	Quality Assurance Plan		Baseline	
13	Software Development Plan		Baseline	
14	Software Management Plan	Rev A		
15	Software Assurance Plan	Baseline	Baseline	
16	Platform Project IT Security Plan		Baseline	
17	Concept of Operations			In Work
19	Work Breakdown Structure (WBS)			Rev B
20	Lexicon (SOFIA glossary)			Rev 6.6
21	Supplier Statement of Requirements (SSOR)		Baseline	
22	Integrated Master Schedule (IMS)	New Baseline	New Baseline	New Baseline
23	Level 1 & 2 Milestones	New Baseline	New Baseline	Rev E
25	Risk List	Baseline	Baseline	Rev H

Legend			
	Complete	Open, On-going	In Review
	New/Change Status	Program Issue	Impacts Schedule

SOFIA First Light Image

May 16th 2010

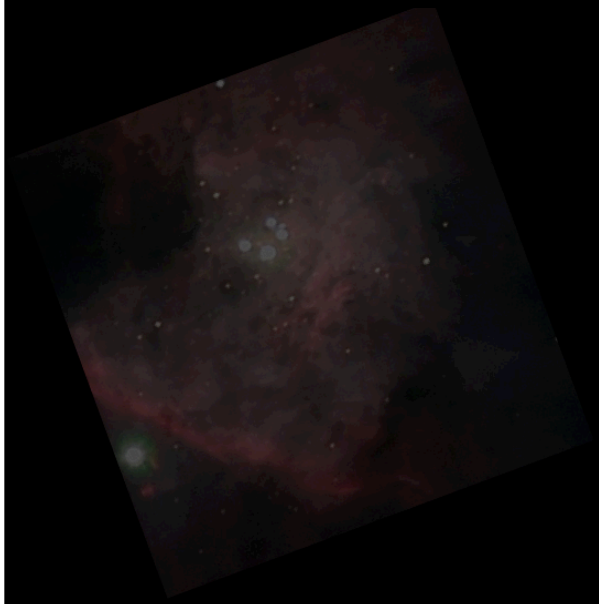


- SOFIA is beginning to produce outstanding science data at a fraction of the cost of comparable space based observatories

http://www.nasa.gov/mission_pages/SOFIA/

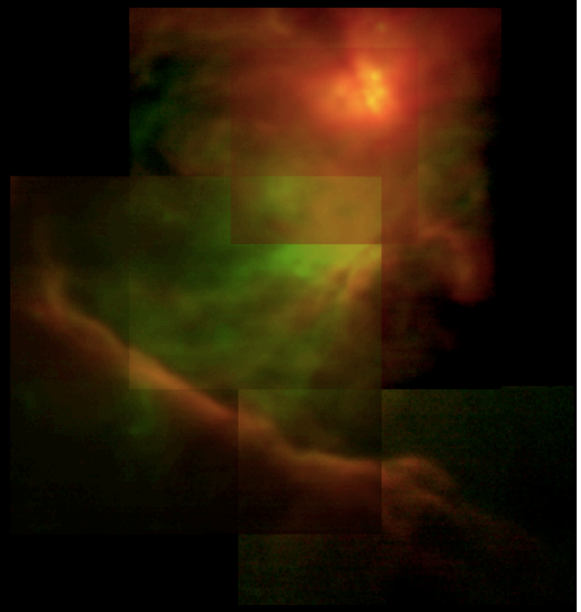
SOFIA First Science Image

Dec 1st 2010



Visible light
(ground-based)

Near infrared (ESO VLT)



SOFIA (FORCAST)

- Image of the Orion star-formation region obtained by SOFIA compared to images obtained from ground-based telescopes

http://www.dlr.de/DesktopDefault.aspx/tabid-1/117_read-28014/

Concluding Message

- After almost being cancelled and a major Program structure change, the SOFIA Program operated at Risk with known Systems Engineering deficiencies
- Several important strategies were employed to mitigate the risk
  - Established a new incremental life-cycle to complete system development
  - Worked more collaboratively
  - Systematically rebuilt SE&I along the way
    - Provided adequate staffing and priority
  - Made correcting requirements deficiencies a high-priority
  - Distributed CM authority
  - Tracked and status SE Progress
- SOFIA has used Risk Management effectively to compensate for Systems Engineering deficiencies

Summary of SE Lessons Learned

- It is never too late to fix Systems Engineering (SE) deficiencies
- Breaking complex development activities into increments can improve the overall chance of success
- Management needs clear insight on the status of SE products
- SE must account for and tailor to various Center and cultural differences
- “Better is the enemy of good enough”

Summary of SE Lessons Learned

- Making the "Lack of Requirements Definition" a Program risk, is an effective way to highlight and address the problem
- Phasing system development has bought time to establish a significantly improved set of "final" requirements
- It takes time to become knowledgeable enough of complex systems to effectively develop "good" requirements
- Having a comprehensive specification/product tree (and ICD list) is critical to system integration

Summary of SE Lessons Learned

- To improve CM process efficiency, delegate CM responsibilities to the lowest level possible
- Informal collaboration with contractors improves the probability of success of formal deliverables
- On SOFIA it was beneficial to have a problem reporting process that spanned informal development activities and formal acceptance testing
- The lack of a carefully designed Data Management systems hinders effective communication and collaboration
- Management must set the cultural tone for the importance of SE on a Program/Project