STROBE-X Study Processes and Deliverables

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Science Team Meeting
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Most slides adapted from NASA Probes Kickoff instructions to PIs

NASA's Goal

- NASA is supporting the Probe Studies for submission to the Decadal Committee
- These Studies are chartered by NASA and the Study PIs are responsible for delivering the final products (a Study Report report and an Engineering Concept Data Package) to NASA
- NASA will submit the Studies' final products to the Decadal Committee, as defined later in this package
- The Decadal Committee will have the option to prioritize any of these mission concepts, or recommend a competed line of Probes (similar to Explorers)

Selected Probe Mission Concept Studies

PI	Affiliation	Short title	Design Lab/Prog Office
Camp, J.	NASA's GSFC	Transient Astrophysics Probe	IDC/PCOS-COR
Cooray, A.	Univ. California, Irvine	Cosmic Dawn Intensity Mapper	TeamX/ExEP
Danchi, W.	GSFC	Cosmic Evolution through UV spectroscopy	IDC/PCOS-COR
Glenn, J.	Univ. of Colorado	Galaxy Evolution Probe	TeamX/ExEP
Hanany, S.	Univ. of Minnesota	Inflation Probe Mission Concept Study	TeamX/ExEP
Mushotzky, R.	Univ. of Maryland	High Spatial Resolution X-ray Probe	IDC/PCOS-COR
Olinto, A.	Univ. of Chicago	Multi-Messenger Astrophysics	IDC/PCOS-COR
Plavchan, P.	Missouri State Univ.	Precise Radial Velocity Observatory	No design lab funded/HQ grant
Ray, P.	Naval Research Lab	X-ray Timing and Spectroscopy	IDC/PCOS-COR
Seager, S.	MIT	Starshade Rendezvous	TeamX/ExEP

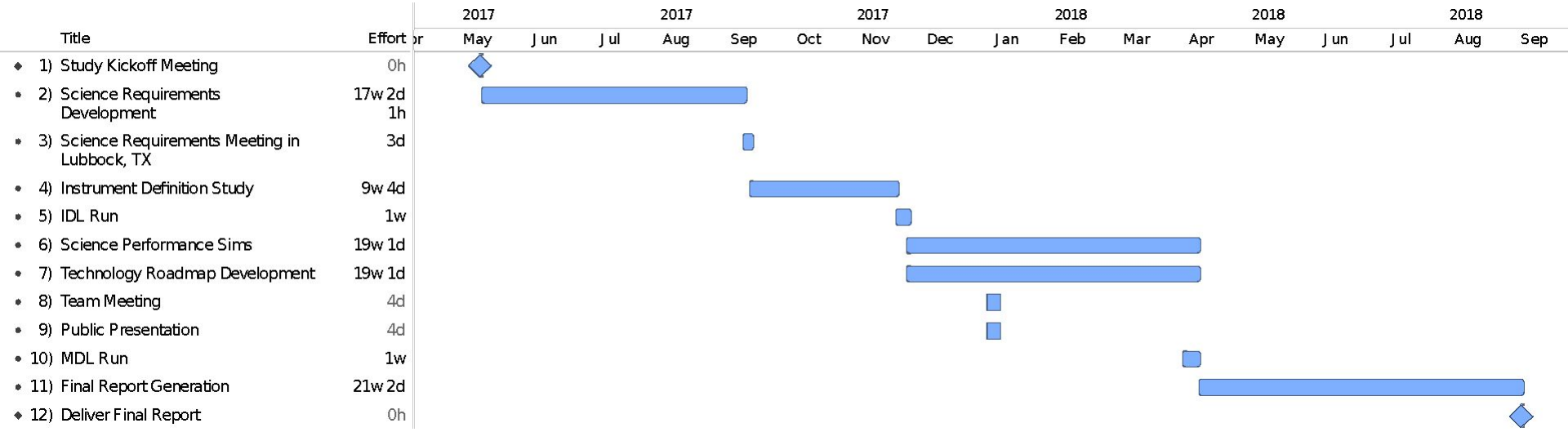
Plus other self-funded studies are ongoing

Points of Contact (POCs) for the Study Teams:

- **G. Karpati, PCOS/COR**
- K. Warfield, ExEP

Studies not in "competition", but TAP has significant overlap. Need to highlight how STROBE-X does on LIGO EM-followup and GRB science!

