



Stratospheric Observatory For Infrared Astronomy (SOFIA)

Presented by

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Outline

- SOFIA Description
- Progress Highlights
- Observatory Photo Update
- Instrument Program Update
- Data Cycle System Status
- Schedule and Budget Summary

SOFIA



SOFIA Description



Salient Features

- 2.5-meter, airborne telescope optimized for mid- to far-IR observations, mounted in 747SP
- Access to full spectral range from 0.3 to 1600 μm
- Range covered by numerous state-of-the-art focal plane instruments
- Stratospheric operation for over 6 hours per mission, 960 observing hours per year
- Diffraction limited beyond 10-15 microns
- Deployable for all-sky/opportunity coverage



Implementation Characteristics

- Cooperative 25-year program with Germany under formal MOU
 - U.S.: Aircraft modification, onboard mission control system, ground support system, integration, FAA Certification, 80% of operations
 - Germany: Telescope Assembly, support for integration, 20% of operations
 - U.S. and Germany share telescope time in same proportion – 80:20
- Single prime contract for U.S. development and operations as a GOCO facility
- Science-led development and operations: prime contractor is USRA
 - Operations out of Moffett Field, CA, as proposed by USRA team
- Lead NASA Center: Ames Research Center

SOFIA Team

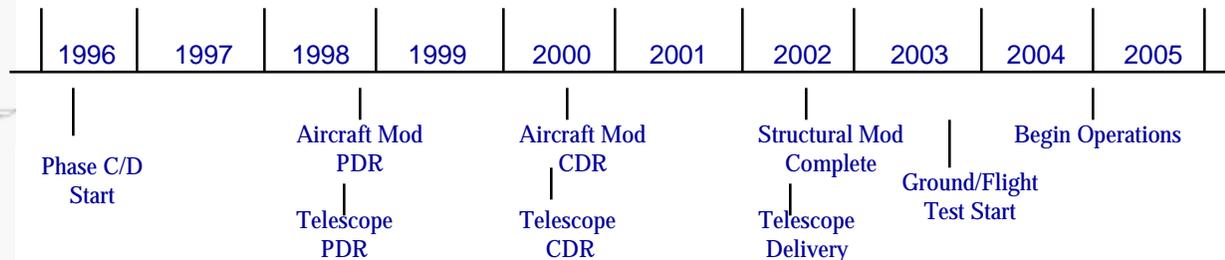
- USRA: Project management; science operations, software development, sys. admin.
 - Raytheon AIS – Waco: aircraft modification, MCCS, integration
 - United Airlines: aircraft operations
 - NASA Ames Research Center: work products (airfield operations, SSMOC, cavity door design/dev., science products)
 - SASP Alliance: education & public outreach
 - University of California: science support
- Telescope Consortium
 - MAN Technologie - Mainz (MT-I): general project management and systems engineering; suspension assembly; inertial pointing control system; secondary mechanism
 - MAN Technologie - Augsburg (MT-A): Nasmyth tube/metering structure; primary mirror cell; integration facility
 - Kayser-Threde - Munich: Optics, cameras, tracking subsystem, electronics and software
 - REOSC: Primary and Tertiary mirrors
 - Astrium: Secondary mirror

PCA: Level 1 Requirements

Requirement	Status
• Effective aperture dia.: 2.5 m	OK
• Elevation range: 20 - 60 deg.	OK
• Wavelength range: 0.3 - 1600 microns	OK
• Image size:* (including telescope jitter but not shear layer seeing)	OK
5.3 arcsec – D(80%) first science flight	
1.6 arcsec – D(80%) first science flight light plus 3 years	OK
• Operations capability: 6 hours at/above 41 kft	OK
• Operations capability: Cabin access to SIs	OK
• Operations capability: 40 PI/GI teams/year	OK
• Operations: 960 hours/yr starting in year 4	OK

*Proposed single requirement replacing both image quality and pointing jitter as recommended by the SOFIA EIRR

Major Program Milestones (CY)



