



Step 1 & 2 Lessons Learned Study

**□ Presentation to the PIF-2
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Agenda

Study Purpose & Approach

Space Science Mission Risks

TMC Risk Envelope Concept

Step 1 & 2 Risk Distribution

Step 1 Major Weakness Trends and Common Causes

Step 2 Major Weakness Trends and Common Causes

Summary & Questions



Study Purpose & Approach

Study Questions

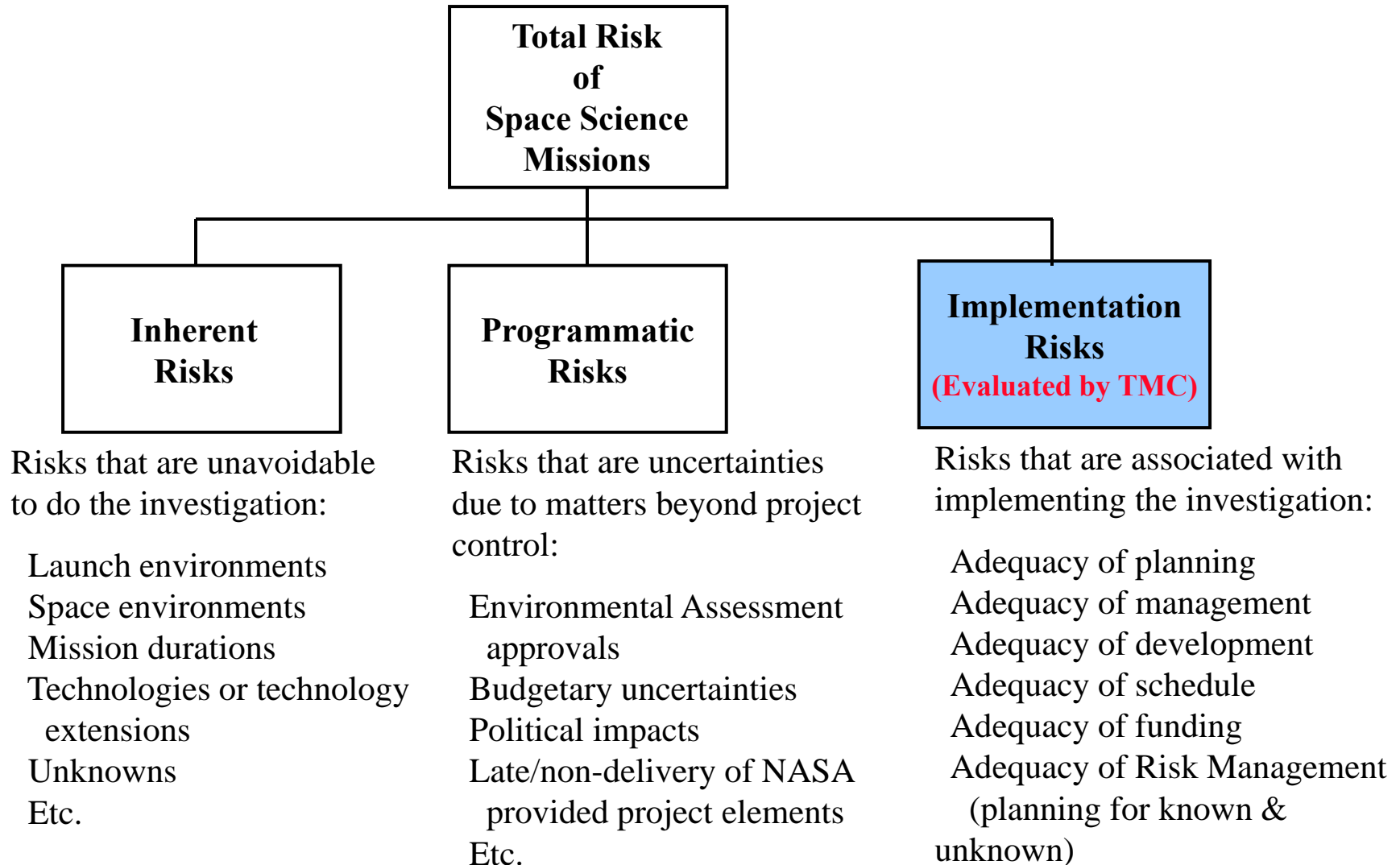
- What is the history of TMC Risk Ratings?
- Are there common causes of major weaknesses?
- For projects selected for implementation did TMC review anticipate subsequent problems encountered in development or flight?