STROBE-X Study Schedule



Probe Session at the Winter 2018 AAS

- NASA is organizing two back-to-back special sessions at the winter 2018 AAS meeting for the Decadal studies, to inform the astrophysics community of the progress achieved thus far in all NASA-sponsored studies:
  - Morning session: Large Scale Studies (includes Lynx)
  - Afternoon session: Probes studies
- Special sessions have an allocation of 90 minutes
- Each Probe study will have ~10 minutes (including questions) to present the status of the Study, including: science case, activities to date, noteworthy results so far, announcements for workshops, future steps
- NASA does **not** expect that at the time of the 2018 AAS meeting the mission design labs will be completed for the purpose of the presentation, nor that cost estimates will be defined.
- NASA has also asked the AAS to allow an adjunct Probes Poster Session for the ten Probe Studies. ** **Please consider presenting! Deadline October 3!**

Final Study Products

- Each 18 month Probe Study is required to generate two major products for submission:
  - A Study Report, and
  - An Engineering Concept Definition Package

- The principal product of the 18 month Probe Study is a Study Report.
  - Your Study Report is due at the end of either the 18-months or the no-cost extension, but absolutely no later than December 31, 2018.
  - Submit your Study Report to your Point of Contact, your POC will then forward it to HQ with a qualitative internal assessment. HQ will append the Independent Cost Estimate to it and deliver that package to the Decadal Committee.
  - At initial delivery, the Decadal will only receive your Study Report and the Independent Cost Estimate, but not your Engineering Concept Definition Package. Upon request from the Decadal, HQ will also deliver to them your Engineering Concept Definition Package after removal of any ITAR sensitive information.

- The other major study product is your Engineering Concept Definition Package.
  - The Engineering Concept Definition Package is originally generated by the Concurrent Design Lab supporting your Study. You may later choose to create a modified version of it. The final version of your Engineering Concept Definition Package gets submitted to the Independent Cost Estimator organization (SOMA) alongside your Study Report for an independent cost estimate.
  - The Independent Cost Estimator organization will see both your Study Report and your final Engineering Concept Definition Package.

Study Report – Content

- The Study Report is the complete standalone definition and documentation of your proposed mission.

- The Study Report should be science heavy. The Decadal Panel makes its recommendations based on science, or more specifically based on science for the costs stated. At least half of the Study Report should cover:
  - The science case,
  - The observations, and
  - The science yields.

- The Study Report should cover areas similar to a typical AO response, although not with the same emphasis and proportions, as your document should be relatively heavier on science. Recommended contents:
  - Executive Overview (suggest 2-4 pages)
  - List of Participants
  - Science Case
  - Observations, Measurements, Design Reference Mission (w/ Science Yield Estimate)
  - Instrumentation, Payload, Optics, Detectors, etc.
  - Mission Design, Observatory, Spacecraft, Launch Vehicle, Ground Stations, etc.
  - Concept of Operations
  - Technology, Technology Roadmaps
  - Project Schedule
  - PI Team's (or Design Lab's) Cost Estimate with Justification

Study Report – Page Limits

- The maximum page limit for the Study Report is 50 pages
  - Strongly suggest keeping the page count between 20 and 40 pages
  - Appendices are allowed but not required, and count against the 50 page limit
  - *The above page counts assume conventional "proposal style" formatting comparable to the THEIA Study Report shown as a sample in Appendix B*

- Your Study Report may be released to the public by the Decadal Committee. No ITAR sensitive or Proprietary material!
  - The responsibility for compliance with ITAR and Proprietary Material regulations rests 100% with the authors. If not sure, request assistance from qualified services at your supporting organization. NASA will not provide additional funds for that activity.