Progress highlights over past 6 months

- Program
 - Rebaseline completed
 - Independent Management Review conducted; recommendations implemented: *Fly it then tune it*
 - Extra reserves created in FY02 & 03 with HQ help
- Telescope
 - Primary, secondary, and tertiary mirrors accepted
 - Structures manufacturing complete
 - Telescope integration underway
- Aircraft/Observatory
 - Aircraft systems fabrication over 50% complete
 - SSMOC hangar modification essentially complete
 - Mirror coating system delivered
- Instruments
 - AIREAS Assessment Review held; AIREAS cancelled
 - Instruments prioritized by SOFIA Science Council
 - Quarterly instrument reviews implemented

Progress photo gallery

Aircraft modification progress



Forward bulkhead assembly



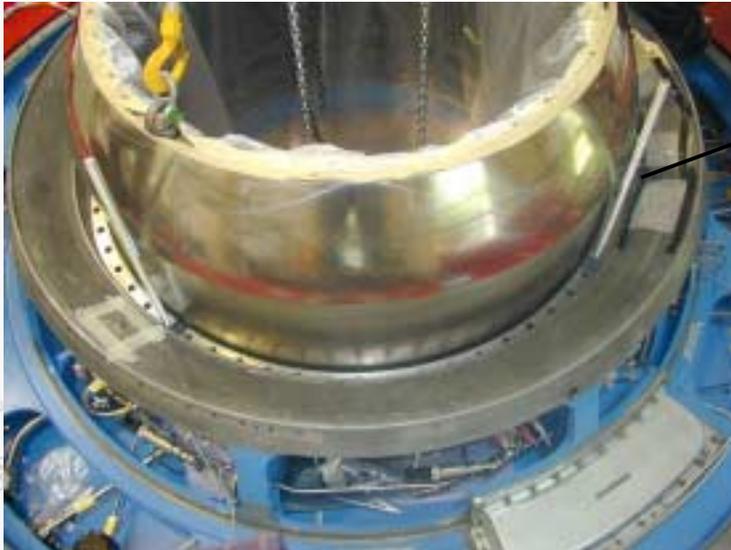
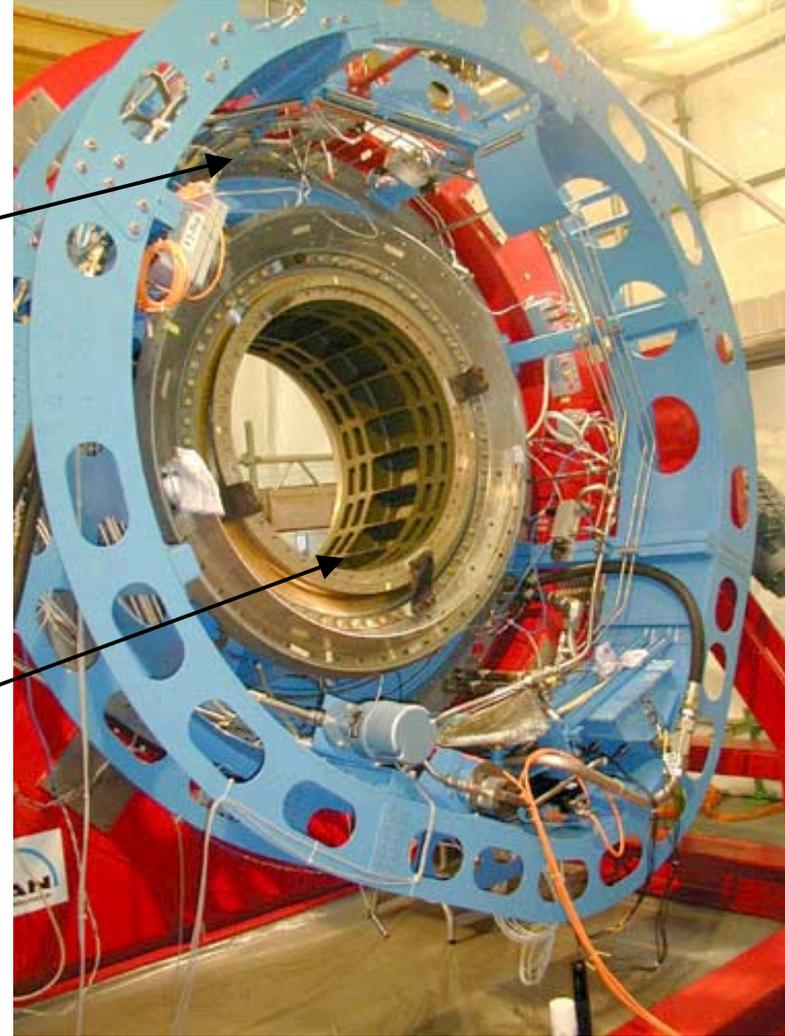
Aft bulkhead installation