Study Approach

- Conduct a comprehensive review of formal records of more than 800 proposals and concept studies retained by SOMA in the on-site archive library – TMC risk ratings, strengths and weaknesses
- Utilize the SOMA database of Form C findings and descriptive characteristics



Space Science Mission Risks

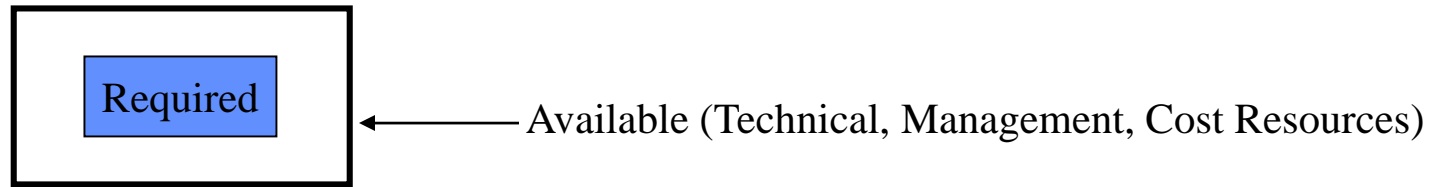




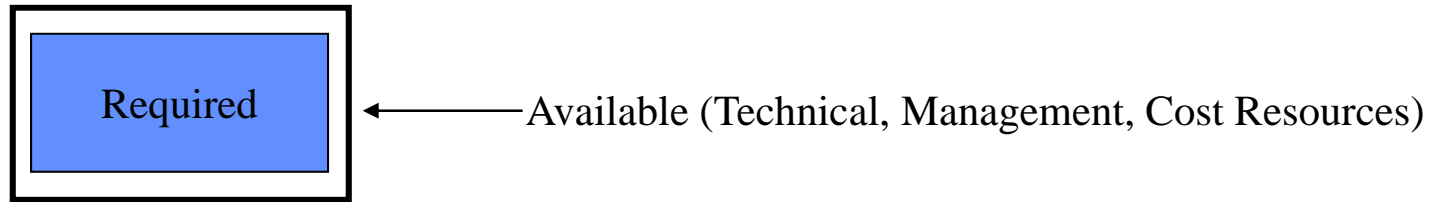
TMC Risk Envelope Concept

Envelope: All TMC Resources available to handle known and unknown development problems that occur.

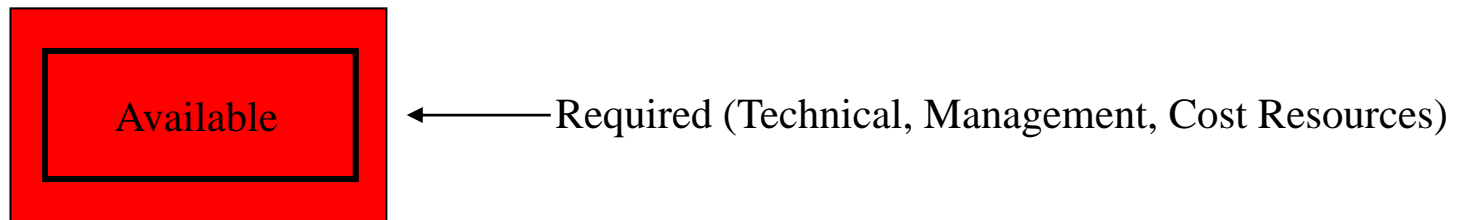
Low Risk: Required resources fit well within available resources



Medium Risk: Required resources just barely inside available resources.



