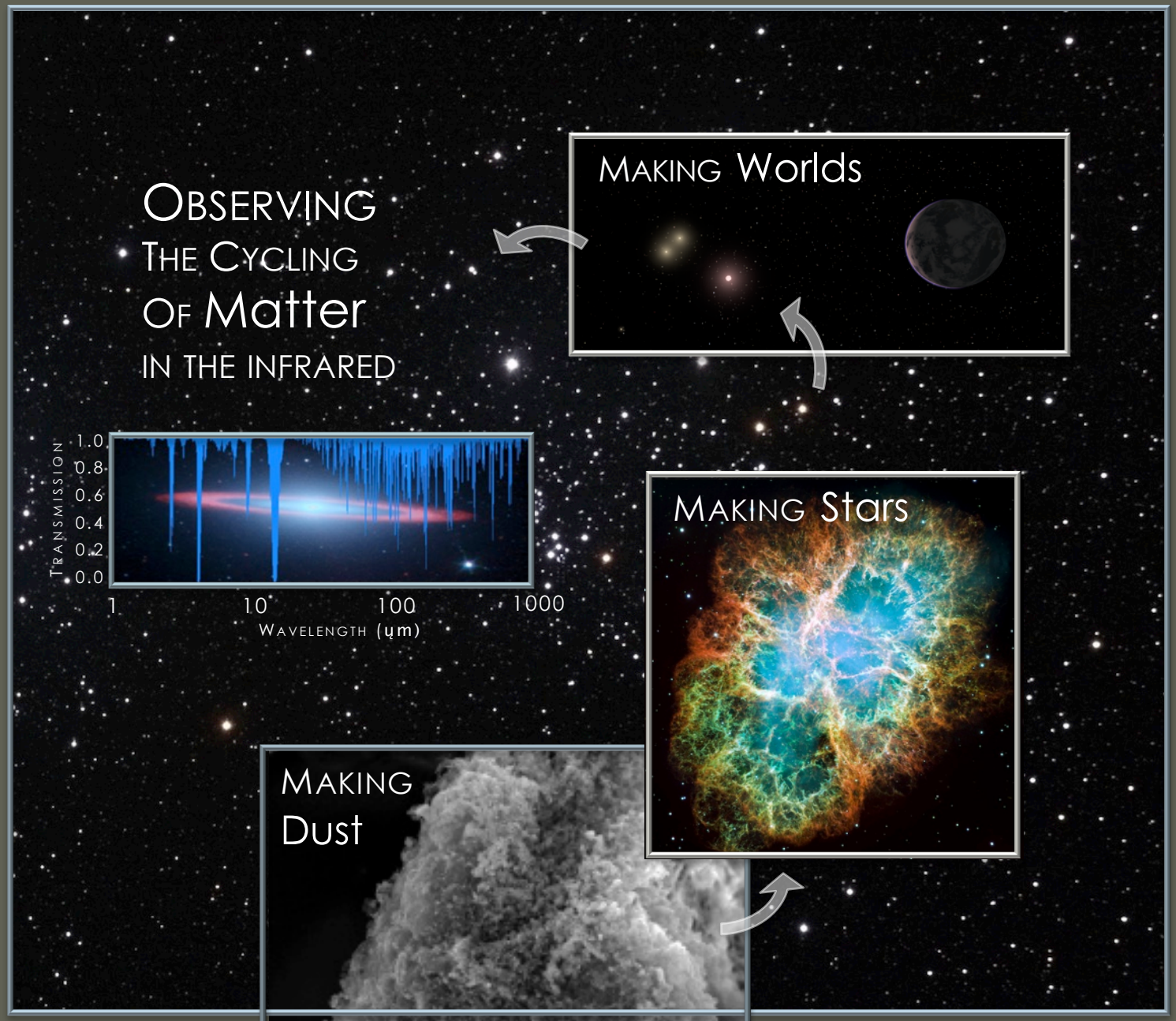


NOVEMBER 2016

Program Manager's Update

SOFIA

Stratospheric Observatory for Infrared Astronomy

Presented to:

SOFIA USERS GROUP (SUG)

Presented by:

