



Considerations for using the ObsVisSAP protocol for multi-observatory coordination with HST and JWST

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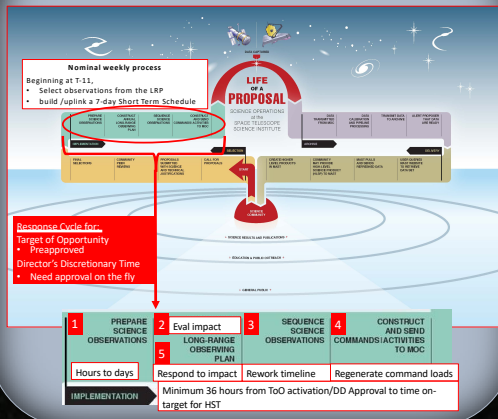
Abstract

The Hubble Space Telescope and the James Webb Space Telescope are operated at the Space Telescope Institute (STScI) by the Association of Universities for Research in Astronomy (AURA) for the National Aeronautics and Space Administration (NASA) as peer reviewed, General Observer, queue planned and scheduled observatories. As their science mission operator, STScI is charged by NASA to maximize the science return of these observatories. This presentation describes some of the observatory operating constraints, ground system processes, and philosophy considerations that affect the operation of these observatories and which have implications for multi-messenger collaboration and observatory coordination using the proposed ObsVisSAP search protocol.

Space Telescope Science Institute Observatory Use Goals

- Maximize overall observatory efficiency/time on-target
- Execute all observations for a given program in as short a time interval as feasible given their observing constraints
- Facilitate cutting-edge science by allowing Long Range Plan (LRP) and short term schedule changes without compromising other goals

Space Telescope Science Institute Science Operations Lifecycle

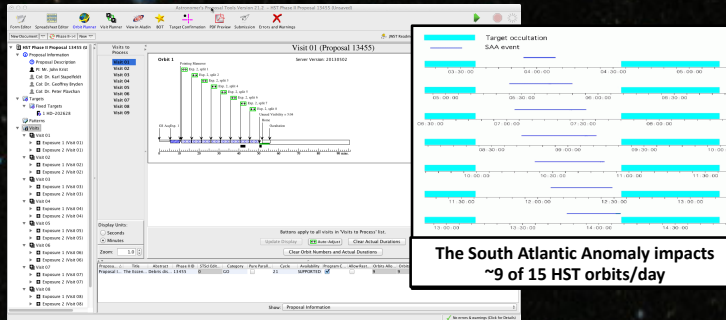


Observatory Constraints Comparison

HST	HST & JWST Fields of Regard		JWST
LEO	HST Field of Regard	JWST Field of Regard	L2
Orbit relative events			Orbit relative events
<ul style="list-style-type: none"> • Earth Occultation/Target Visibility <ul style="list-style-type: none"> • ~43 min/53 min per 96 min orbit at low DEC • Moon occultation • Change of orbit precession rate <ul style="list-style-type: none"> • Earth/SAA avoidance entry/exit times shift earlier over time as the HST orbit altitude decays • Limits long term predictability of orbit level viewing periods • South Atlantic Anomaly interrupts viewing during many orbits 			<ul style="list-style-type: none"> • Momentum Management <ul style="list-style-type: none"> • To prevent reaction wheel saturation • Minimized via intelligent planning and scheduling • L2 Orbit Station Keeping <ul style="list-style-type: none"> • Required on regular cadence • Maintains orbit stability and long term predictability of target viewing periods • Both introduce periodic, hours long avoidance periods that must be scheduled around
Communications			Communications
<ul style="list-style-type: none"> • Space Network/Tracking and Data Relay Satellite System • 1-2 contacts per orbit 			<ul style="list-style-type: none"> • Deep Space Network • Nominal 4 hour contacts twice per day / ~12hrs apart
Command execution (absolute time)			Command execution (event relative)
<ul style="list-style-type: none"> • Activity execution times pre-determined 			<ul style="list-style-type: none"> • Activity execution is relative to previous onboard activity
Science constraints (absolute and relative timing/orient constraints)			

HST, Target 'visibility' does not equal Observation 'schedulability'

A target may be in the HST Field of Regard but an HST observation on that target may not be schedulable. The reason is that the preconstructed HST observation cannot be scheduled in the desired orbital viewing period.



The Observation Plan Window STABILITY Horizon

- Solar activity = HST Orbit degradation
- Orbit degradation = changing orbit precession rate
- Change in orbit precession rate = event time uncertainty
- Orbit event time uncertainty = planning time instability
- The orbit in-track position change is quadratic in time
- Currently during Solar Minimum, HST orbit events slip about 1 minute every 10 weeks
- But the slip is ~4 minutes in 20 weeks
- The stability of observing windows over time for phase constrained observations depends on:
 - a. The size of the observation's phase tolerance
 - b. How tightly the observation 'packs' the orbit viewing
 - c. The rate of change of the HST orbit altitude
- Therefore, **Observing windows for tight phase-constrained observations are only stable for several months even during Solar Min (now). This horizon will shrink as solar activity increases as we head into the Solar Max period.**

HST Observation "Orbit Packing"

- HST (LEO) target viewing is interrupted by earth occultations and SAA events.
- PIs use the Astronomers Proposal Tool (APT) to 'construct' observations that will fit into a predictive model of the HST orbit.
- The model of the observation includes all overheads required to execute the observation
 - GS Acq, Small Angle Maneuvers, Instrument/exposure overheads, etc.
- Therefore, the actual 'schedulability' of an HST observation over time is not known until this observation model is created.

Limitations of using the ObsVisSAP protocol for multi-observatory coordination for HST and JWST

- The current ObsVisSAP protocol search result only says when a target is in an observatory's Field of Regard
- An option to specify an observatory orientation constraint would enhance the protocol.

For HST

- An actual HST observation is needed in order to know if that observation can fit in an orbit
- The current ObsVisSAP protocol cannot determine whether an HST observation will actually schedule on a given day.
- A preconstructed HST observation that models the complete observation timing is needed to make that determination.
- Even then, the answer is not deterministic for tightly timed coordination due to the uncertainty in Earth occultation and SAA event timing.

For JWST

- This is sufficient for most JWST observation planning since JWST does not have the LEO timing observing dependencies of HST.
- **Avoidance periods** for momentum management and orbit station keeping activities are not included in target viewing constraint computations.
 - Momentum management activities can be scheduled around science activities
 - Station keeping activities cannot be avoided, but are relatively infrequent.
- Therefore, these are minor limitations to using the ObsVisSAP search results.

ObsVisSAP protocol has limited utility for coordinating a specific observing time (orbit) with HST.

ObsVisSAP protocol could be helpful in coordinating observations with JWST.