JOHNS HOPKINS
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Tipping Our Caps: How Well Does SMEX Fit into its Cost Cap?

NASA Cost & Schedule Symposium 2022

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A Brief History

- *Faster, Better, Cheaper*
  - Small, quick development, low cost missions
  - Began in 1988
- Cost cap has fluctuated over the years, but always under $200M FY22$
  - However, is this baseline definition of “cheaper” realistic?

Summary of SMEX Missions

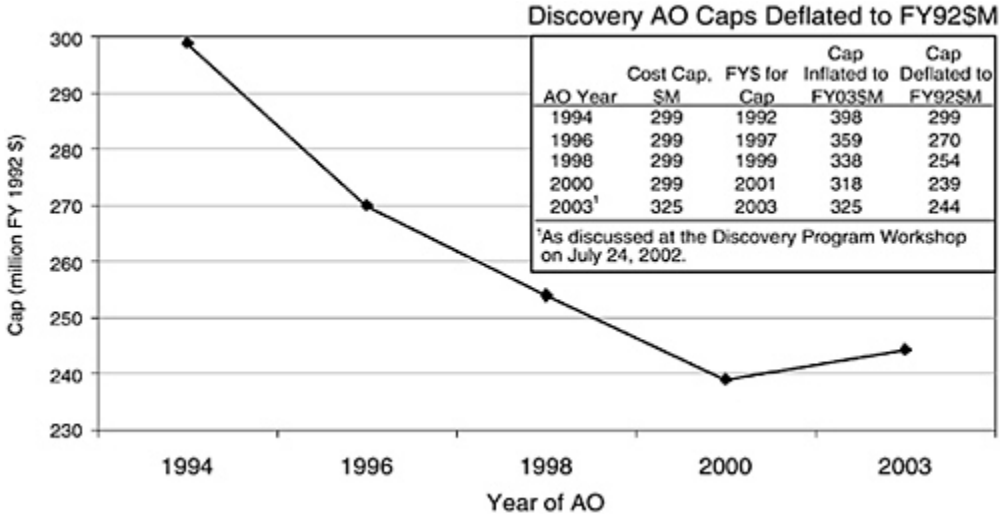
- SAMPEX (H)
- FAST (H)
- SWAS (A)
- TRACE (H)
- WIRE (A)
- RHESSI (H)
- GALEX (A)
- SPIDR (A – *cancelled*)
- AIM (H)
- IBEX (H)
- NuSTAR (A)
- IRIS (H)
- GEMS (A - *cancelled*)
- IXPE (A)
- PUNCH (H – *in dev.*)
- TRACERS (H – *in dev.*)
- COSI (A – *in dev.*)

17 SMEX missions initiated

- 9 Heliophysics SMEX
- 8 Astrophysics SMEX
- 2 cancelled

Impact of Inflation

- A previous study by ESSSO in 2002 on Discovery AO cost caps resulted in HQ raising the Discovery 2004 AO cost cap



AO Year	Cost Cap, $M	FY$ for Cap	Cap Inflated to FY03$M	Cap Deflated to FY92$M
1994	299	1992	398	299
1996	299	1997	359	270
1998	299	1999	338	254
2000	299	2001	318	239
2003[1]	325	2003	325	244

[1]As discussed at the Discovery Program Workshop on July 24, 2002.

- Has the same thing happened with SMEX?
  - *Spoiler alert: YES!*

Chart from "PI-Led Mission Performance: Cost, Schedule, and Science" (2006)

