TRACE[1]: Astro2020

(Technical Risk and Cost Evaluation)

Randy Persinger

July 16, 2019

[1] Previously known as CATE

Recent Decadal Survey Timeline

- **2009 - Astro2010 (Astrophysics)**
  - *8 space-based concepts ($1B - $9B)*
  - *9 ground-based concepts*
  - *Concepts chosen from community white papers*

- **2010 – Planetary Sciences**
  - *15 space-based concepts ($1B - $7B)*
  - *Concepts generated by panels & NASA Centers*

- **2011 – Heliophysics**
  - *6 concepts plus 3 variations ($0.5 - $1B)*
  - *12 conceptual designs developed by Aerospace*

- **2017 – Earth Science and Applications**
  - *3 measurement proof of concepts ($0.6B - $1B)*
    - "Binning estimates" for 20-30 concepts
    - No real design concepts, minimal definition

NAS & Aerospace partnership created and improved the TRACE process

Independence Is Paramount

- **Independence of the TRACE Team, or contractor, is mandated by law**

- **TRACE is based on "*life cycle costs*" of "*missions assessed*"**
  - ***"Technical readiness"*** *is an important factor*

PUBLIC LAW 110–422—OCT. 15, 2008

SEC. 1104. NATIONAL ACADEMIES DECADAL SURVEYS.

(a) IN GENERAL.—The Administrator shall enter into agreements on a periodic basis with the National Academies for independent assessments, also known as decadal surveys, to take stock of the status and opportunities for Earth and space science discipline fields and Aeronautics research and to recommend priorities for research and programmatic areas over the next decade.

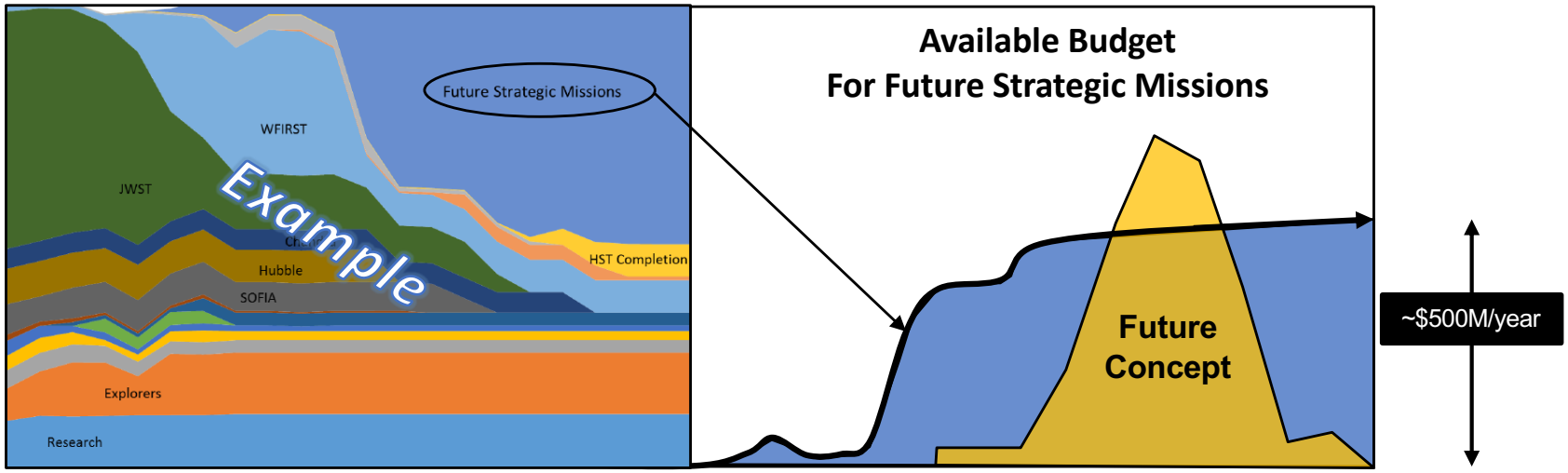
(b) INDEPENDENT COST ESTIMATES.—The agreements described in subsection(a) shall include independent estimates of the life cycle costs and technical readiness of missions assessed in the decadal surveys whenever possible.

