SOFIA Update

German Science Community
SOFIA Workshop

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Outline

• Background
• Brief description of SOFIA
• SOFIA science Themes
• First light and first science example results
• Near term schedule
• Typical mission description overview
• SOFIA Science instruments Available this Summer
• Overview of current telescope characteristics and performance
• Summary
Background

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

- SOFIA established as a 80/20 partnership between US and Germany (NASA and DLR)
  - Development: NASA platform (80%), DLR telescope assembly (TA)(20%)
  - Operations costs: NASA (80%), DLR (20%)
  - Science time: NASA (80%), DLR (20%)

- US Organization of Program:
  - Program management is at NASA Dryden
  - The Science Project is at Ames Research Center
  - The Platform (aircraft) Project is at Dryden (Palmdale, CA)
Brief SOFIA Description
SOFIA
Stratospheric Observatory for Infrared Astronomy

Boeing 747SP

2.7-meter

International partnership:
80% -- NASA (US)
20% -- DLR (Germany)
Layout of Personnel and Accommodations
(upper deck not shown)

- 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
Why SOFIA?

At 41,000 ft, above more than 99% of the water vapor.
Top Level Requirements

• Telescope Requirements
  ✓ Effective aperture of telescope: 2.5 meters - Meet
    ✓ Telescope elevation range: 20 – 60 degrees - Meet
    ✓ Telescope wavelength range: 0.3 to 1600 microns - Meet
    ✓ Telescope image size: 80 percent of encircled energy
      ✓ 5.3 arcsecond diameter at the focal plane at First Science Flight – Meet
      (~4 arc seconds)
        • Goal 1.6 arcseconds diameter by Dec 2013 (initial science + 3 yrs)
  ✓ Operational capability: 6 Hours above 41,000 ft – Meet (demonstrated)

• 960 science hours per year during routine operations

• At Least 40 Principal or Guest Investigator teams per year

• Global Operations

• Twenty year operational life

• Promote educational opportunities and public outreach
SOFIA Organization - Post LOC

Program Office

- Yearly Resource Allocation
- Reserve Distribution
- Define and Manage Key Milestones
- Ensure Accomplishment of Level I Milestones
- Briefs External Stakeholders
- Oversight of Observatory & Science Operations
- Conflict resolution
- Contract Oversight
- Int’l Interface & Obligations
- Configuration Management
- Instrument Acquisition/Upgrades

Program Manager
NASA Deputy Program Manager

Program Control

Safety & Mission Assurance

Education & Public Outreach

Observatory CE

Airborne Systems Operations Director (NASA)

- A/C, TA & Mission Systems Maintenance/Upgrades
- Flight Crew & Training
- Flight Planning
- Deployment Logistics
- Observatory Ground Support Equipment
- Configuration Management
- SI Integration for flight safety and aircraft compatibility (NASA/DSI)

Science Mission Operations Director (USRA/DSI)

- TA & Mission System Operations
- Scientific Productivity
- Mission Planning
- Instrument Maintenance/Operations
- Science Planning & Allocation
- Data Collection/Analysis/Storage/Access
- Science Community Support
- Science Ground Support Equipment
- Science EPO
- Configuration Management
- SI Integration and Commissioning (USRA/DSI)
SOFIA Science Themes
SOFIA “Science Vision” Themes

Galaxies and the Galactic Center
- The ISM and the Star Formation
- History of External Galaxies

The Formation of Stars and Planets
- Massive stars, protoplanetary disks, & astrochemistry in star forming regions
- What physical, chemical, and dynamic processes are at work in the formation of stars and planets?

The Interstellar Medium of the Milky Way
- The physical processes that regulate the interaction of massive stars and their environment
- The origin of dust in the Milky Way and other galaxies
- The role of large and complex molecules, such as PAH’s in the interstellar medium

Planetary Science
- Primitive Bodies
- Giant Planets
- Small Worlds of our Solar System: Venus and Titan
SOFIA First Light and First Science Example Results*

*Detailed brief by Terry Herter, later in agenda
SOFIA First Light: Observations with FORCAST

Terry Herter + FORCAST team + Project Team (Ames, Dryden, USRA)
SOFIA Early Science

**Short Science** has 3 flights each with FORCAST and GREAT to allow the instrument teams to get on the sky at the earliest possible opportunity.