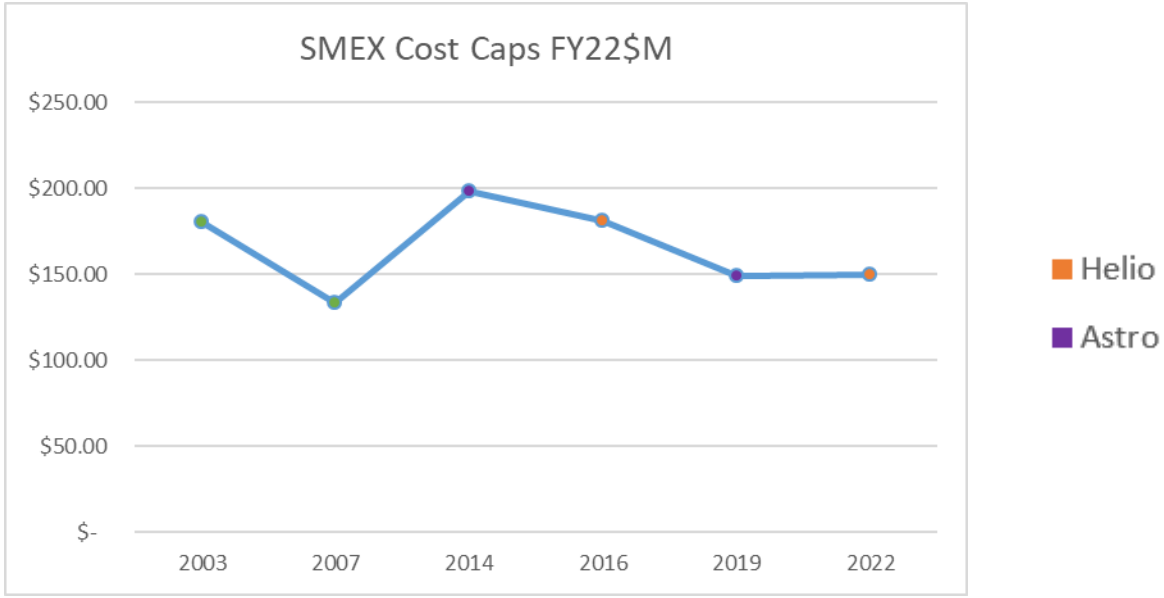
Inflation on SMEX Cost Cap

- Another study done by SMD on Explorer-class mission cost caps in 2018 shows the SMEX cap has decreased over time when discounting the launch vehicle cap

Chart from "Explorer-class Cost Caps" (2018)

Motivation

- Latest Helio SMEX Community Announcement of an expected cost cap of $150M FY22$
  - Historical data seems to indicate this may be low for the expected science return
  - When baselined in FY22$, it is also tied for the second lowest cost cap for a SMEX solicitation*

