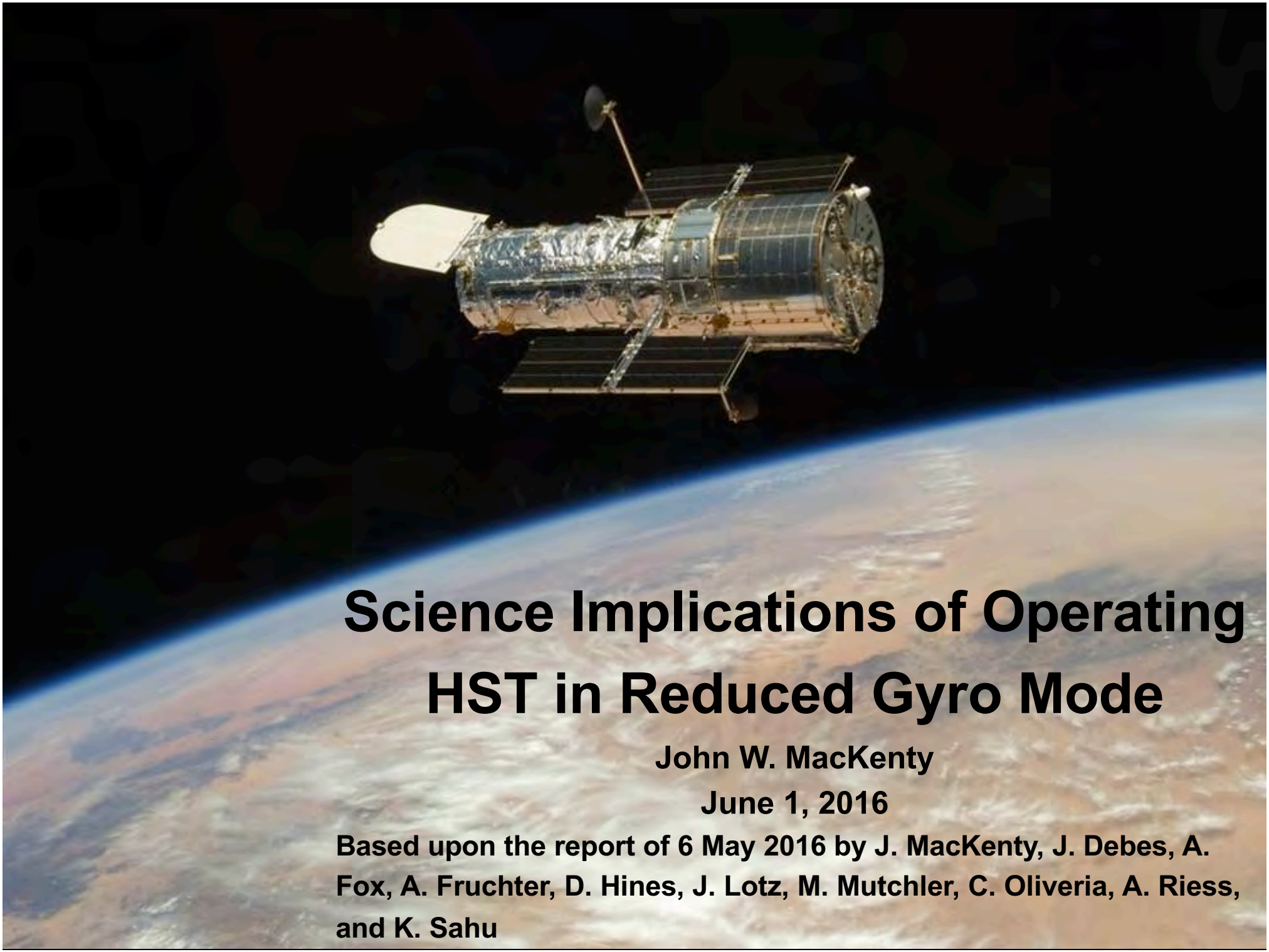


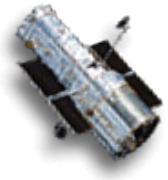
Science Implications of Operating HST in Reduced Gyro Mode

John W. MacKenty

June 1, 2016

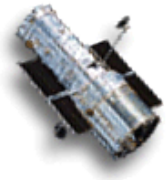
Based upon the report of 6 May 2016 by J. MacKenty, J. Debes, A. Fox, A. Fruchter, D. Hines, J. Lotz, M. Mutchler, C. Oliveria, A. Riess, and K. Sahu

Summary



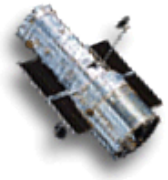
- ~25 percent reduction in scientific productivity in Reduced Gyro Mode (RGM)
  - Fewer schedulable orbits per year
  - Precludes several existing science observing strategies
  - Reduces synergies with other observatories
  - Decreased likelihood of responding to time critical events