SOFIA Program Manager Eddie Zavala

The SOFIA Observatory studies astronomical observations at wavelengths between 0.3 and 1000 microns

Agenda

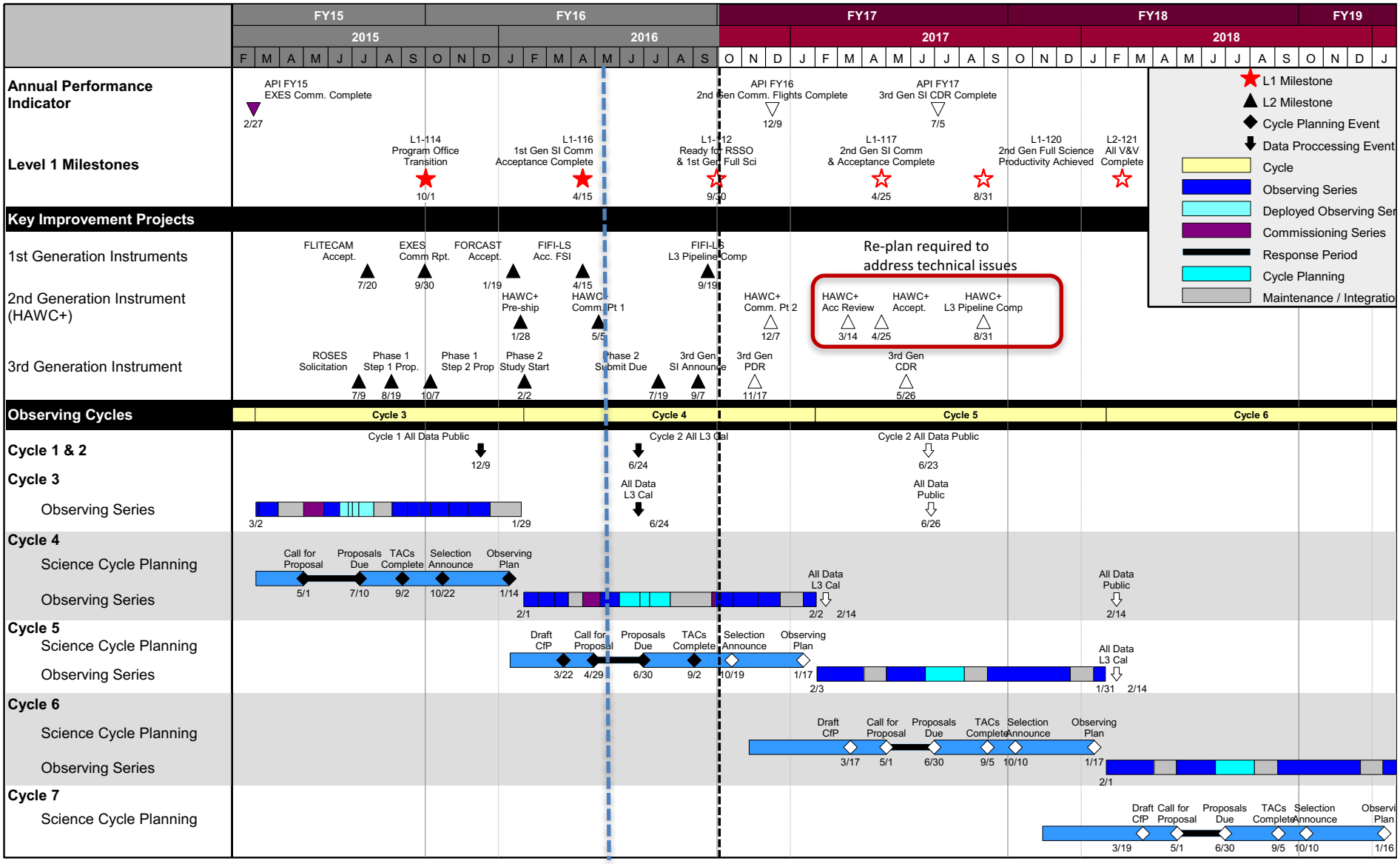
01 SOFIA Top-Level Schedule & Milestones