Mirror coating facility vacuum vessel

Progress photos (cont'd)

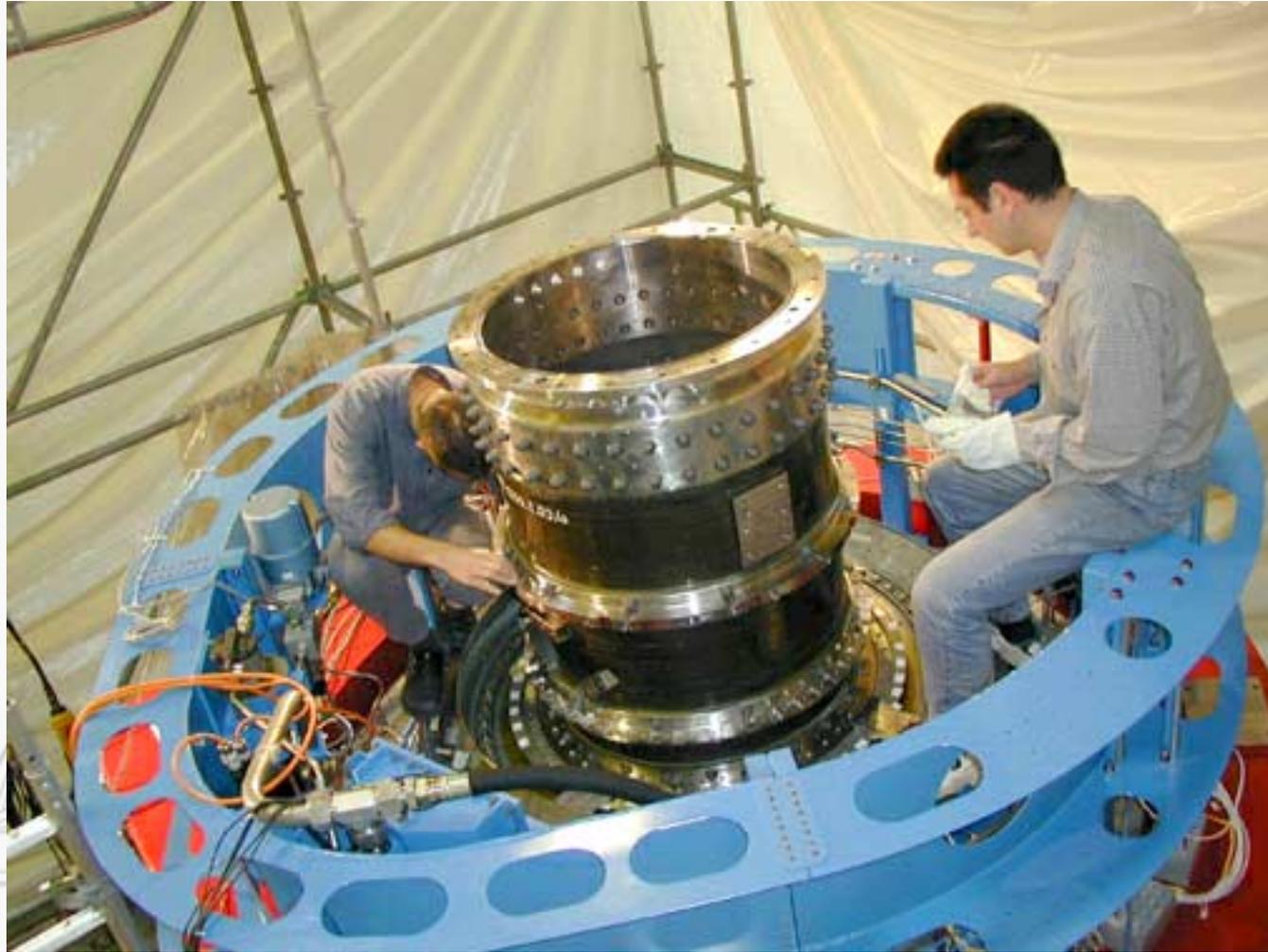
TA Suspension & Bearing Assemblies



Cabin Side

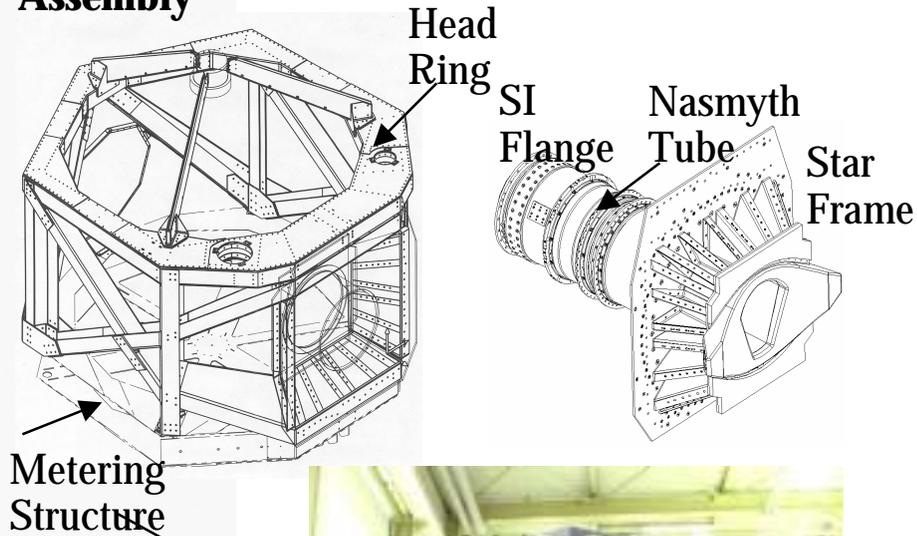
Progress photos (cont'd)

**Cabin side of Suspension Assembly with
Nasmyth Tube installed**



Progress photos (cont'd)

Telescope Structural Assembly



Nasmyth Tube Assembly

SOFIA



A NASA
Origins
Mission

Progress photos (cont'd)

Aircraft modification progress



Progress photos (cont'd)

Aircraft modification progress



747SP belly skin
removal and installation

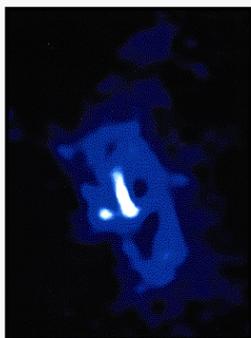
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SOFIA Science

- Uniqueness: Only SOFIA opens the entire visible-to-millimeter spectrum
- Versatility: High resolution, good sensitivity, and long life make SOFIA a versatile Origins observatory

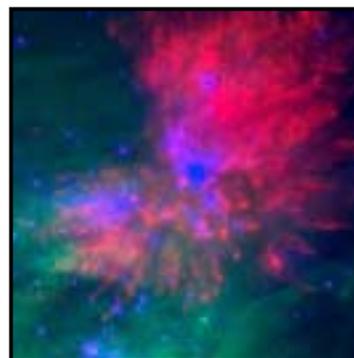
Black Hole in Galactic center:



Ring of matter in galactic center

- How fast does matter fall in?
- How much energy is released?
- How does our galactic center compare to Active Galactic Nuclei?