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

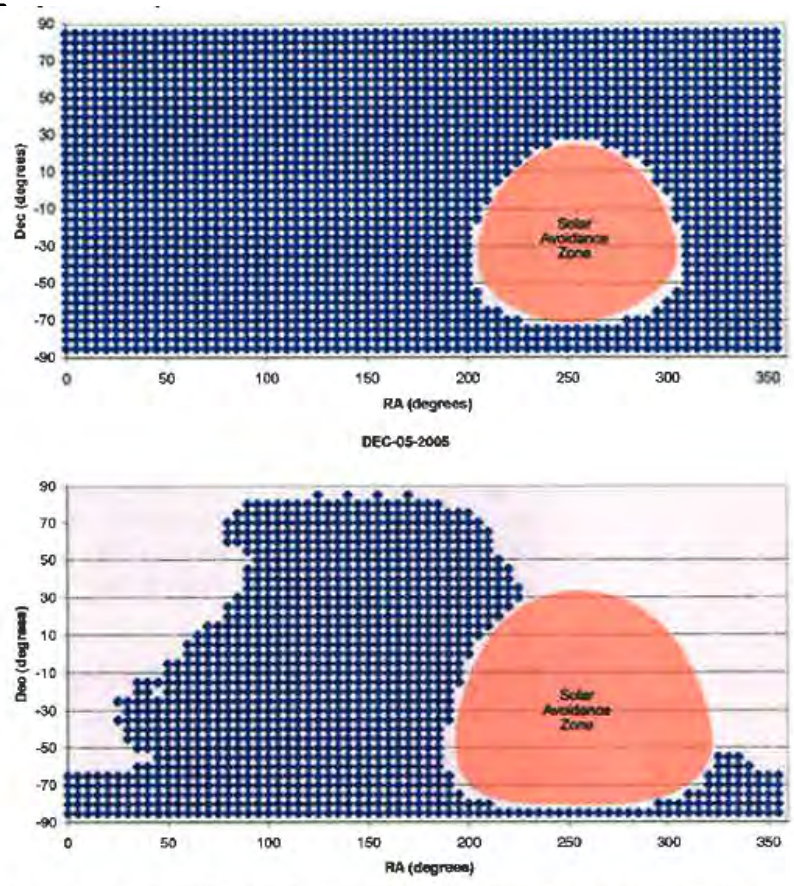
- Loss of 550-600 orbits per year
  - Assuming that calibration requirements remain the same
- GO + DD is ~3800 orbits per year implying a 15% reduction

- 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

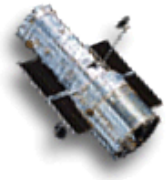
- Increase in the frequency of failed acquisitions by 1%
  - Loss of ~40 orbits per year

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)



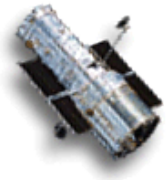
Science Impacts (1)



- 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.

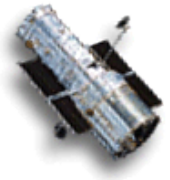
- Solar System Objects
  - Completely excluded: Venus (solar angle), Moon (gyro pointing control)
  - Reduced probability of observing: transient phenomena (*e.g.* comets, impacts, coordination with interplanetary spacecraft).
    - Comets are most interesting nearest to the solar exclusion zone
  - 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}<~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 → impact uncertain
  - Roll angle deconvolution more difficult (scheduling and restriction to one angle per orbit)

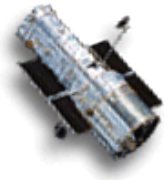
Science Impacts (3)



- 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

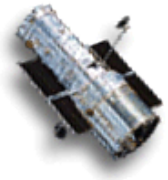
- Targets of Opportunity and Simultaneous Observations
  - Reduction in field of regard reduces TOO by 50%
  - Overlap of field of regard with JWST (and near-term follow up) impacted

Science Impacts (4)



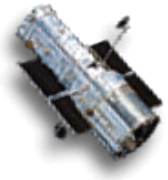
- Imaging Surveys using ACS+WFC3
  - Efficiency multiplier since SM4 is parallel observations of ACS and WFC3
  - Roll angle constraints to efficiently tile larger areas impacted (PHAT, CANDELS)
  - Pairs of fields observed six months later (180 degree roll)
    - Without this Frontier Fields would require 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)



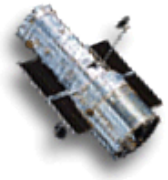
- COS Orient constraints due to dual apertures
  - Necessity of avoiding placing bright sources in secondary aperture
  - Roll constraints will complicate scheduling some COS observations
- Very long term observing campaigns
  - Long term synoptic campaigns will be difficult to impossible depending upon 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.)

Summary



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