02 Program Status (Cycle 4)

03 Program Status (Cycle 5)

04 Future Improvements

SOFIA Top-Level Schedule & Key Milestones



Program Status (Cycle 4)

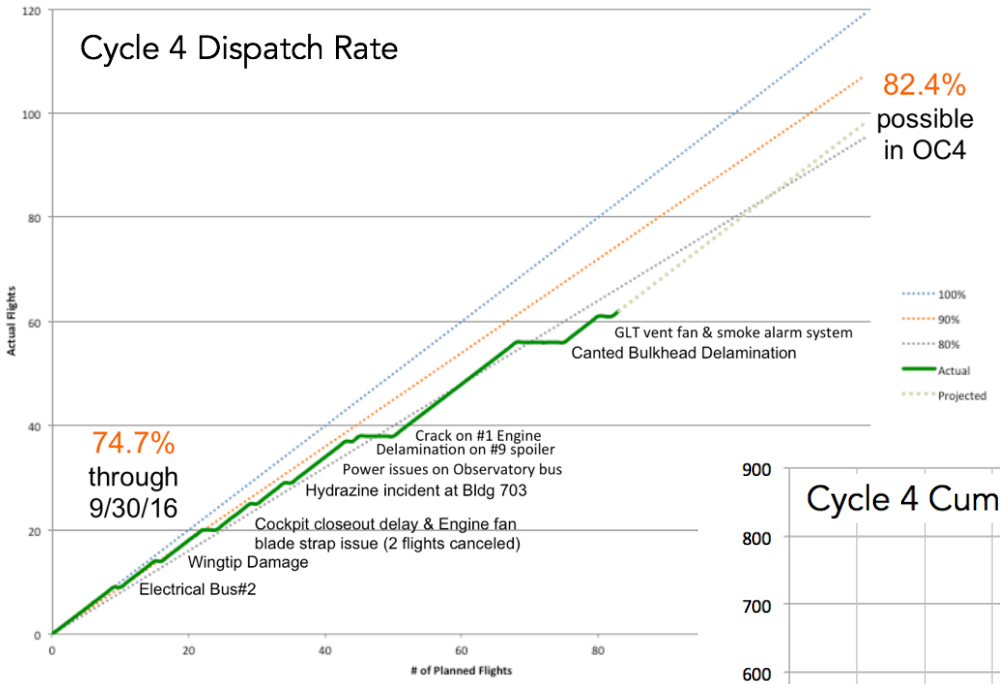
- SOFIA is currently in Science Cycle 4 (2 years, 5 months into the Operations Phase)

- Program goals, priorities, and metrics are focused on ensuring scientific production
  - Preparations for the 2018 Senior Review
  - Complete final planning and preparations for start of Cycle 5 science observations
  - The publication and dissemination of unique / impactful science results
  - Rapid production of science ready data from reliable and accurate pipeline software
  - Increased and sustained funding to investigators for the analysis of the results
  - Availability of relevant scientific instruments and observatory capabilities
  - Safe, efficient, and reliable science flight opportunities
  - Improved response to annual call for proposals