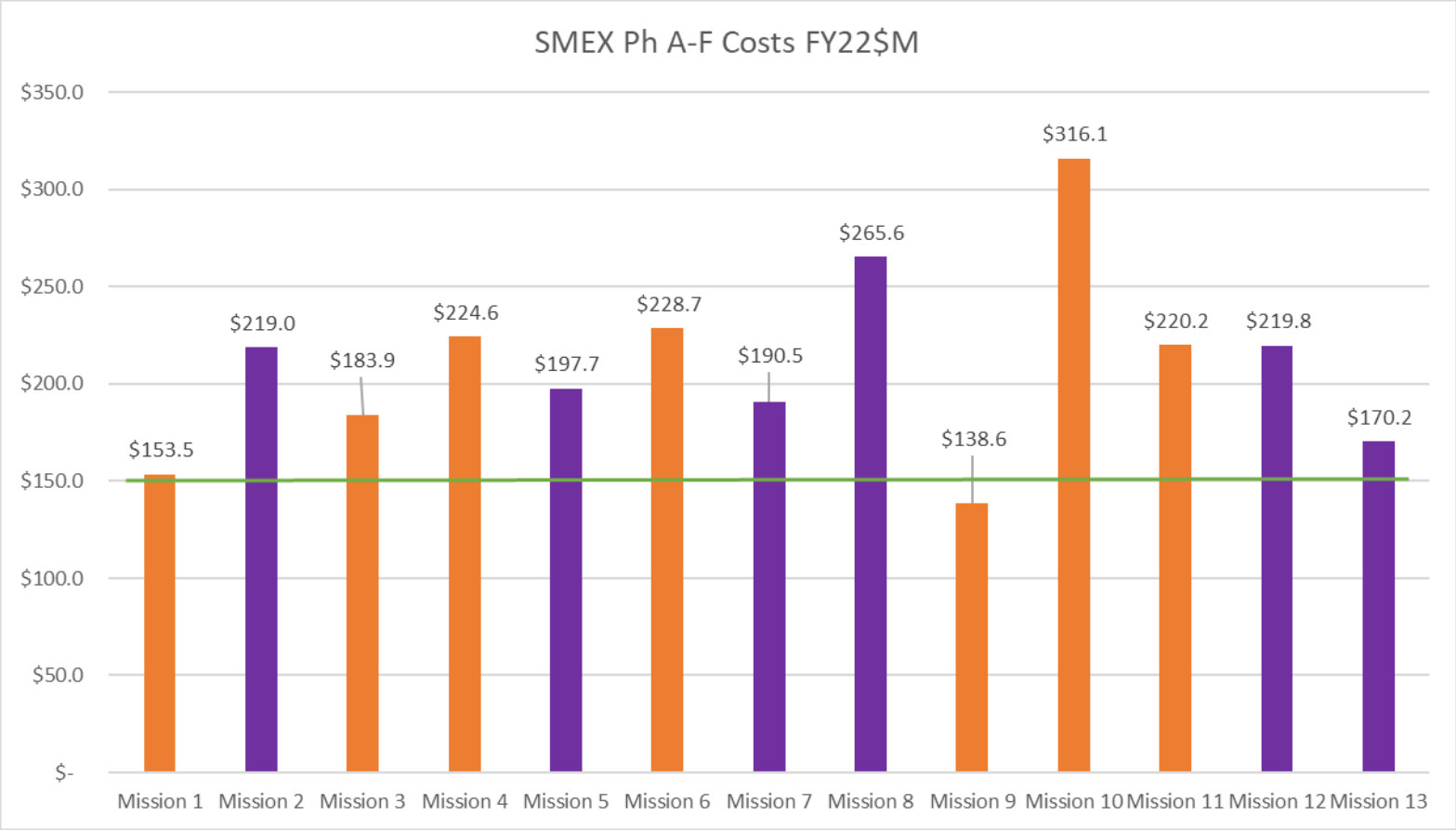


** Based on SMEX AOs available on NSPIRES*

Methodology

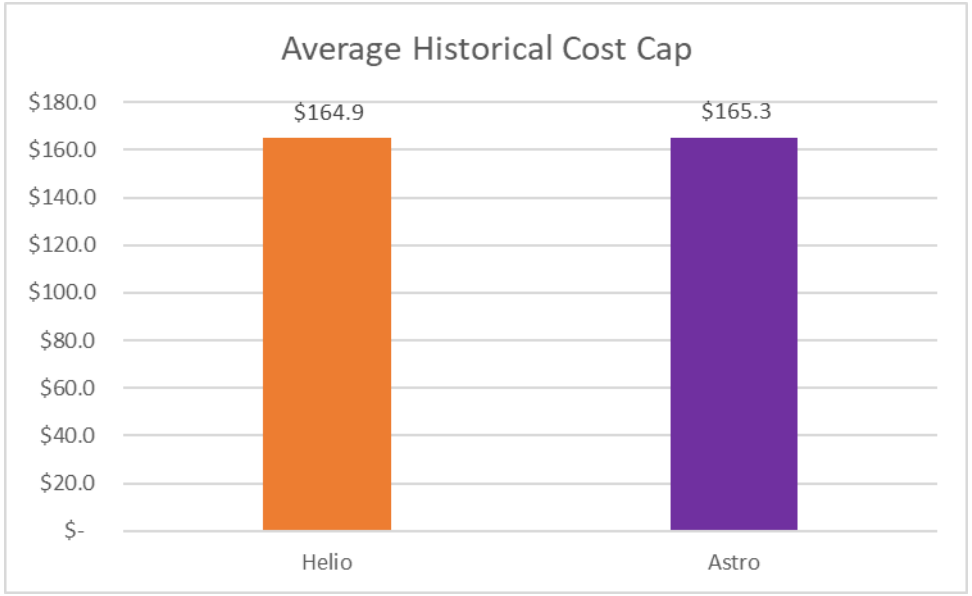
- Cost cap data gathered directly from solicitations on NSPIRES
- Actuals gathered from CADRe
  - Two exceptions (NASA press releases)
- Costs baselined to FY22$
- Costs are for Phases A-F
- No LV costs have been removed