Decadal Steering Committee incorporates TRACE evaluation into prioritization process

What is a TRACE?: Technical Risk and Cost Evaluation

- **TRACE is a "*look forward*" budget evaluation process with a technical risk assessment**
  - *Incorporates future cost threats*
  - *Technical maturity and Top 5 risks are evaluated*

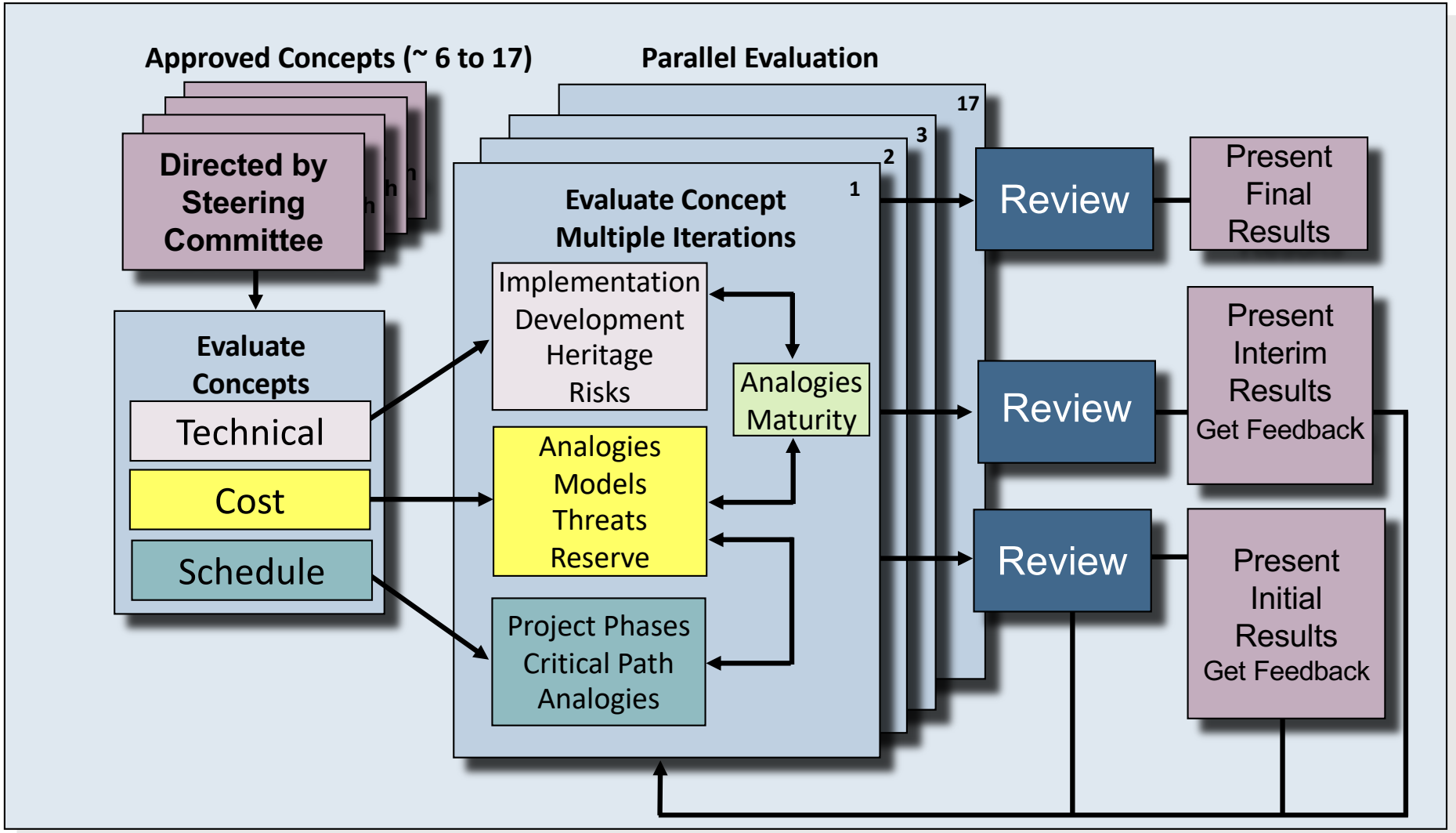
- **TRACE is an "*interactive*" discussion with the Steering Committee**
  - *Committees seek a balanced science program within the available budget*
  - *TRACE process is adaptive to differing Decadal Survey requirements*