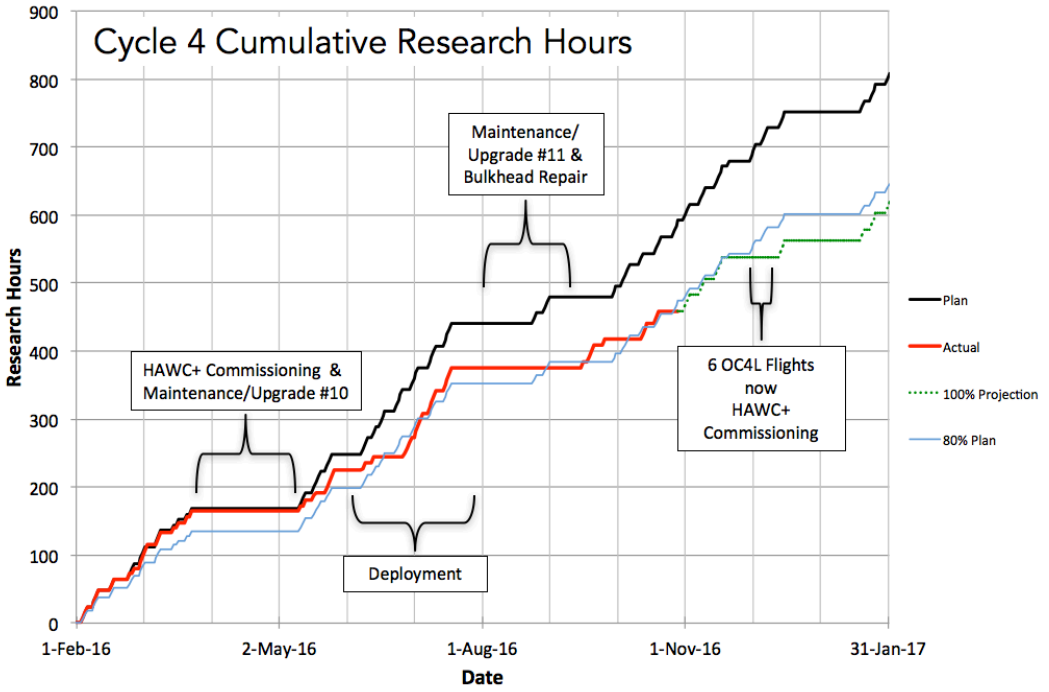
Program Status (Cycle 4)

- Cycle 4 Science Observations are proceeding well despite some operations challenges
  - Since 2013, Program operations continue to ramp up with increasing annual flights and research hours
  - Team continues to demonstrate exceptional ability to efficiently plan science flights and adjust to changing conditions (Flight cancellations, Contingency flight options, HAWC+ schedule impacts, etc.)
  - 2016 New Zealand deployment completed with 19 of 25 planned science flights, 1 RTB
  - New operational challenges have occurred that have impacts on dispatch rate; Program is continuously improving, making key adjustments, incorporating lessons learned to achieve improved operational performance
  - Observatory improvement projects targeted for maintaining operational capacity, improved science capability, and observatory improvements

Cumulative Cycle 4 Metrics



- Dispatch rate has been predominately impacted by aircraft issues
- ~7% of contingency flights utilized
- Making adjustments to improve Observatory reliability for Cycle 5



- Research Hour impacts due to flight cancellations and flight schedule changes driven by HAWC+ technical issues
- Program scheduling additional Cycle 4 science flights to achieve 80% RH
- Increasing Cycle 5 margin with more planned contingency flights ~15%

Cycle 4 Daily Overview (1 of 2)

Key Observing Cycle: 4 Baseline Science Flights: 101 Baseline RHs*: 808 Planned Science Flights: 80 Planned RHs*: 632 * Max available research hours *PMB sequence approval: 10/14/16*