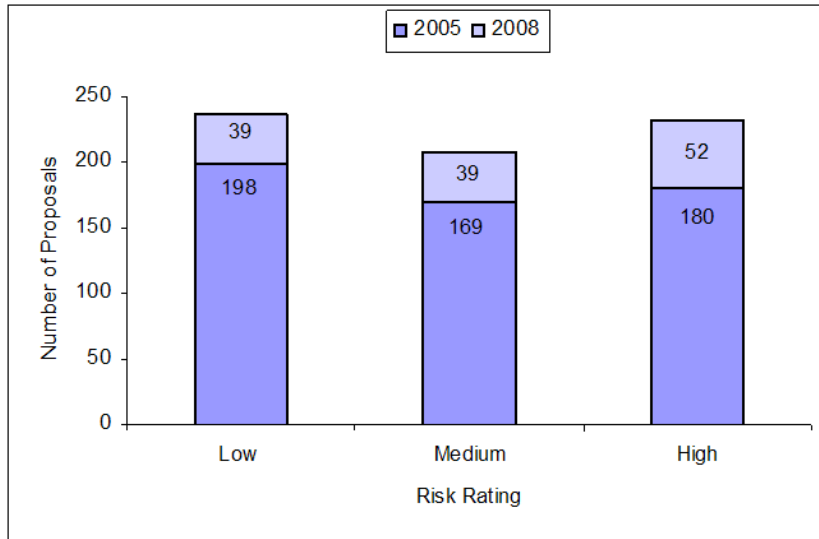
High Risk: Required resources DO NOT fit inside available resources.