*FORCAST flew in Dec 2010*
*GREAT flies in April 2011*

**Basic Science** is a series of 15 flights (12 US & 3 German) that will be open to the astronomical community

• US time was openly competed via a call for proposals
  • 60 proposals received
  • ~ 20 selected

• German time will be used by the GREAT consortium

*Begin Spring 2011*

• Three flights for German science community
  • Added to basic science flights
visible light (HST)

near-infrared (ESO)

mid-infrared (SOFIA)
Current Telescope Characteristics and Performance*

*Detailed brief by Terry Herter, later in agenda
Telescope Temperature vs. time

- TA primary (red) and secondary (blue) temperatures vs. UT for short science flight #1
Bottom Line

• SOFIA works and is obtaining images!
  – Potential for promising science
• FORCAST works!*
  – FORCAST images a 3.2x3.2 arcminute FoV with 0.75 arcsecond pixels from 5 – 37 μm
  – Obtained near diffraction limited performance for λ > 30 microns
• Flew 10 hour flights with ~ 3 hours at 43,000 feet and 6 hours at or above 41,000 feet
  – Corresponding improvements in background and transmission
    • Temperature stabilized
    • Less aerodynamic buffeting
    • Less water vapor overburden above 41,000 ft

*Detailed brief by Terry Herter, later in agenda
Near Term Events and Schedule
Near Term Schedule

- Systems upgrades 2011 Feb-Mar
- Final test flights (1-2 flights) 2011 mid Mar
- GREAT line ops 2011 late Mar
- GREAT Short Science (3 flights) 2011 Apr
- FORCAST prep/line ops 2011 Apr
- GO Basic Science w/ FORCAST (10 flts) 2011 May-Jun
- Telescope Engineering flights 2011 mid-Jun
- GREAT prep 2011 mid-Jun
- GO Basic Science w/ GREAT (8 flts) 2011 Jun-Jul
- Req maintenance, avionics upgrade 2011 Aug
- Commissioning or TA V & V (6 flights) 2011 Aug-Sep
- Commissioning or TA V & V (5 flights) 2011 Oct
- Upgrades (part 1 of 7) 2011 Oct – 2012 Mar
  - avionics, cavity insulation, mirror coating, TA, workstations, MADS
- Functional test flights 2012 Apr
- Commissioning 2012 May
SOFIA Science Instruments
Available this Summer*

* Detailed brief by Eric Beklin, later in agenda
Instrument $R/\lambda$ graph

SOFIA 1$^{st}$ Generation Science Instruments

- GREAT
- FIFI LS
- EXES
- FLITECAM w/ grisms
- HIPO
- FORCAST w/ grisms
- FORCAST
- HAWC
• From left: FORCAST w/ foreoptics (test equipment), counterweight rack, and PI rack
FORCAST on the telescope

- Positioning FORCAST to mount on telescope
- Cryogen transfers on the plane
• GREAT testing
  – EMI test completed
    – Preliminary analysis indicates no interference or standing-wave issues
  – Software testing in HILS complete
    – Both the GREAT team and the KOSMA-to-SCL interpreter team have been identifying and fixing bugs
  – Line Ops #1 complete
    – No major issues, planning additional GREAT/Aircraft test prior to LO#2
• GREAT Mission Ops support
  – Procedure development
  – Supported Installation of instrument
  – Line Ops
Typical Mission Characteristics
Water Vapor “Overburden” at 41,000 feet (winter, spring, summer, fall)

Fig. 7.—The MLS-determined zenith water vapor overburden for (a) winter (DJF), (b) spring (MAM), (c) summer (JJA), and (d) autumn (SON)
Typical Science Mission
(Altitude vs Time)

Best Science
- Least aero buffet
- Cold soaked
- Low water overburden

Start Descent, Based on fuel remaining

~ 6 hours

35k ft
~2.75 hours

41k ft

43k ft, 3.75 hours

~6 hours

~10 hour flight

~10 hour flight

~14 hour duty day

~10 hour flight

~14 hour duty day

Crew Brief

Debrief

Note: Altitude is based on fuel remaining (weight)
Sample Flight Plan

FORCAST DRM flight for Feb. 3, 2008
ETD: 0120 Z
ETE: 09:30
ETA: 1050 Z

A. Meyer, USRA
April, 2007
Summary

• SOFIA progressing well!
• FORCAST and observatory worked well on short science I
  – Already obtaining promising scientific results
• Best results obtain at highest altitudes in about last 6 hours of flight
  – Less aero buffeting of telescope
  – Less water vapor overburden
  – Telescope assembly cold soaked
• Pointing ???
• On Track to start flying GREAT in April
• On track to start basic science I in May
• On track to start basic science II in July
• SOFIA program looking forward to upcoming German science flights
Questions?

For additional information:
http://www.sofia.usra.edu