Science Implications of Operating HST in Reduced Gyro Mode

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June 1, 2016
Summary

• ~25 percent reduction in scientific productivity in Reduced Gyro Mode (RGM)
  – Fewer schedulable orbits per year
  – Precludes several existing science observing strategies
  – Reduces synergies with other observatories
  – Decreased likelihood of responding to time critical events
Assumptions

• One and two gyro modes are essentially identical for this discussion

• Other components of the PCS are unchanged from the current level of performance (*i.e.* FGS, FHST, etc.)

• Actual performance in RGM will be comparable to that achieved in 2007-2009 (*e.g.* jitter, failed acquisitions, field of regard, etc.)
### Observing Efficiency

- **Single largest impact of RGM**
- Currently averaging >84 orbits per week (plus 5+ Snaps)
- Expect ~73 orbits per week in RGM

- **Loss of 550-600 orbits per year**
  - Assuming that calibration requirements remain the same
- **GO + DD is ~3800 orbits per year implying a 15% reduction**

- **Increased target acquisition time of 2 minutes → 4% reduction**
  - Impact varies greatly by science program (small S/N to one less filter or target)
  - Aggregate impact is ~160 orbits per year

- **Increase in the frequency of failed acquisitions by 1%**
  - Loss of ~40 orbits per year
Field of Regard

- Reduced from 82% to 40-50% of Sky
  - FHST require view of sky during acq
  - Solar exclusion increased from 50° to 62.5°
- Negative Implications for:
  - Time critical observations: availability and long cadence requirements
  - Coordinated observations with other observatories (esp. JWST) which also have limited fields of regard
  - Efficient ACS and WFC3 observations: 180° rolls after six months to observe pairs of fields
  - Uneven demand for observing certain regions of the sky
  - Limitations on orientations (i.e. roll angles)
Notes:
- This is not an exhaustive list.
- Some observations become infeasible, some have reduced populations of targets, and some merely become more inefficient to conduct.

Solar System Objects
- Completely excluded: Venus (solar angle), Moon (gyro pointing control)
- Reduced probability of observing: transient phenomena (e.g. comets, impacts, coordination with interplanetary spacecraft).
  - Comets are most interesting nearest to the solar exclusion zone
  - Loss of (rarely used) capability of guide star handoff for fast moving objects
Science Impacts (2)

• Exoplanet Observations
  – Difficult to schedule observations of repeated transits (esp. long period)
  – Spatial Scans limited to 5 arc sec per second (vs. 8 arc sec per sec with gyros)
    • IR Grism observations of targets brighter than $H_{AB} < \sim 4$ impossible precluding the
      brightest targets
    • Serpentine scans rate restriction is 1 arc sec per second (2 mags further restriction)
      – Serpentine scans provide improved S/N and efficiency for faster transits
    • Roll angle constraints make avoiding nearby sources more difficult to schedule

• Debris Disks and other Coronagraphic Observations
  – Increased power in PSF wings due to jitter excursions $\Rightarrow$ impact uncertain
  – Roll angle deconvolution more difficult (scheduling and restriction to one angle per orbit)
Science Impacts (3)

• Parallax Measurements and ultra-high precision astrometry using the Spatial Scanning technique
  – Key tool for measuring Ho and other new programs at 20 micro arc seconds
  – Spacecraft orientation is key (detector columns and scene)
    • Reduced scheduling opportunities (sometime impossible)
  – Earth parallax requires repeated observations six months apart (see FoR)
  – ESA’s GAIA mission surpasses some HST astrometric capabilities but HST will continue to provide complementary and unique capabilities

• Targets of Opportunity and Simultaneous Observations
  – Reduction in field of regard reduces TOO by 50%
  – Overlap of field of regard with JWST (and near-term follow up) impacted
• Imaging Surveys using ACS+WFC3
  – Efficiency multiplier since SM4 is parallel observations of ACS and WFC3
  – Roll angle constraints to efficiently tile larger areas impacted (PHAT, CANDELS)
  – Pairs of fields observed six months later (180 degree roll)
    • Without this Frontier Fields would require 50% more orbits

• Tiling Mode Observations with WFC3/IR
  – New strategy introduced in Cycle 23
  – Enables wide-shallow surveys with up to 8 pointings per orbit
  – Relies upon gyro pointing control → not possible at all in RGM
Science Impacts (5)

• COS Orient constraints due to dual apertures
  – Necessity of avoiding placing bright sources in secondary aperture
  – Roll constraints will complicate scheduling some COS observations

• Very long term observing campaigns
  – Long term synoptic campaigns will be difficult to impossible depending upon source location
  – Example science programs include supermassive black hole reverberation mapping (6 months of daily COS observations) and long term tracking of supernovae decays
Other Impacts and Considerations

• Calibration Target availability
  – Instrument teams are assessing the need to pro-actively develop additional calibration targets required for monitoring instrument calibration

• Interactions with other aspects of HST life limiting systems
  – For example, FGS usage constraints or failures would further complicate the impacts discussed above

• If voluntary entry into RGM is selected, provision for rapid return to three-gyro observations should be considered
  – Needed to respond to once-in-a-lifetime opportunities (e.g. nearby supernovae, comet impact, etc.)
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