Astro 2020

Decadal Survey on Astronomy and Astrophysics

Addressing Programmatic Concerns for the current Flagship Cadence

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References

- Tumlinson, etal, “The Next Great Observatories: How Can We Get There?”, White Paper 269
- Bitten, etal, “Challenges and Potential Solutions to Develop and Fund NASA Flagship Missions”, 2019 IEEE Aerospace Conference

Questions??

- Great Observatories: HST (1990 -), Chandra (1999 -), Spitzer (2003 - 2020[1]), CGRO (1991 - 2000)
- JWST (2021 -), WFIRST (mid-2020s -), future flagships?
- Expected life cycle costs
  - JWST →$9B+ (RY)
  - FROM LCIT: LUVOIR-A → >$10B (FY20), HabEx and LUVOIR-B → $8 – 10B (FY20)

- How to enable concurrent large observatories given budget constraints?
- At what point are large observatories no longer affordable on reasonable timelines?

1 – Cryogen exhausted in 2009

Key concerns identified in Bitten Paper

- Initial cost estimates for missions are typically done through cost models, and analogy.
- Flagships are typically first of a kind.
  - Complex across multiple areas (in new ways)
  - New technologies
  - No expensive to fail
- The ability to accurately predict the cost of a complex flagship mission is not possible until CDR.
- Costs/schedule over-runs not limited to Space. Major construction projects – average cost overrun 80% and 2 years late - (R. Agarwal, etal, "Imagining Constructions Digital Future," McKinsey & Company, June 2016).
- Ditto for other gov development efforts, e.g.: LHC, SSC.

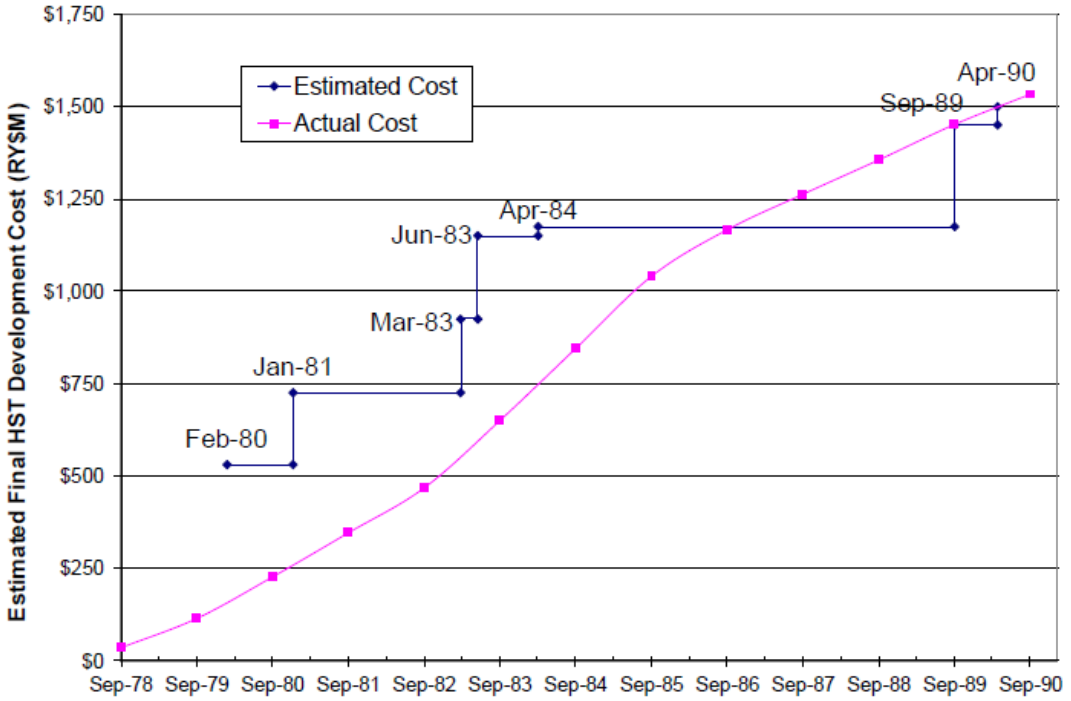


Figure 3. HST Cost Estimates vs. Actual Cost

Recommended New Approach (open ended fixed level of funding)