SMEX22 Proposed Cap vs Actuals



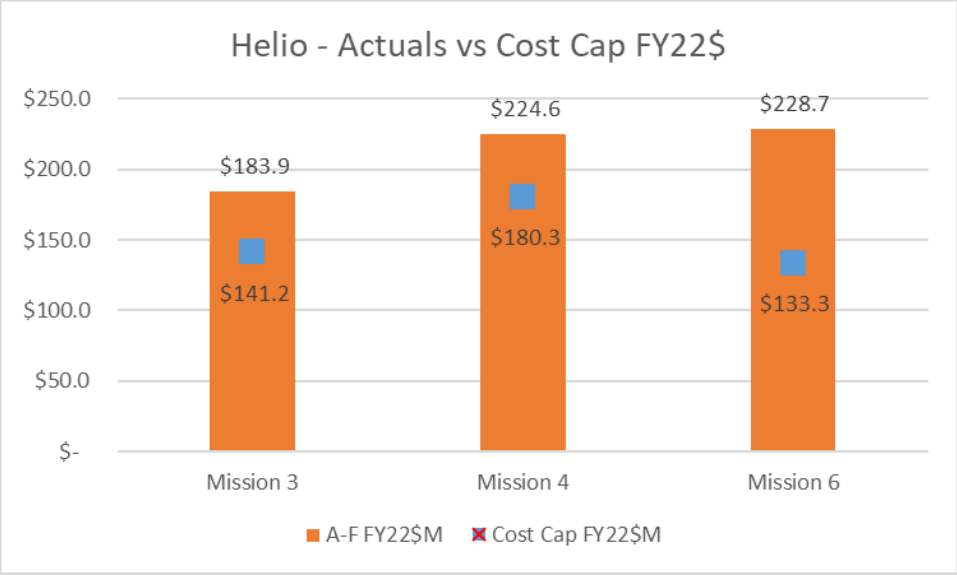
- Average mission cost: $209.9M FY22$
- Median mission cost: $219.0M FY22$

Astro vs Helio Cost Caps (2003 – Present)



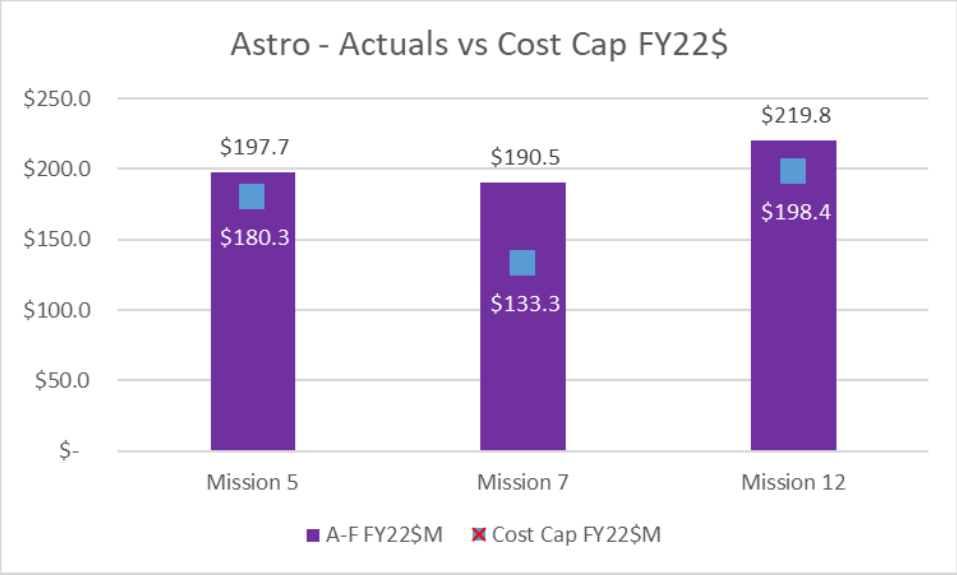
- Average historical Helio cost cap is $164.9M FY22$
- Average historical Astro cost cap is $165.3M FY22$
- Cost cap is trending downwards
  - SMEX 2007 cost cap: $105M FY08$ ($133.3M FY22$)
  - Astro SMEX 2019 cost cap: $145M FY20$ ($149.2M FY22$)