- **Weekend day** (black text with no fill)
- **US or German Holiday** (day of week box H or GH w/ red fill)
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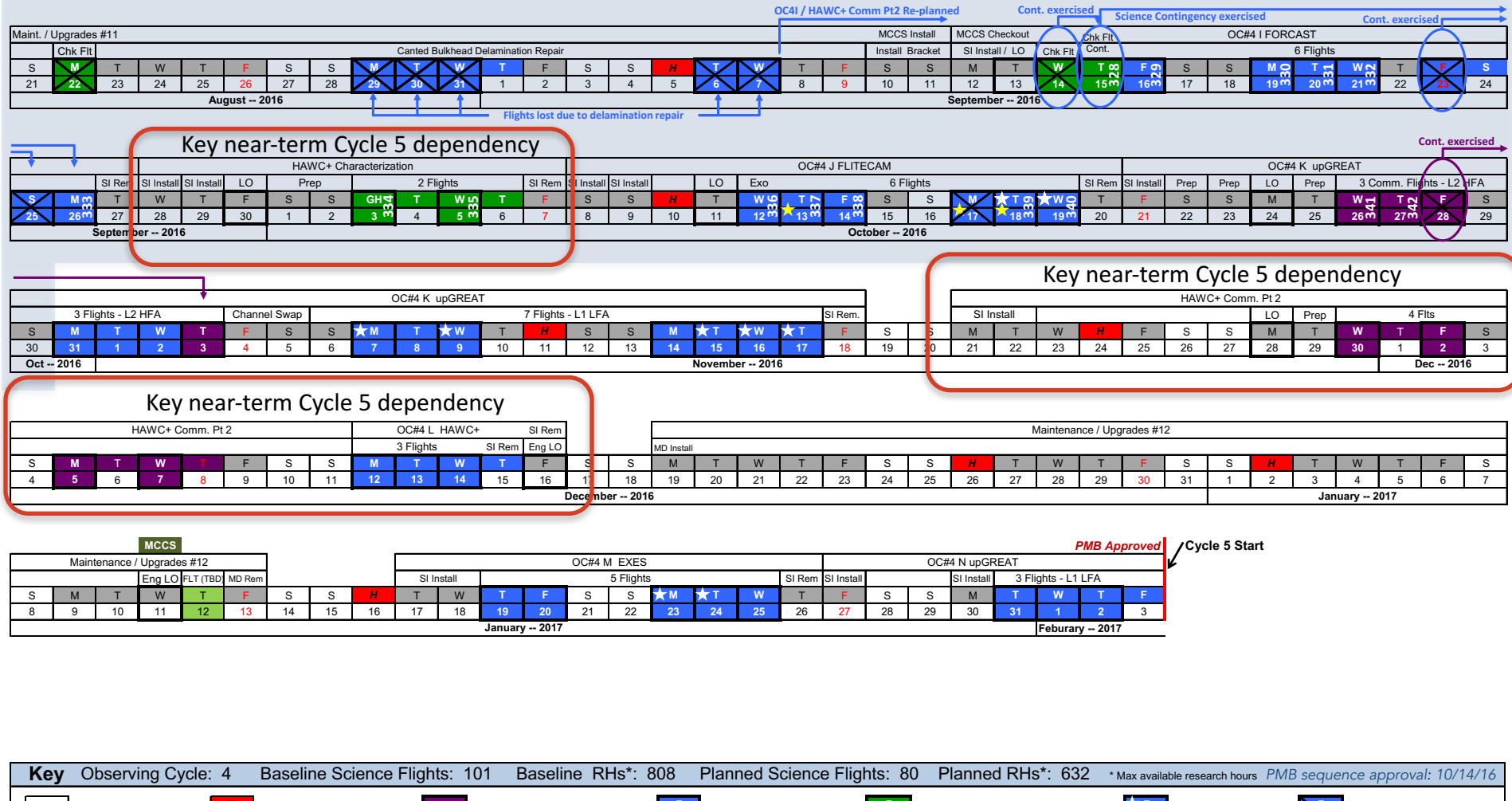
- **Deployment Observing Flights** (bold white text, light blue fill, bold border)
- **Short Flight** (colored fill only lower half, bold bdr.)
- **Half Sci. & Half Ferry/Maint./Non-Sci** (two colored fill)
- **Restored Flight** (check mark below day)
- **Notional Unfunded Flight** (yellow fill with U below day)