Engineering Concept Definition Package

- The primary purpose of the Engineering Concept Definition Package is to demonstrate feasibility of your science.
  - It will almost certainly not define as is the mission that will actually fly if your mission is selected by the Decadal Committee
- The primary use of the Engineering Concept Definition Package is for an independent cost estimate.
- The initial version of your Engineering Concept Definition Package is generated by the Concurrent Design Lab supporting your Study (Team-X or IDC).
  - It is possible, but unlikely, that the initial version of the Engineering Concept Definition Package will suit you to serve as your final deliverable as is, without any modifications.
- It's probable that after your Concurrent Lab run, you may need to modify your original concept to meet performance, mass, cost, and other constraints.
  - Doing so, you may wish to create a modified version of the Engineering Concept Definition Package to accurately reflect your modified concept.
- It is IMPERATIVE that at submission time, the final version of your Engineering Concept Definition Package reflect the mission described in your Study Report with 100% accuracy, as that package serves (alongside your Study Report) as the basis of the independent cost estimate.
  - The following slide defines three options for the Engineering Concept Definition Package modifications, all of which are suitable for an independent cost estimate, therefore submissible.

Engineering Concept Definition Package Options

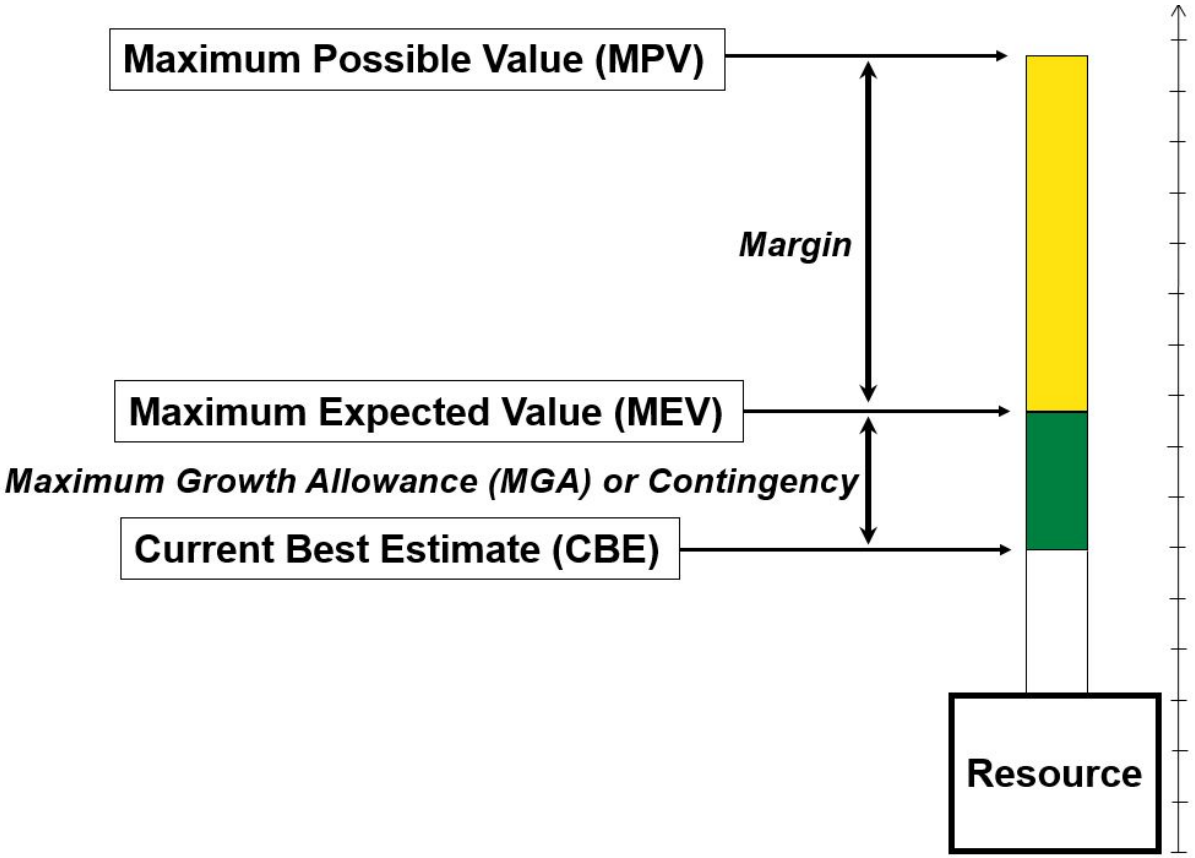
- Three options of the Engineering Concept Definition Package are acceptable for submission to the independent cost estimate:
  - Option A: **Submit the original Final Products of the Concurrent Labs** as is
    - This option will be used if the Probe Team gets really lucky, or has planned exceptionally well, and as a result the Final Products of their Concurrent Labs runs are acceptable for submission as is without any modification, as they reflect with 100% accuracy the true Final Configuration of their mission as described in the Study Report.
  - Option B: **Submit modified versions of the Final Products of the Concurrent Labs**, which are very similar in form and style to the original Products of the Concurrent Labs.
    - This option will probably be the most "popular" one. It is for Probe Teams that need to modify the Final Products of their Concurrent Labs, and managed to enlist capable engineering help to do so. The modified versions of the Concurrent Lab Products must be similar in form and content to the originals, must document a modified design that "closes", and must reflect with 100% accuracy the Probe Team's true Final Configuration as described in their Study Report.
  - Option C: **Submit the original Final Products of the Concurrent Labs as is, with an appended "Errata" in plain English language.**
    - This option is for those Teams that needed to modify the Final Products of the Concurrent Labs, but could not enlist sufficient engineering help to execute the modifications properly; nevertheless they need to convey to SOMA that their true Final Configuration as described in their Study Report is not well reflected by the Final Products of the Concurrent Labs. All the differences that should be taken into account in costing are described in the Errata.
    - In the Errata, the Probe Team describes as best they can the final configuration of their mission in agreement with the Study Report, enumerate the differences between the Concurrent Labs' Final Products and their true Final Configuration, and also attempt to account for and describe all derivative effects.