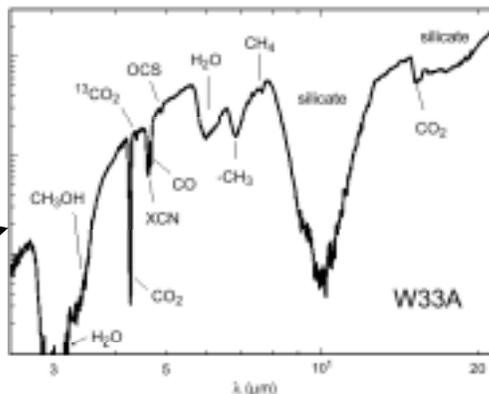
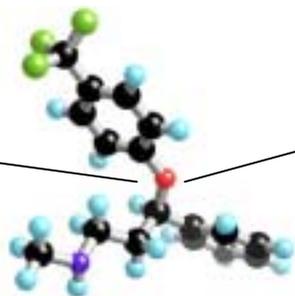
Star and Solar System Births:



Young stars and jets in Orion seen by HST/NICMOS

- Dynamics of protostar mass infall & outflow; Observe protostars at peak wavelengths
- Disk evolution and planet formation

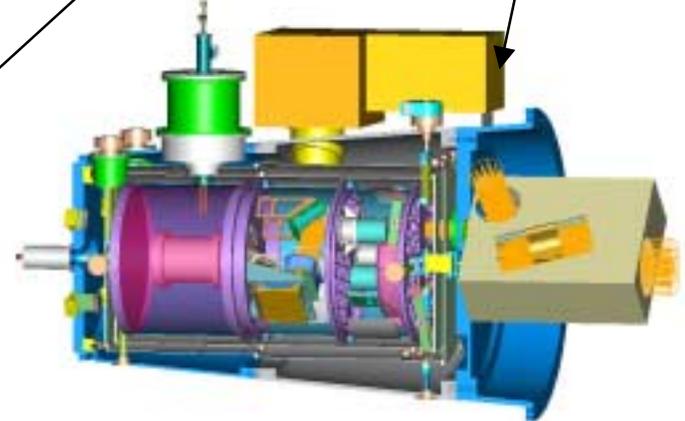
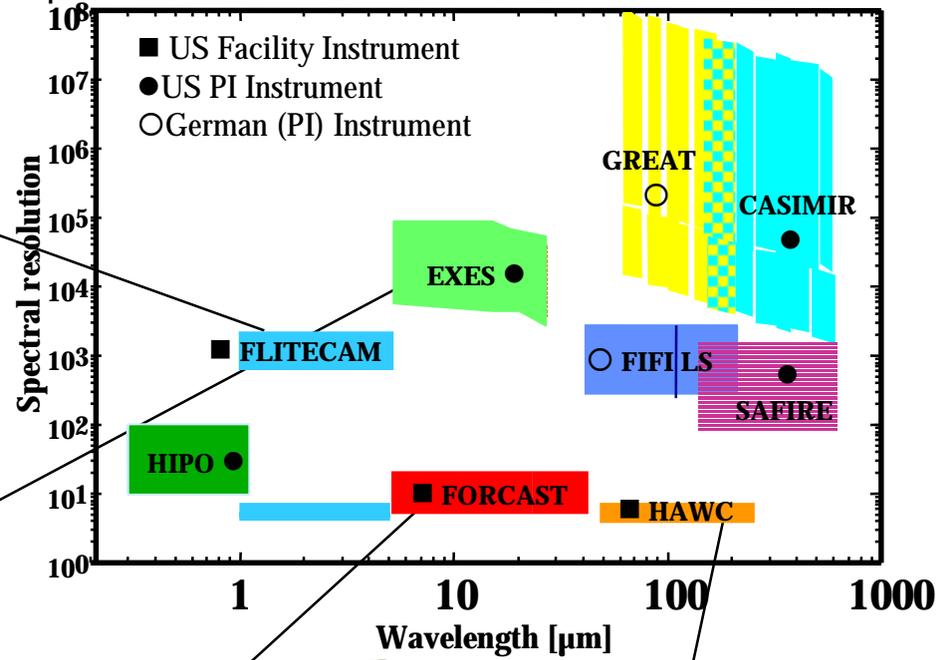
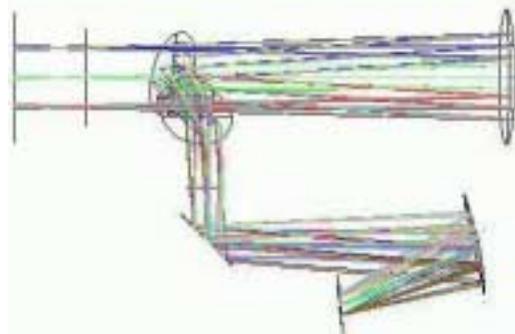
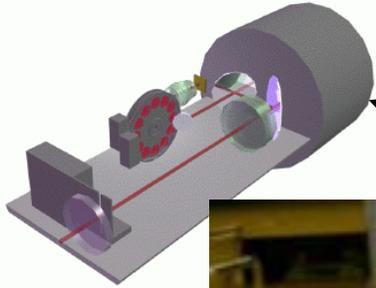
Evolution of Organic Matter in the Interstellar Medium:



- Only SOFIA will provide high-resolution 5-10 μ m spectroscopy needed to see evolution of organic matter from the ISM to protostellar environments

First-Generation SOFIA Instruments

- SOFIA Instruments are making good technical progress
 - All 3 facility instrument CDRs successfully completed
 - Many High-risk technology components fabricated



SOFIA



A NASA
Origins
Mission

Instrument Program Update

- AIRES assessment review held 28-29 June. Chartered by USRA and ARC, chaired by R. Joseph.
- Joseph committee recommended AIRES cancellation. Accepted by USRA (and SSC, SOFIA program, and NASA HQ). AIRES funding terminated.
- Discussed IMR-suggested science instrument phasing plan extensively with SSSC and SSC 23 – 25 July.
- SSC made phasing recommendations. Accepted by USRA and NASA with no further phasing needed.
- USRA has instituted quarterly instrument development reviews, contiguous with SSSC meetings. New USRA instrument coordinator (M. Savage) and NASA project scientist involved.

SOFIA

A line drawing of the SOFIA aircraft, showing its unique configuration with a large telescope mounted in the upper fuselage.

SSC Instrument Phasing Recommendations

- Highest priority is a far-IR camera. Either FORCAST or HAWC will do; both would be best.
- CASIMIR should also target 1st light.
- Contingency for FY02 should be increased to ensure success of these 1st light instruments.
- FLITECAM and HIPO are needed as scheduled to commission the observatory.
- EXES will be most useful after SOFIA achieves low pointing jitter.
- The SSC accepts that SAFIRE will not be ready at 1st light due to its funding profile.
- The SSC accepts that AIRES is no longer being developed as a 1st light instrument.
- USRA policy will be consistent with these recommendations

The SOFIA logo features the word "SOFIA" in a large, bold, serif font. To the right of the text is a stylized line drawing of the SOFIA aircraft, a Boeing 747 with a large telescope mounted on its upper deck.

SOFIA



Science Instruments Status

- 1st USRA Science Instrument Review held 11 Oct 2001.
- Status of all US instruments (and FIF-LS) presented:
 - Summary instrument description
 - Team members & responsibilities
 - Mechanical, optics, electronics, software, detector, documentation status
 - Status of FAA approval / certification
 - Accomplishments in quarter and planned milestones next quarter
 - Budget status – actuals vs. planned
 - Schedule milestones by above WBS elements
 - Risks & Mitigation Status
 - Summary red / yellow / green status for above elements in technical, cost, and schedule categories
 - FIF-LS naturally did not present budget information



General findings for all instruments

- FAA certification documentation review is a significant schedule risk for all SIs. The process is taking longer than expected (6+ months for review).
- All instruments have clear performance goals.
- Instrument budgets are tight in FY02. This forces teams to accelerate work schedules in '03 and '04, increasing schedule risk.
- Almost all instruments are in good shape. The 5 test and first light instruments (HIPO, FLITECAM, FORCAST, HAWC, CASIMIR) plan to be ready on time and within budget.
- These reviews will be held on a quarterly basis for now.

