Welcome!

- Thank you all for serving on the Cycle 25 HST TAC

- The Hubble Space Telescope has now completed 27 years in operation!
  - We are now 8 years past Servicing Mission 4
    - At that time planning was for 5 years of operations
  - In most respects, Hubble is working now at its very best
    - There is some slight instrument performance degradation
    - But we (GOs and STScI+GSFC) have become smarter in how we use the observatory

- Over the next several days, the team in this room has the privilege and responsibility of defining what Hubble does next.....
Hubble is As Powerful As Ever

Deep, precise, stable pan-chromatic imaging
Slitted and slitless spectroscopy, coronagraphy, astrometry

Architecture of the universe

Life stories of galaxies

Mysteries of dark matter and dark energy

Births and deaths of stars

Recipes for building planets

TAC - 11 June 2017
Operate Hubble out to 2020 or beyond so that there is at least one year of overlapping science observations with the James Webb Space Telescope, performed in a manner that maximizes the science return of both observatories by taking full advantage of Hubble's unique capabilities and the astronomical community's scientific curiosity.

How long will Hubble continue to operate?

As long as it remains scientifically productive

What is needed to keep Hubble scientifically productive?

Current best estimate: >4 years of overlap!

- An operating observatory
- Capable science instruments
- Scientific drivers (demand)
- Adequate staffing and user support
- Appropriate funding
- Common purpose & teamwork
The Road to 2020+

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<tbody>
<tr>
<td><strong>Observatory Health</strong></td>
<td>• Good reliability of science instruments and major systems well beyond 2020 (NESC)</td>
</tr>
<tr>
<td><em>Excellent</em> (even better than expected after SM4)</td>
<td>• Known modes of degradation</td>
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<tr>
<td><strong>Orbit Decay</strong></td>
<td>• Orbit stable until mid-2030s</td>
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<tr>
<td>Nominal orbit</td>
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<tr>
<td><strong>Scheduling Efficiency</strong></td>
<td>• Efficiency declines to ~40 upon transition to reduced-gyro mode (see next slide)</td>
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<tr>
<td>~50%, near all-time high Averaging &gt;84 orbits/week</td>
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<tr>
<td><strong>Scientific Productivity</strong></td>
<td>• Publication rate remains high</td>
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<tr>
<td>~800 papers per year; ~40 PhDs per year</td>
<td>• New discoveries continue</td>
</tr>
<tr>
<td><strong>Demand</strong></td>
<td>• No near-term decrease expected</td>
</tr>
<tr>
<td>&gt;1000 proposals per year; 6:1 oversubscription (time)</td>
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<tr>
<td><strong>Staffing</strong></td>
<td>• Work efficiencies are harder to achieve beyond FY17 without loss of capability</td>
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<tr>
<td>Lean operations</td>
<td></td>
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<tr>
<td><strong>Mission Funding</strong></td>
<td>• Uncertain mission budget presents challenges</td>
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<tr>
<td>$98.3M/year total budget</td>
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<tr>
<td><strong>Grant Funding</strong></td>
<td>• Strong support for science analysis</td>
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<td>$28-30M/year in grants to the community</td>
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## Hubble is in Excellent Health

<table>
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<tr>
<th>Observatory Systems Status</th>
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<tbody>
<tr>
<td><strong>Science Instruments</strong></td>
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<tr>
<td>ACS</td>
<td>Operating well. Improved CTE corrections and SBC cals.</td>
</tr>
<tr>
<td>COS</td>
<td>Far-UV sensitivity remains excellent. Moving to LP4 in October 2017 with new operating strategy.</td>
</tr>
<tr>
<td>STIS</td>
<td>Operating well. BAR5 coronagraphy competitive with ground reaching 1E-6 with ADI and KLIP. Spatial scanning now available.</td>
</tr>
<tr>
<td>WFC3</td>
<td>Excellent stability, sensitivity, astrometry. Spatial scanning and Tiling (DASH) available. CTE corrections for UVIS channel. Persistence maps available for IR channel.</td>
</tr>
<tr>
<td><strong>Fine Guidance Sensors</strong></td>
<td>Slow degradation being monitored, understood.</td>
</tr>
<tr>
<td><strong>Electrical and Power System</strong></td>
<td>Batteries and solar arrays - no serious issues.</td>
</tr>
<tr>
<td><strong>Pointing and Control System</strong></td>
<td>GYRO lifetime estimates indicate 3-gyro operation until ~2023. One-gyro science operation &gt;2036.</td>
</tr>
<tr>
<td><strong>Data Management System</strong></td>
<td>Lockups are rare (1-2x per year) and understood.</td>
</tr>
<tr>
<td><strong>Thermal Control System</strong></td>
<td>Excellent, no serious issues.</td>
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Critical System Reliability