Cycle 4 Daily Overview - 2 of 2

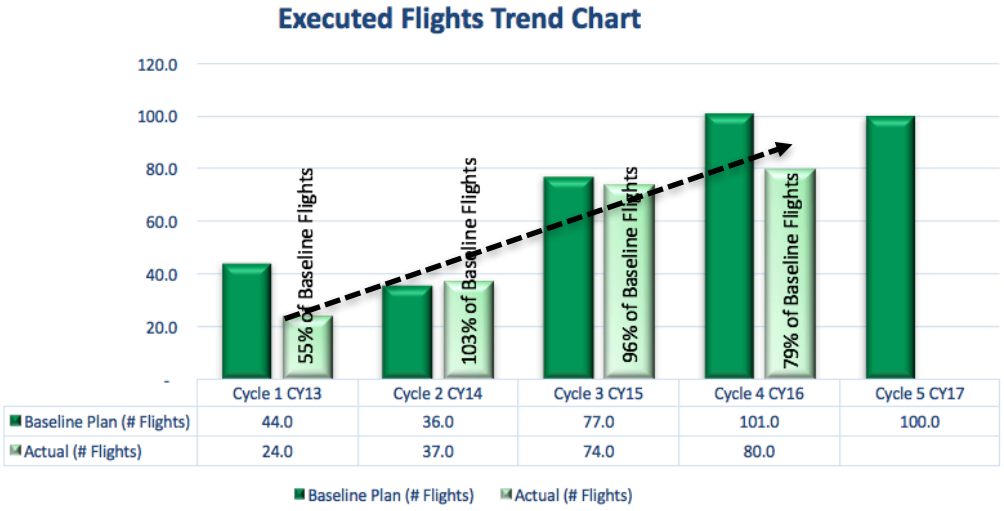


Key Observing Cycle: 4 Baseline Science Flights: 101 Baseline RHs*: 808 Planned Science Flights: 80 Planned RHs*: 632 * Max available research hours *PMB sequence approval: 10/14/16*

S 7 — **Weekend day** (black text with no fill)	*H* 4 — **US or German Holiday** (day of week box H or GH w/ red fill)	F 6 — **Instr. Commissioning Flight** (bold white text, purple fill, bold border)	F 6 — **Observing Flight** (bold white text, blue fill, bold border)
F 6 — **Work day** (black text w/ day box grey fill)	F 6 — **Line Operations** (bold border)	F 6 — **Contingency Instr. Comm. Flight** (day box with purple fill)	F 6 — **Contingency Obser. Flight** (day box with blue fill)
F 6 — **AFRC Regular Day Off** (day and date shown in red)	F 6 — **Possible Maint/Up. Check Flt** (day and date box filled with lt. green)	F 6 — **Deployment Observing Flights** (bold white text, light blue fill, bold border)	S 28 — **Short Flight** (colored fill only lower half, bold bdr.)

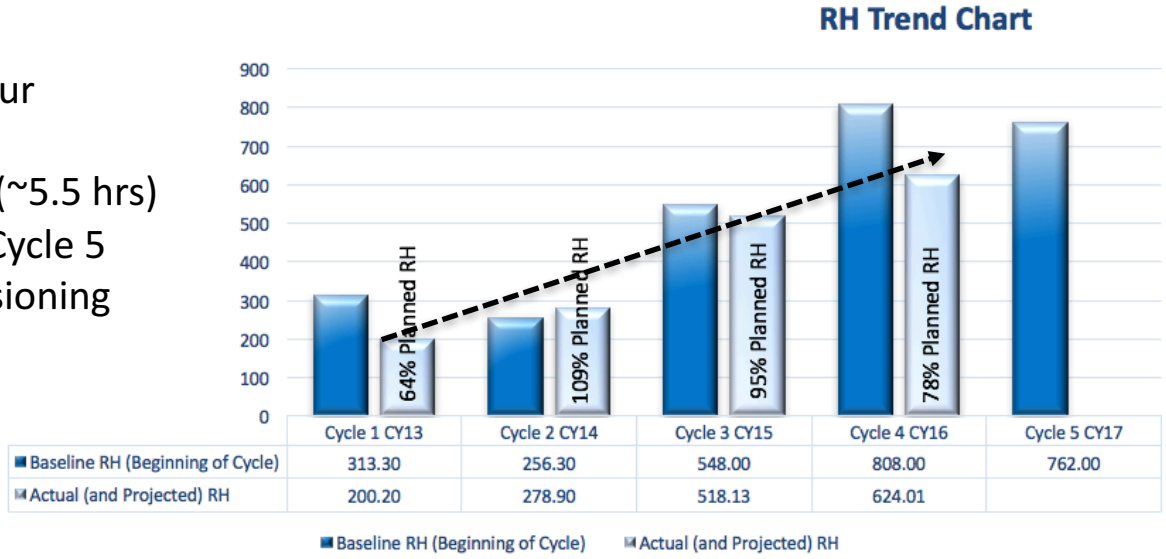
F 6 — **Ferry/Maint./Non-Sci Flight** (bold white text, green fill, bold border)	★F 6 — **Educator on Flight** (white star on day of week)	F 6 — **Return to Base (RTB) Flight** (single slash through day and date)	
F 6 — **Contingency Ferry/Maint./Non-Sci Flt** (day box with green fill)	★F 6 — **Media/VIP on Flight** (yellow star on date)	F 6 — **Canceled Flight** (x through day and date)	
S 13 — **Half Sci. & Half Ferry/Maint./Non-Sci** (two colored fill)	✓ — **Restored Flight** (check mark below day)	U — **Notional Unfunded Flight** (yellow fill with U below day)	