Instrument Program Mitigations

- FAA certification progress will be more closely tracked by Raytheon & USRA. Resources (DERs) will be reprogrammed from aircraft systems if/when needed
- Instrument PIs are motivated to produce the best instruments possible.
- Program budget requires that we accept budget-driven schedule risks.
- ARC (Greene, Wiltsee) is working with USRA to improve review format and give constructive feedback to instrument teams.



Data Cycle System (DCS)

- *Minimum* Data Cycle System was presented to SSC (July) , SSSC (April, July, October), and HQ (May) and endorsed:
 - Proposal preparation tool
 - Observing time estimators
 - AOTs, flight planning, proposal submission
 - Flight Planner
 - Manual at first, automated by full operations
 - Flight Scheduler
 - Needed before frequent operations
 - In-flight Quick Look
 - Data Archive
 - Search, Browse, retrieve SOFIA data
 - Reduced / calibrated or raw science data in FITS format
 - Housekeeping data
 - Data Pipeline
 - Algorithms provided by instrument teams & implemented by DCS

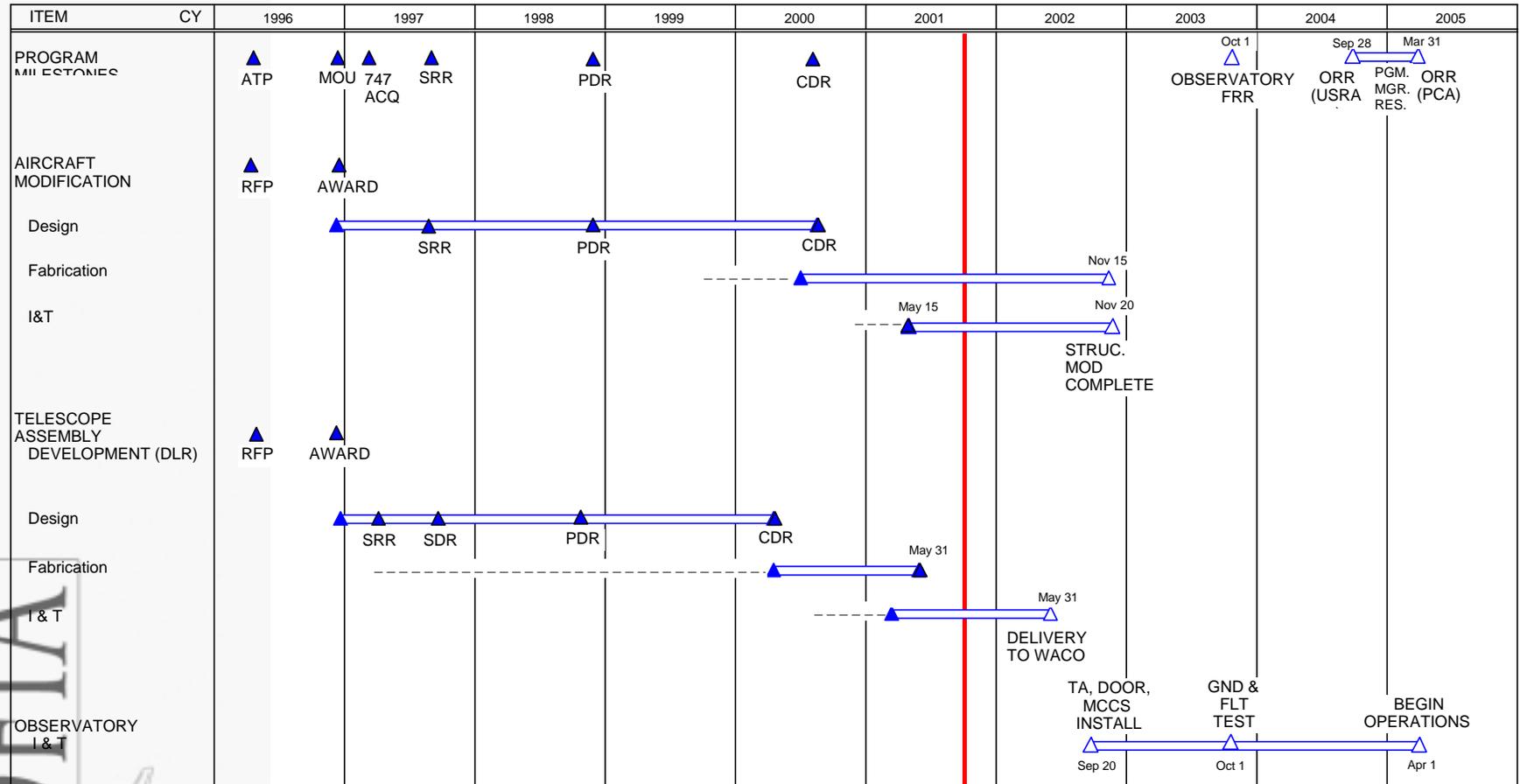
Data Cycle System Status

- DCS development being done by RIT (core / pipelines), UCLA (archive), ARC (advanced flight planning), and USRA.
- DCS was discussed extensively at Oct 12 SSSC meeting:
 - Minimum science requirements
 - Proposal entry and observing time estimators
 - Core DCS and SOFIA AOTs
 - SOFIA data archive
 - Possible future efforts: planning tools & automated control (unfunded)
- USRA has hired Fran Nelbach as information / data systems manager; will be responsible for DCS development