Gyro Operation 3-3-1-1

- G6: Off
- G5: Off
- G4: On
- G3: Off
- G2: On
- G1: On

Date:
- Jan-16
- Dec-16
- Dec-17
- Dec-18
- Jan-20
- Dec-20
- Dec-21
- Jan-23
- Jan-24
- Dec-24
- Jan-26

Reliability:
- RF Mux & HGA 2 Ax Gimbal
- SSAT
- Solar Array III, Diode Box, SADM
- RGA
- RWA
- PCU
- EP/TCE
- DMA Block 1 with CU/SDF
- FGS & FGE
- FGS and FGE

HGA Gimbal and RF Multiplexer

TAC Cycle 25
Advanced Camera for Surveys

- ACS astrometry is now improved (outgrowth in part of Frontier Fields)
  - Time dependence is well understood and modeled
  - Improved 47 Tuc proper motions and Detector/Filter corrections $\rightarrow$ 1 mas
- Observers should pay attention to CTE for low background (<20e-) images
  - Improved CTE correction algorithm (based on UVIS) becoming available
- Improved calibrations of SBC PSF wings, darks, and flats

![WFC G.Dist.: Astrometric Residuals](image)
• COS currently operating at Lifetime Position #3 until Oct 2017
• Duration at each LP a function of number of photons on detector
  - Geocoronal Ly-alpha creates holes or dead regions on detector
• Off-center LP’s result in some resolution loss
• Slow throughput declines otherwise
• COS operating very well
• Current usage approach would result in significant decrease in COS usefulness in late 2019 with exhaustion of LP4
  - An LP5 may be possible with issues
COS2025 – a strategy to maintain full COS capabilities until 2025+

- Places all geocoronal Ly-alpha in G130M at a single detector location
- Will rapidly create a second “gap” in the detector at LP4
- Some efficiency hit for programs requiring full wavelength coverage or highest possible S/N → let us work this out with GO’s in PHASE 2
  
  • TAC should ignore this change in strategy for Cycle 25 selections
- Discussed with STUC and approved in May 2017

Observations of M-dwarfs stars

- COS count rate limits may pose a concern for observations of bright or variable sources
- Observer must demonstrate observation is safe (long standing policy)
  
  • STScI augmented policy recently to accept 1:10,000 risk with clarified rules
- Bright object limit issues will be resolved between GO and STScI at PHASE 2
- TAC should judge the science and not get bogged down in implementation
New Items:
Spatial scanning with the STIS CCD can be used as an available-but-unsupported mode. Spatial scanning may be beneficial to programs requiring high S/N spectral observations that are limited by pixel level flat fielding and IR fringing.

BAR5 Coronograph Provides $10^6$ Contrast or Better

Ongoing work to improve echelle calibrations
WFC3 Continues to Operate Nominally

Improved background subtraction:
- G102, G141, F110W & F105W are sensitive to HeI 1.083μm sky line when HST is in daylight

IR “DASH” Mode:
- Up to 8 tiles per orbit
- Gyro pointing with post-observation removal of small drifts (~0.25 pixel)

Improved identification and tracking of “bad” pixels:
- Flagging of hot, sink, and unstable pixels

The WFC3/ can observe point sources as bright as V~0 mag using the GRISMs in spatial scanning mode
**Long Range Plan Highlights**

- **Cycle 24 efficiency remains high (83.3 orbits/week)**
  - 84.0 orbits/week since Cycle 17.
  - Key factors:
    - (+) Flexible mix of science accepted by TAC.
    - (+) Larger-than-normal “tail”.
    - (-) Impacts of highly constrained observations (Juno, Exoplanets).
HST Science Productivity Remains High Refereed Papers per Year

Programs not Assigned
Part GO Part Archive
AR
GO

Year of Publication

Number of Refereed Papers per Year

TAC - 11 June 2017
Data from the Programs You Select Will Produce Science for Years to Come

- HST archive size is >100 TB
- HST archive retrievals doubled after Servicing Mission 4 in May 2009
- >12,000 registered archive users (85 countries, 50 states)
- HST archive now online cache for rapid retrieval & improved/scripted queries
Congratulations! Your program, GO-12345, “Amazing HST Observations”, is nearing completion. As your program draws to a close, we would like to ask you to coordinate with Space Telescope Science Institute to improve the dissemination of your results and help us better follow HST usage......
• **In reviewing Cycle 25 proposals, Panels and TAC should focus on the best science**
  – Leave scheduling constraints to us to consider in the context of the entire Cycle 25 pool of recommended proposals
Hubble may be 27 years old, but its best years are still ahead....