Heliophysics SMEX Cost Growth



- 2 missions with cost cap vs actuals, 1 mission with proposed costs (AO cap not available) vs actuals
- Average growth from cost cap through EOM: 42%
- Average of all Helio SMEX cost: $209.4M FY22$
- Median of all Helio SMEX cost: $220.2M FY22$

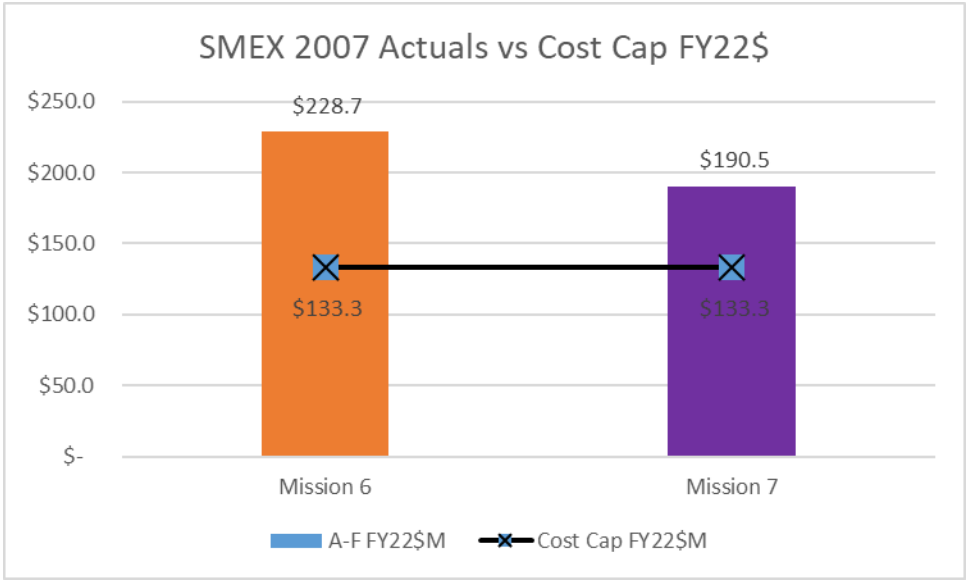
Astrophysics SMEX Cost Growth



- 2 missions with cost cap vs actuals, 1 mission with cost cap vs estimated LCCE before cancellation
- Average growth from cost cap through EOM: 21%
- Average of all Astro SMEX cost: $210.5M FY22$
- Median of all Astro SMEX cost: $208.4M FY22$

What happened to SMEX '07?

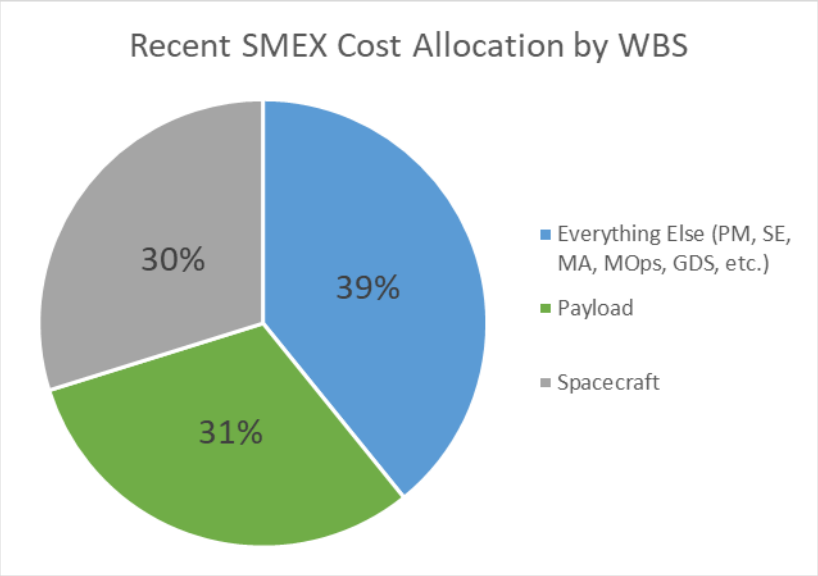
- AO 2007 cost cap of $105M FY08$ ($133.3M FY22$)
  - Lowest cost cap for SMEX of available AOs on NSPIRES with completed missions
- Two missions selected
  - 1 Helio: Mission 6
  - 1 Astro: Mission 7