- Nelbach, Sandell (USRA DCS scientist), and others are working on a DCS functional requirements document and product development plan (due March '02).

DCS Status (cont'd)

- DCS review (by USRA) will occur Dec 10 & 11. Functional requirements will be discussed and allocated to DCS groups for detailed development.
- Detailed low-level requirements & interfaces to be finalized by 1 April '02.
- Much of the low-level detailed designs of Core DCS and Archive are complete.
- USRA has negotiated with RIT to produce 1st release of core DCS by 1 April '02 and updates every 6 months.
- RIT will also produce pipelines for HAWC, FORCAST, and possibly FLITECAM
- UCLA will have DCS data archive CDR (final incremental) before Sept. '03

SOFIA Program Milestone Schedule

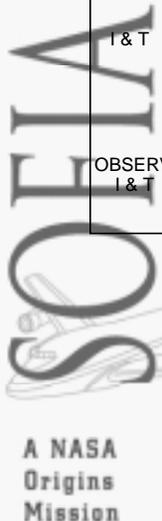


Highlights through CY02:

Begin TA integration and testing 4/01
 Hangar modification complete 5/01
 Joint integrated software testing #2 9/01
 Telescope subsystem testing done 2/02

Telescope delivery to Waco 5/02
 Aircraft structural mod complete 9/02
 Begin telescope integration in aircraft 10/02
 1st call for observing proposals 10/03

OCTOBER 2001



Life Cycle Budget

Current SOFIA Budget (\$M)

		PRIOR	FY 96	FY 97	FY 98	FY 99	FY 00	FY 01	FY 02	FY 03	FY 04	FY 05	FY 06	BTC	TOTAL
	Phase B	30.0													30.0
Development	Phase C/D		30.0	21.3	45.8	51.2	42.0	43.1	38.0	46.9	41.3	30.0			389.6
	Totals	30.0	30.0	21.3	45.8	51.2	42.0	43.1	38.0	46.9	41.3	30.0			419.6
Operations	Phase E											8.8	42.8	1107.3	1158.9
	Totals	30.0	30.0	21.3	45.8	51.2	42.0	43.1	38.0	46.9	41.3	38.8	42.8	1107.3	1578.5

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