NASA Astrophysics, Presented by Paul Hertz, Orlando, FL, 2016

TRACE is a look forward evaluation needed for future budget analysis & decisions

Typical Decadal Survey TRACE Process



Every Steering Committee and Statement of Task is Different

Key Aspects of a TRACE Evaluation

- **Typically performed above a specific cost threshold**
- **Must be fair to concepts with differing levels of development**
- **Each concept receives a technical risk rating**
- **Historical record of past concepts/missions used wherever possible**
- **Process uses a Monte Carlo analysis to capture appropriate reserves**
  - *Concept maturity*
  - *Technology readiness*
- **Process uses historical data to address likely future cost threats**
  - *Design growth or mission/concept creep*
  - *Schedule*

TRACE is suitable for prioritization and long-range planning

Typical TRACE Products: Technical Risk & Cost

Project X Top Technical Risks and Concerns

Project X Technical Risk Rating is Medium

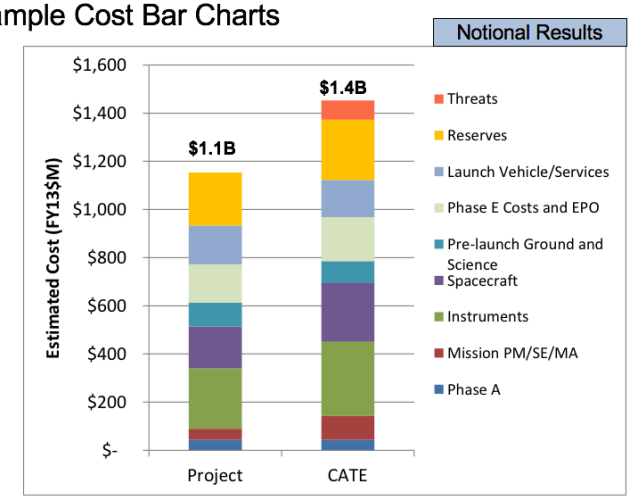
- **Medium new development, mostly in the engineering implementation**
  - *Increase in detector array size*
  - *Migration from FPGAs to ASICs*
  - *Modernization of heritage instrument control unit*
- **Mass margins and power margins are aggressive and launch mass margin is very sensitive to changes in dry mass**
  - *Concept design is closer than recommended to Atlas V 551 capacity limit and the system is very sensitive to changes in mass*
  - *Several mass liens against concept design*
- **Time critical mission operations contributes to medium operational risk**
  - *Fault management for autonomous mode requires further definition*
  - *Sampling operations and hardware need further definition*