SOFIA Operational Capacity Ramping Up



- Program flight plans approaching full ops levels in Cycle 4 & 5 (dark bars)
- Program demonstrating increase in annual science flight execution and annual Research Hours (light bars)

- Planned Cycle 5 Research Hour estimate is reduced due to:
  - Low HAWC+ hold time (~5.5 hrs) which affects ~25% of Cycle 5
  - New upGREAT commissioning requirements



Program Status (Cycle 5)

- Cycle 5 Science Planning is proceeding well
  - Draft schedule approved to support Cycle selection announcement
  - Preliminary analysis of HAWC+ characterization flight data indicates that performance is sufficient to support shared-risk science observations
    - *Further work is required to improve ADR hold time and instrument sensitivity* and meet SI performance requirements
  - The Program Office has adopted *an approach that prioritizes preservation of high-priority science flights* awarded as shared-risk and implementing technical fixes between awarded flight series to bring the performance of the SI in line with performance requirements
    - Needed repair will be performed in January – April 2017 and May – September 2017 to avoid science schedule impacts
  - SOFIA SMO to develop contingency flight plans for Fall 2017 HAWC+ science flights

Program Status (Cycle 5)

- Cycle 5 Science Planning is proceeding well
  - Approaches to mitigate future observatory outages (Aircraft)
    - Maximize contingency flight opportunities in the schedule; increase to ~15%
    - Expanding ground crew schedule to 7 days/week to provide weekend shifts to fix problems
    - Staging more aircraft spares, including a spare engine, in New Zealand to improve recovery time due to problems
    - Improved maintenance plan and acquisition for engine maintenance, repair, and overhaul
    - Acquisition of additional 747SP airframe with ready access to remove spare parts
    - Collaborating with Pratt &Whitney Canada (PWC) 747SP project team for exchange of best practices and lessons learned for aircraft maintenance
  - Known risks and constraints
    - HAWC+ performance and repair implementation
    - NASA directive for centralized procurement may introduce time-delays for time-critical parts
    - Budget sensitivity to large fuel price changes

Cycle 5 Daily Overview – DRAFT – Page 1 of 2

OC4N is upGREAT

Cycle 5 Start

OC#5 A (upGREAT LFA)																						
												7 Flights										
T	F	S	S	M	T	W	T	F	S													
2	3	4	5	6	7	8	9	10	11													
Feburary -- 2017																						

OC#5 A (upGREAT LFA)									OC#5 B (FIFI-LS)																					OC#5 C (EXES)										
					SI Rem				SI Install	SI Install			7 Flights												SI Rem	SI Install			SI Install	6 Flights									
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Feburary -- 2017									March -- 2017																																

MCCS

OC#5 C (EXES)						Maintenance / Upgrades #13																														OC#5 D (FORCAST)										
				SI Rem	MD Inst.																			Eng LO	Chk FLt	MD Rem	SI Install			SI Install	6 Flights									
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
March -- 2017																						April -- 2017																				

First shared-risk science with HAWC+ (before repair)

									OC#5 E (HAWC+)																											OC#5 F (EXES)										
				SI Rem	SI Install			SI Install	9 Flights																							SI Rem	SI Install			SI Install	3 Flights						
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
23	24	25	26	27	28	29	30	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4
April - 2017								May -- 2017																																			

OC#5 F (EXES)					OC#5 G (upGREAT HFA/LFA)																				OC#5 H (upGREAT) NZ																				
		SI Rem	SI Install	SI Install							7 Flights														Aircraft Prep							Ferry - 2 flts	Time	Media	Orient	8 Flights HFA/LFA				Down		
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5	6	7	8	9
May -- 2017					June -- 2017																																						