- Mission 7 cancelled due to cost overruns
  - LCCE before cancellation of $190.5M FY22$
- Mission 6 spent $228.7M FY22$, growing 72% over the cap

Where are the costs being spent?

- A majority of a SMEX mission's costs are spent on hardware
  - Survey of 6 latest SMEX missions actuals



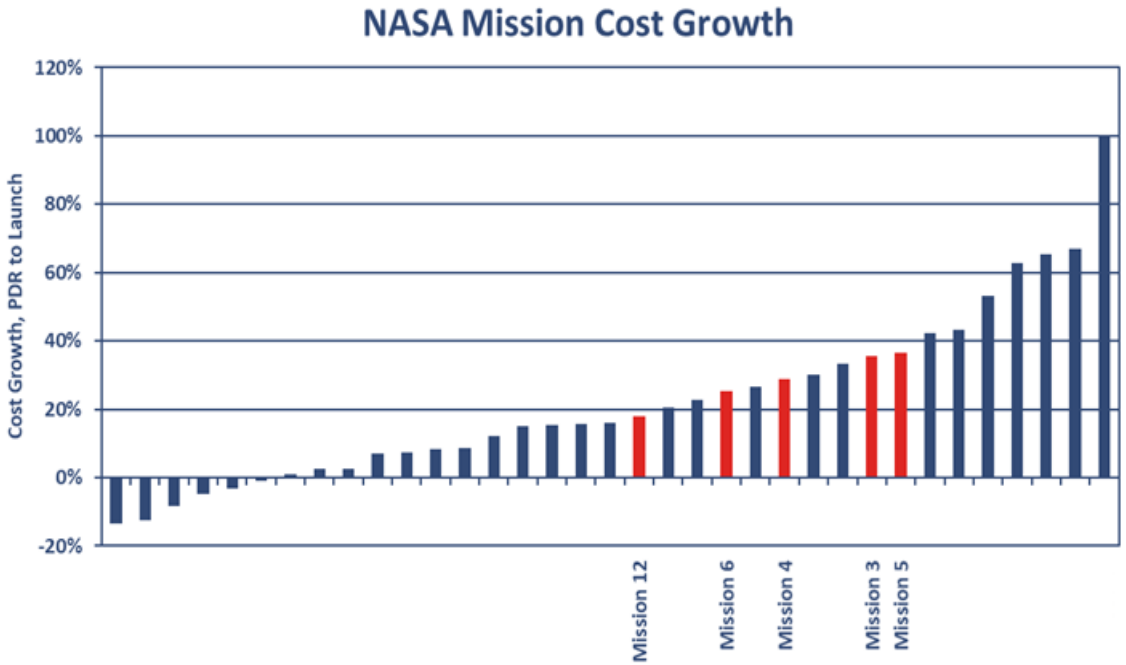
  - In dollars, this is $45.7M FY22 spent on WBS 5 and $45.0M FY22 spent on WBS 6

Bridging the Gap: Expectation and Reality

- Potential disconnect between desired science return and cost expectations
  - Only 2 previous SMEX missions have come in ~$150M FY22$ (potential Helio SMEX 2022 cost cap via Community Announcement)
- Smaller, faster, more efficient?
  - Focus on utilizing procured or COTs S/C when able to
  - Balance cost controls and meeting schedule deadlines against science
- Do SMEX grow more than typical NASA missions?
  - Need to do a deeper dive to be sure
  - Comparisons were made to cost cap, not cost growth from PDR to Launch as is typically calculated for cost growth %