Technology for Probes Mission Concepts

- The funding for the selected Probe Study does **not** include funds for technology maturation. NASA will **not** provide separate funds for technology maturation to the study teams. Technology maturation is being accomplished through the normal APRA and SAT processes. Decadal prioritization will be needed first to change current technology maturation funding priorities.
- The final Study report should provide a list of technologies needed to accomplish the mission (a "Technology gap" list), and a roadmap for its maturation should the Probe mission concept be prioritized by the Decadal
- NASA will include planning for the maturation of technologies needed for all Decadal Survey prioritized activities (including large and medium missions) in its planning for the 2020s that will follow the Decadal Survey.
- The Independent Cost Estimators (SOMA) will generate independent estimates of the costs required to mature to TRL 5 the technology gaps described in the Probe Study's Technology Roadmaps
  - TRL-5 must be reached by Phase-A start date, assumed to be 10/1/2023
  - TRL-6 must be reached by PDR
  - The independent technology maturation cost estimates will be treated entirely separately from the Probes' Independent Cost Estimates, and will only be used by HQ and the Decadal as secondary or advisory information

Contingency and Margin Definitions

- Contingency: a possible occurrence or result
- Margin: an amount beyond the necessary



Mandatory Rules

- **MISSION CLASS:** All 2020 Decadal Probes shall be CLASS-B
  - That is "pure" unmodified Class-B
- **LAUNCH VEHICLE COSTS:** All probe studies shall use $150M as their EELV Launch Vehicle cost
  - The $150M only applies to all EELV's, any version, any configuration (incl. DPAF). It includes all launch services.
  - The above cost doesn't apply to the SLS, the Falcon 9 Heavy, and other "Heavies". If you plan to use any of those LV's, contact your POC.
  - You may only use US LV's listed in NASA's LV "stable"
- **COST RESERVES:** Unencumbered cost reserve shall be 25% of the Phases A/B/C/D cost
  - Unencumbered reserve are reserves that are free of liens and are held for risks that may be realized during project execution.
  - Concepts that are unable to show adequate unencumbered cost reserves are likely to be judged a high cost risk and not selected.
- **DOLLAR YEAR:** All cost numbers, including the $1B grand total lifecyle cost, are/shall be presented in FY18 dollars.