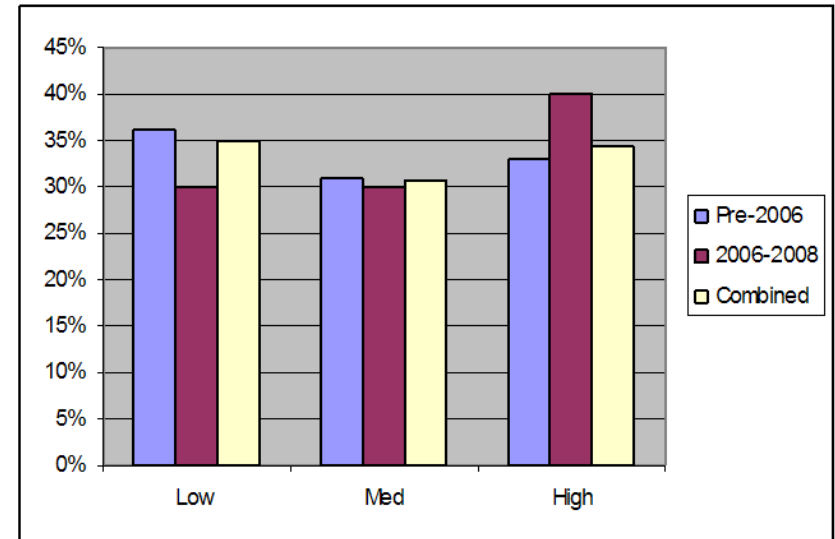


TMC Step 1 Risk Distribution Comparison Pre-2006 vs. Recent Missions*

Distribution by Number



Distribution by Percentage



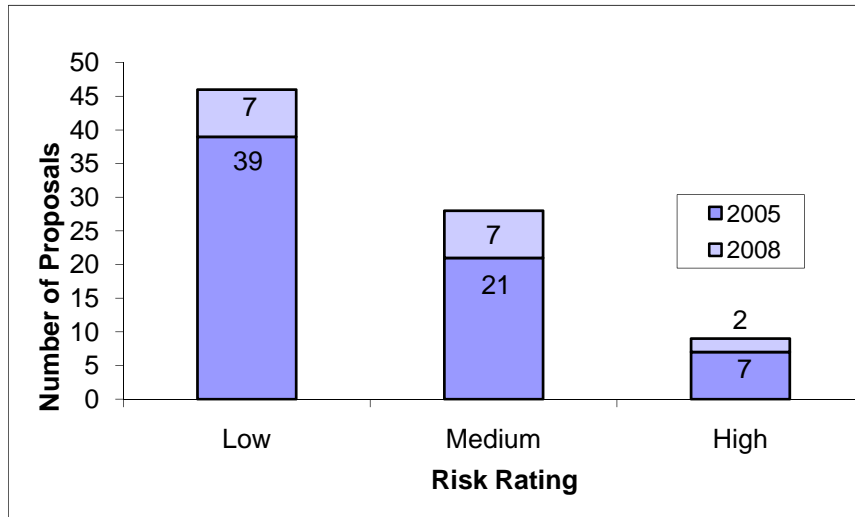
- ❑ There continues to be a slightly bipolar but roughly equal distribution of overall risk ratings
 - The distribution is skewed slightly more toward high risk with the addition of the 2006-2008 missions
 - Recent TMC teams have increased expertise and depth of investigation in many areas, e.g. instruments, operations, etc. (Page 28 examines trends in specific categories of major weaknesses)
- ❑ Overall, more than a third of Step 1 proposals are still rated Low Risk
 - Step 1 AO responses contain many proposals with serious implementation flaws so this suggests that benefit of the doubt is still being applied.