- **Establish a programmatic baseline after the technology and design has matured.**

1. Assess the value of the science
2. Fund technologies in an open ended manner to TRL-6 with defined pass/fail criteria. Fund till pass TRL gates.*
3. Begin open ended Phase B to mature system to TRL-6
4. Agree to open ended funding level until prototype is complete*
5. After technologies matured, develop a prototype to understand scope of work
6. As prototype nears completion, complete Project cost estimate and approve Project in conjunction with CDR
7. Get congressional approval for all remaining development funds (like US Navy funding for aircraft carrier procurements, Shuttle Endeavour) – "no year funding" – lowers uncertainty in future funding
8. Conduct Phase CD as is currently defined

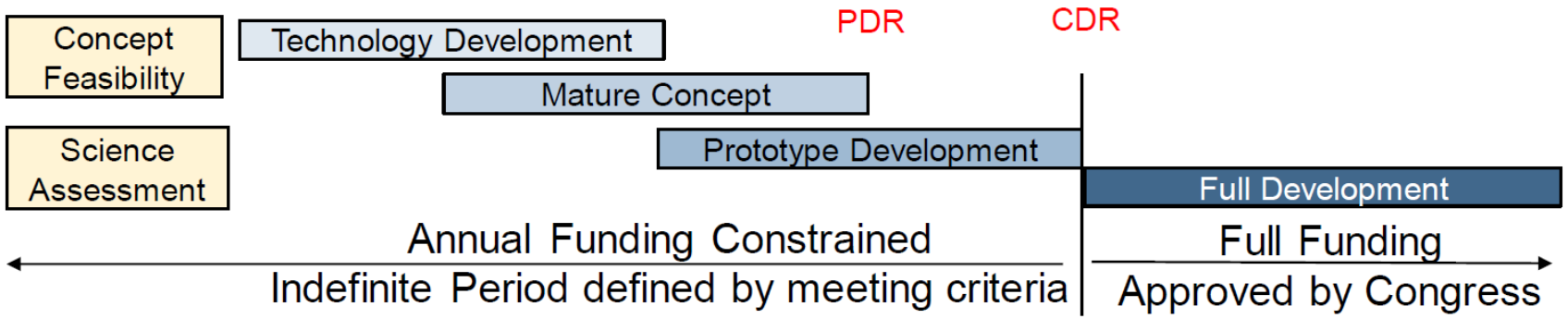


Figure 10. Proposed Approach to Developing and Funding Flagship Missions

Simulation Results

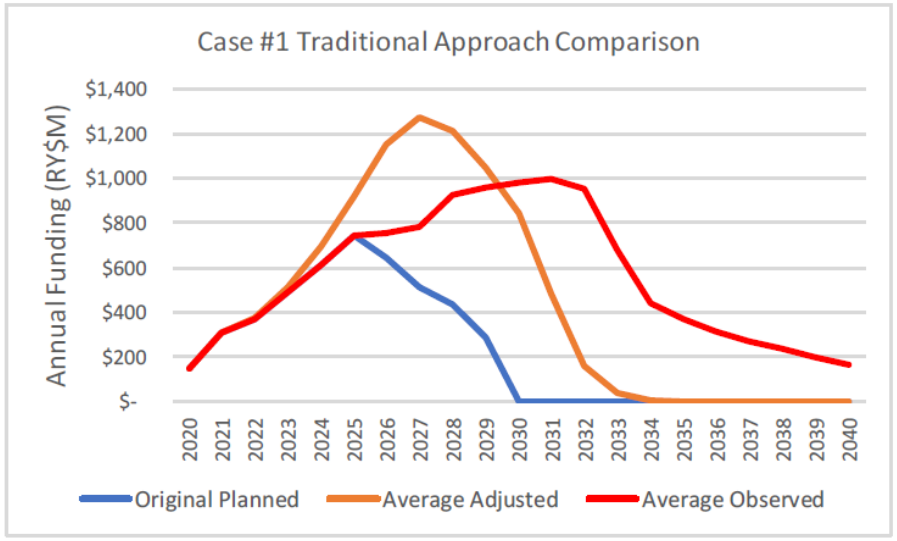


Figure 11. Case #1 Traditional Funding Comparison

Table 2. Planned vs. Observed Comparison for Case #1

Case #1 Traditional	Original Planned	Simulation Observed
Launch Date	March 2029	May 2035
Cost (FY$20)	$4.0B	$9.5B

Table 3. Planned vs. Observed Comparison for Case #2

Case #2 New Approach	Original Planned	Simulation Observed
Launch Date	March 2033	January 2034
Cost (FY$20)	$7.0B	$7.7B

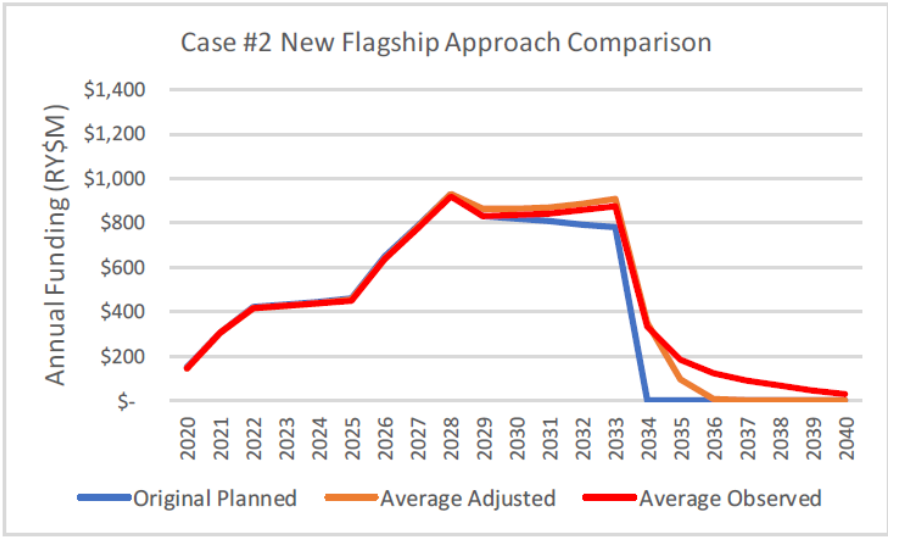
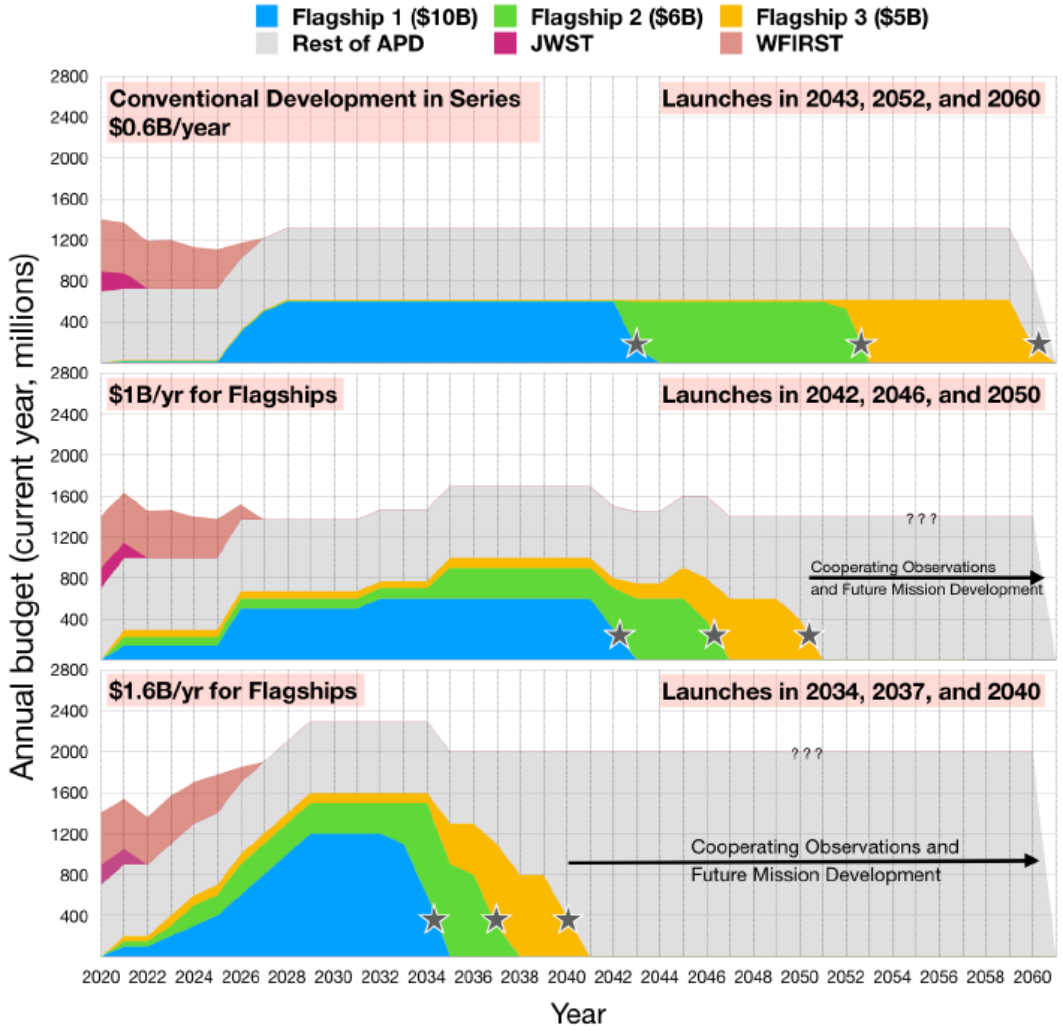