Example Only

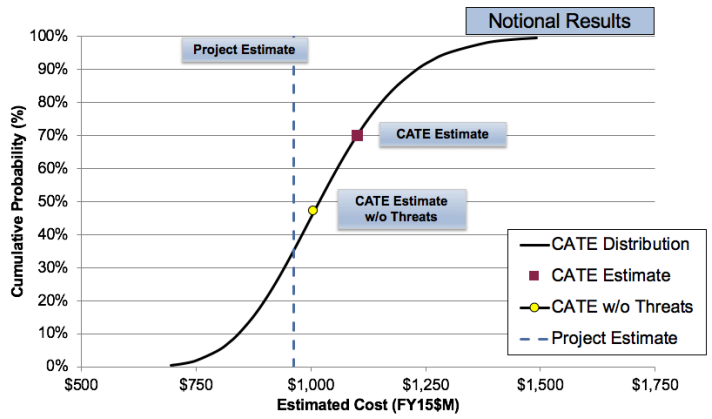
8

AEROSPACE

Example Cost Bar Charts



Example Cost Risk S-Curve



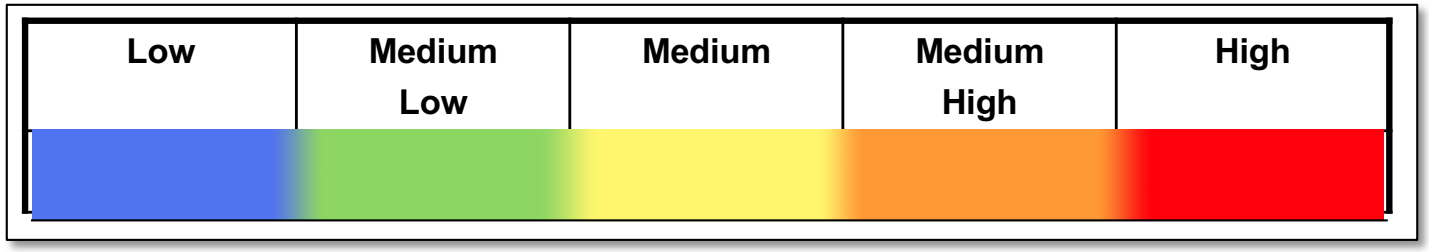
Standardized TRACE chart formats used wherever possible

Technical Risk & Maturity Assessment Approach

- **Identify Top 5 key risks to achieving required performance**
  - *Highlight significant deviations from current state of the art performance*
  - *Trace performance risk to science mission impact*
  - *Evaluate potential of planned risk mitigation efforts*

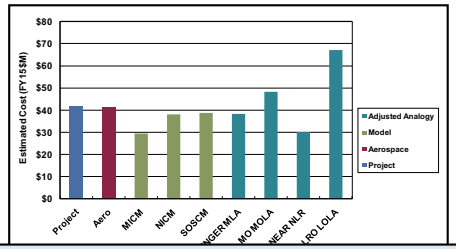
- **Assess technical maturity risk liens on cost and schedule**
  - *Assess technical readiness and maturity of key technologies*
  - *Late technology maturation steps identified*
  - *Complex system integration issues identified*