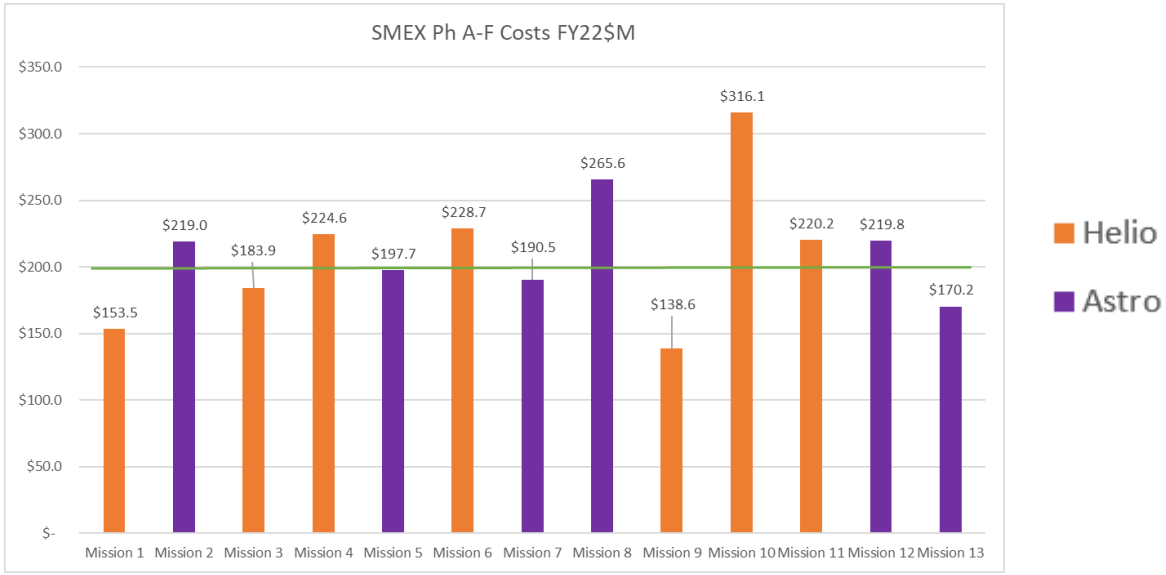
Math is Hard (Sholder, 2022)

- Tomorrow's presentation will go over one of the ways the community can help with controlling costs
  - Different portion of mission costs studied than this presentation
    - Cost growth studied from PDR to Launch
  - 5 SMEX missions included in dataset of presentation tomorrow



Conclusions

- Currently, the “sweet spot” for SMEX mission costs seems to be ~$200M FY22$



- $150M FY22$ is not impossible, but will require compromise on science or embracing emerging technologies in the small spacecraft field
- The effects of inflation (compounded and sudden) should be taken into account and mitigated

Areas for Further Study

- Study cost growth from AO cost cap to EOM for other lines of NASA missions (Discovery, MIDEX, etc.) to see if the growth on SMEX is in family
- Capability and cost for commercially available small spacecraft vs in-house or custom builds
- Effect of payload size on costs
  - Helio SMEX tended to have a larger # of instruments in the payload vs Astro SMEX tended to be single instrument payloads
  - Would there be cost savings if Helio science can be completed with fewer instruments?
- Is there a way to quantify science return to inform future cost caps? How much science are you buying?

References

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  - SMEX AO 2007
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- Web: SMEX 99 Down Select Information (https://www.hq.nasa.gov/office/oss/codesr/smex/smex99/index.html)
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  - Chapter 5: PI-Led Mission Performance: Cost, Schedule, and Science
- Steps to Facilitate Principal-Investigator-Led Earth Science Missions (2004) National Academies of Sciences, Engineering, and Medicine. (https://doi.org/10.17226/10949)
  - Appendix: PI-Led Missions and Their Characteristics

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