Mandatory Rules (cont'd)

- **START DATE:** The Start Date for Phase-A of your hypothetically selected mission shall be 10/1/2023
  - The 10/1/2023 start date shall be used in all Probe studies' design, schedules, and cost estimates.
  - That start date is based on the anticipated release of the Decadal Survey Report in 2021, followed by a two year Congressional Budget Cycle, putting the earliest conceivable start date of a Probe mission at October 1, 2023.
- **TRL:**
  - All technology used in the Probe mission shall be at TRL-5 or higher at the start of Phase A
  - All technology used in the Probe mission shall be at TRL-6 or higher at PDR

Costing Rules of Thumb (cont'd)

- The spacecraft and payload costs are about or less than half of the total cost of the mission:

- L/V	150M
- Reserves	215M
- Operations (5yrs@$15M/yr)	75M
- Mgmt, Sys Engrg, Mission Assurance	40M
- Ground System Dev. And Ops Team	40M
- Pre Launch Science, EPO, and Misc.	20M
Sum Non-Spacecraft/Payload:	*540M*
Total Remaining for Spacecraft, Payload and ATLO	**$460M**

- The total of Launch Vehicle and Reserves are usually well over 1/3 of the $1B total budget
  - Non-hardware costs have limited potential for savings
  - Launch mass becomes a significant cost driver

Costing Rules of Thumb (cont'd)

- A spacecraft bus comparable to the Kepler bus would cost today ~$160M to $170M
- OTS S/C bus able to handle a 500kg payload costs $80-$180M
  - Costs based on a 2011 Team X survey of OTS S/C vendors
  - All will likely need uncosted upgrades to meet pointing and other require
  - Cost includes ATLO
  - Generally, lower cost equals lower capability
- Instruments typically cost $800-1000k/kg
  - Based on NASA Instrument Cost Model (NICM) actual instrument cost
  - Assumes Class B Earth orbiting mission
  - Does not include telescope
  - Does not include technology development
- An on-axis 1.0-1.5m telescope costs $50-110M
  - Based on 2013 cost model inflated into $FY15
- Second unit cost is about 50% of the first unit cost
  - Based on NICM instrument re-flight data and 1996 Aerospace Small Sa Cost Model ver. 2.0 data
  - The second unit should be close in time to the first unit to be credibly build-to-print

Our payload is much more massive than this!

We have to argue for a much lower scale factor

Do **not** call us a telescope!

Working on a cost strategy, including analogies with Fermi, a probe class mission with similar mass, complexity and spacecraft capability

Weaknesses from Review

- The value for a wider range of possible science (e.g. GW, high-redshift GRBs and other transient follow-ups) was not addressed in sufficient detail. This would be important, both to serve a broader community and to show that it can address other hot topics to be considered by the decadal survey.
- The proposal did not make clear how STROBE-X measurements of cluster abundances will compare with those of **ATHENA** in the same time-frame.
- The proposal did not adequately describe the impact of telemetry limits on providing full photon event information (energy, time) for bright sources. The proposers note that RXTE was able to use specialized data modes to telemeter data from high count rate sources, and that the same approach could be considered for STROBE-X. However, this would lead to a loss of information which may have an impact on the proposed spectral-timing studies.

Final Thoughts

- STROBE-X concept grew out of LOFT and NICER
- Science case should be broader than either of those
  - Much more area than NICER
  - New energy range and much improved energy resolution compared to LOFT
- Design is highly scalable and we may need to use that to get into cost cap with high confidence. We can NOT afford to be judged too expensive to be a probe!