Technical Risk Assessment Ratings



The "TR" in TRACE is important and is a significant aspect of the process

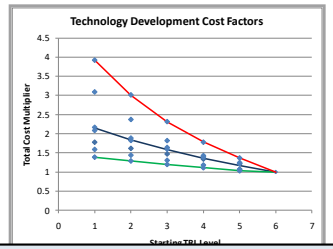
TRACE Cost Estimating Approach Overview



Estimate Hardware

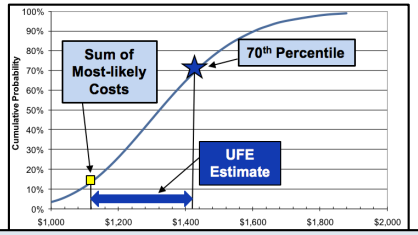
Multiple analogies and models

Previous BOE Data



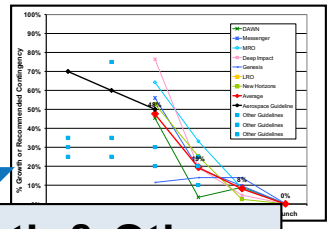
Estimate Other Elements

Based on historical data



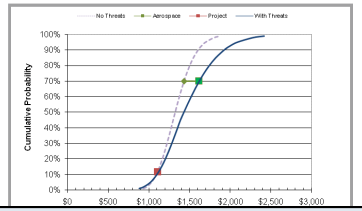
Estimate Cost Reserves

Based on probabilistic cost risk analysis



Design Growth & Other Future Budget Threats

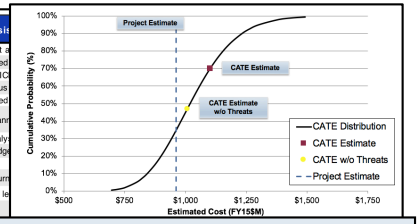
Based on historical data



Estimate Schedule Threat

Based on ISE results and project burn rates

WBS Element	Project Estimate	Aerospace Estimate	Basis
Pre-phase A/Phase A	$ 219	$ 219	Pass through of project a
Mission PM/SE/MA	$ 208	$ 257	Percentage of HW based
Instruments*	$ 710	$ 635	MICM, MICM, SEER, AIC
Flight System	$ 520	$ 637	SEER, PCEC, GSFC Bus
Pre-launch Ground and Science	$ 307	$ 303	Percentage of HW based
Phase E Costs and EPO	$ 303	$ 379	Based on MOCET and ant
Total Reserves	$ 615	$ 709	70% from cost risk analy
Launch Vehicle/Services	$ 302	$ 302	Pass thru of project budg
Total Mission Cost Without Threats	**$ 3,184**	**$ 3,443**	
Schedule Threats		$ 122	5 months at Phase D burn
Mass and Power Cont. Threats		$ 172	Aerospace contingency le
Total Mission Cost With Threats	**$ 3,184**	**$ 3,736**	