EAA AirVenture - Oskosh, WI

OC#5 H (upGREAT)																						OC#5 I (FIFI-LS)									OC#5 J (FORCAST)										
Down	Align	HFA/LFA					Swap	Down	Prep	6 Flights 4G/HFA					Post	Down	Prep	4G/HFA		SI Rem.	SI Install		Down	4 Flights				SI Rem.	SI Install		Down	6 Flights				Post						
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13
July -- 2017																														August -- 2017												

Key

Observing Cycle: 5 | Baseline Science Flights: TBD | Baseline RHs*: TBD | Planned Science Flights: 100 | Planned RHs*: 762 | * Max available research hours | PMB sequence approval: 10/14/16

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- **Restored Flight** (check mark below day)
- **Strategic Capacity** (orange fill on day of week)

Cycle 5 Daily Overview – DRAFT – Page 2 of 2

SOFIA Stratospheric Observatory for Infrared Astronomy

Pluto Occul. | Total Eclipse | MCCS

OC#5 J (FORCAST)															MD Inst.	Maintenance / Upgrades #14																					OC#5 K (HAWC+
Down			Prep				Ferry PMD		SI Rem.		Crew Rest					Eng LO																Eng LO	Chk Flt	MD Rem	SI Install	
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9
August -- 2017															September -- 2017																			

DLR Aero Day | Triton Occul

First shared-risk science with HAWC+ (after repair)

OC#5 K (HAWC+)																			SI Rem	SI Install		SI Install	OC#5 L (FLIPO)									SI Rem	SI Install	SI Install	OC#5 M (FORCAST)	
	SI Install		Prep	Ferry CGN	Prep	Tours	Aero Day	to BGR	to PMD	7 Flights														Ferry	Triton	Ferry	3 Flights									
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5	6	7	8	9	10	11	12	13	14
September -- 2017																			October -- 2017															

First shared-risk science with HAWC+ (after repair)

OC#5 M (FORCAST)															OC#5 N (HAWC+)																								
6 Flights											SI Rem	SI Install			SI Install	9 Flights																							
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
October -- 2017															November -- 2017																				

		MD Inst.	Maintenance / Upgrades #15 w/ 'C Check'																																	
	SI Rem	Eng LO																																		
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
November -- 2017															December -- 2017																				

MCCS | AAS 231st Meeting - National Harbor, MD

Maintenance / Upgrades #15 w/ 'C Check'											MD Rem																										
									Eng LO	FLT (TBD	SI Install	SI Install			Strategic Capacity					OC#5 'O' (EXES)								8 Flights										
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
December -- 2017								January -- 2018																												

Cycle 6 Start

OC#5 'O' (EXES)					OC#6 A																									OC#6 B								
					SI Rem		SI Install	SI Install																				SI Rem	SI Install			SI Install							
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
January -- 2018					February -- 2018																																	

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- **Restored Flight** (check mark below day)
- **Strategic Capacity** (orange fill on day of week)

Future Improvements

- Observatory Mission Systems
  - Improved Mission Command and Control System operational software with deployment of new software loads 2-3 times per year
  - Water Vapor Monitor upgrade deployed and flight calibration in progress
  - Data Archiver System Upgrade
  - Cryo-cooler Phase 2 System Upgrade (2-channel, liquid-cooled system)
  - Cavity Environmental Control System
    - Improved/preventative maintenance plan with increase spares
    - Upgraded system to address nuisance operational issues and improve performance
- Telescope Assembly
  - Continuous software improvements (2-3 year) for more efficient nodding and increased tracking performance during scans
  - Spare Secondary Mirror Mechanism w/ spare Aluminized mirror
  - Head-ring camera upgrade: Wide-Field Imager and Far-Field Imager
  - Spare subsystem components: Network units, power supplies, and various sub-assembly electronics
- Aircraft Systems
  - Required avionics communication system upgrade required for international operations
- Accelerating plans for next science instrument solicitation for 2017

Future Improvements

- The scientific success of SOFIA depends on a timely commissioning of new instruments using cutting edge technology . Consequently, NASA plans to solicit the next generation instrumentation in 2017.
  - Agreement secured with NASA HQ to accelerate plans for next science instrument solicitation
  - Schedule details are being formulated and will be released soon

Back-up Charts

SOFIA

Stratospheric Observatory for Infrared Astronomy