Figure 12. Case #2 New Approach Funding Comparison

- 1) original planned funding, 2) adjusted, unpenalized funding that would be needed if the budget was unconstrained, and 3) observed, penalized funding profile given the annual budget limit imposed by the project.

Tumlinson, etal.

- Figure 1: Hypothetical budget profiles for three different scenarios in which three flagship missions are developed and launched. The top panel shows three launches in sequence but fails to yield simultaneous operation before almost 2060, if at all. **With $0.3-1.0B growth** in the Astrophysics "top line" for flagships, on the order of recent increases to NASA's planetary science division, the three flagships can launch within a decade of one another and potentially operate together for a long time.
- Middle graph applies the Bitten model plus 300M to 400M per year of additional budget
- Bottom graph applies additional budget of 1B per year



Summary Thoughts

- Bitten, etal offer some ideas on how to address flagship cost certainty.
  - Does not address multiple Observatories, but does address cost uncertainty which can lead to additional budget.
  - From experience, developing technologies without maturing the whole system can lead to significant design churn. Model can be tweaked.
- Tumlinson, etal, utilizing methods from Bitten offer thoughts on how to get concurrent flagships, but additional budget is still required.
  - Verification of models is recommended.
- Other thoughts:
  - Probe/Flagship pairs? Probes used as gap fillers to keep science community engaged.
  - Probes as risk reduction/tech demo for flagships.
  - On Orbit assembly in Earth or Cis-lunar
    - Incremental capability, spreading cost over many budget years, new technology infusion?
  - Assessment of Photonics capability (VanBuren, etal. White Paper 272)