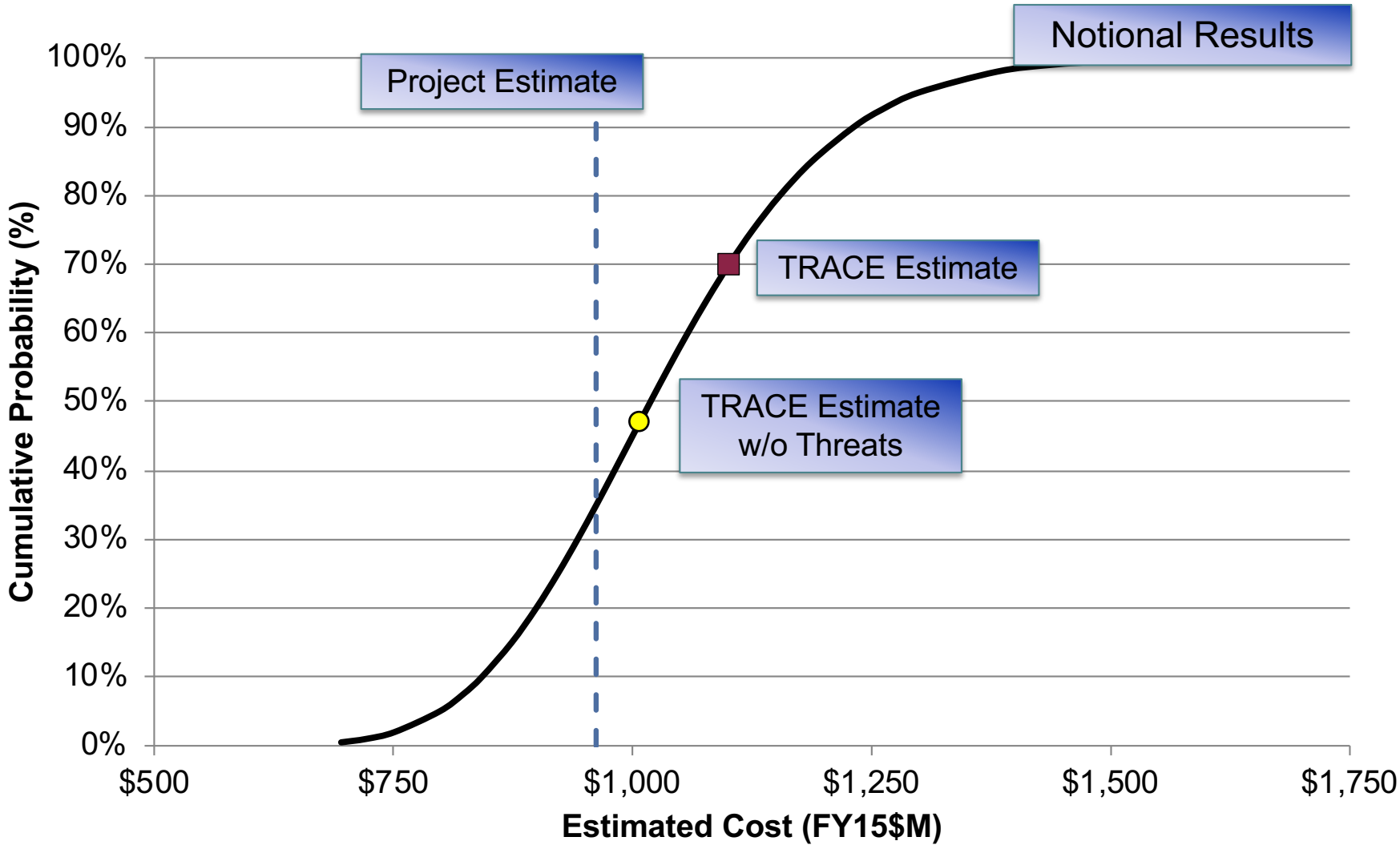


Integrate Results & Level Across Concepts

Validation & Cross-check

Produce Budget Profile

Probabilistic S-curve Represents Cost Assessment



Advocate and a range of TRACE estimates are provided for discussion

Perceived Advocate Team TRACE Concerns

- **Direct interaction with advocate teams did not occur for Astro2010**
  - *This is being reconsidered by NAS*
- **TRACE team does not fully understand and evaluation is too pessimistic**
  - *Results to date indicate CATE results have not been too pessimistic*
  - *Better understanding can potentially be achieved with defined interaction*
- **Will the TRACE process be fair for concepts with less information?**
  - *Yes, a well written proposal is not required*
  - *Questions will be asked if sufficient information is not provided*
- ***How does the TRACE process deal with a range of science value?***
  - *TRACE process can accommodate a range of instruments and concept sizes*
- ***How is the TRACE process applied to Ground Concepts?***
  - *It is similar to Space concepts with unique differences and more limited data bases*
  - *Aerospace has made significant investment to improve the process*

Suggestions for Advocate Teams

- **Advocate for what you believe is in the best interest of the community, consistent with available budgets and reasonable timelines**
  - *Steering committees need to hear the advocate's point of view*

- **Propose a range of science value, not just the ultimate goal**
  - *This allows the Steering Committee to make more informed decisions*
  - *TRACE can accommodate a range of instruments and concept sizes*

- **A well written proposal is not required**
  - *However, key arguments for the range of science should be easily understood*
  - *Science goals proposed should be linked to concept design*
  - *Many forms of information are acceptable for the TRACE process*
    - *Questions will be asked if key information is missing*

Astro2020 and the TRACE Process

- **TRACE is not perfect but has been improved since Astro2010**
  - *Key lessons learned should be incorporated, where appropriate*
  - *TRACE proved to be valuable and adaptable over four Decadal Surveys*

- **TRACE is an independent evaluation of "technical readiness and lifecycle costs" considered for future budget scenarios**
  - *Usually directed by a Steering Committee Programmatic sub-committee*
    - Previous committee chairs have been directly involved
  - *Ultimately a conversation with key decision makers on panels and the full committee*
  - *Mandated by 2008 Public Law*