*Includes full & MOO proposals

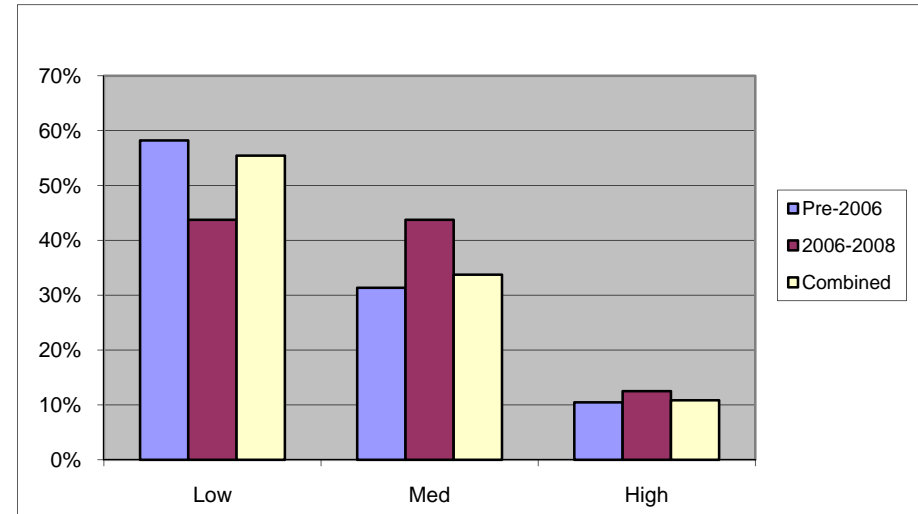


TMC Step 2 Risk Distribution Comparison

Distribution by Number



Distribution by Percentage

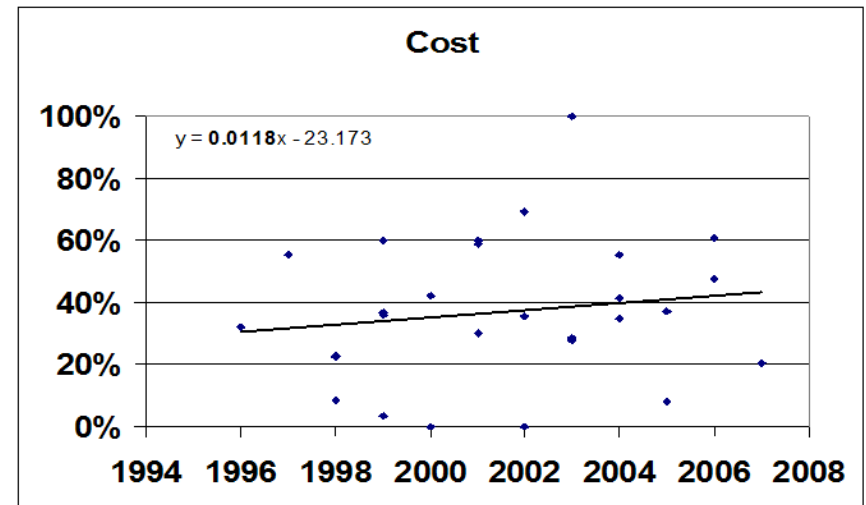
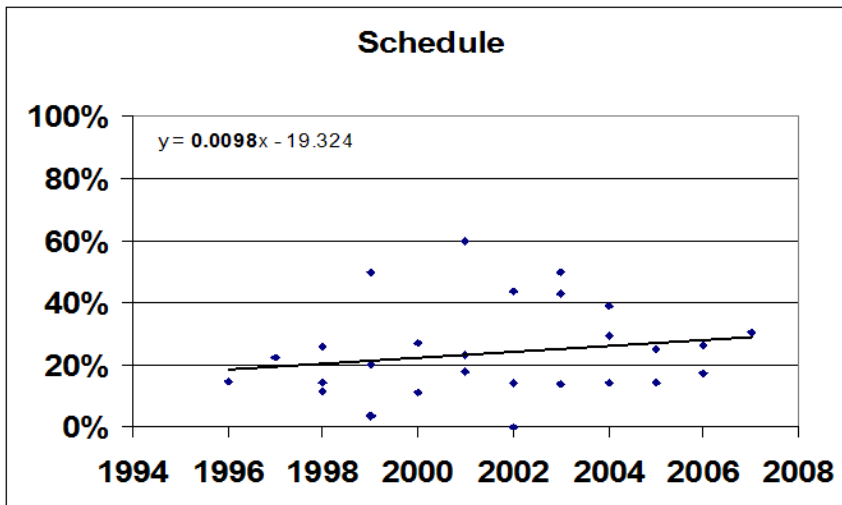
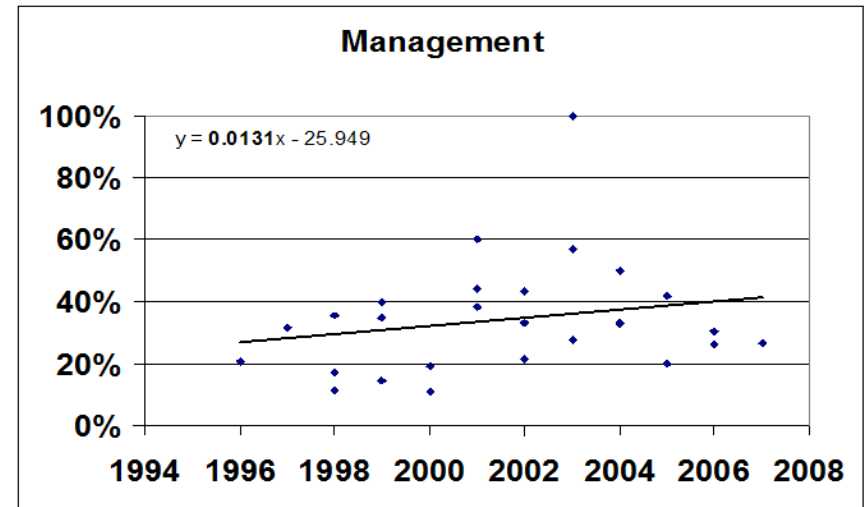
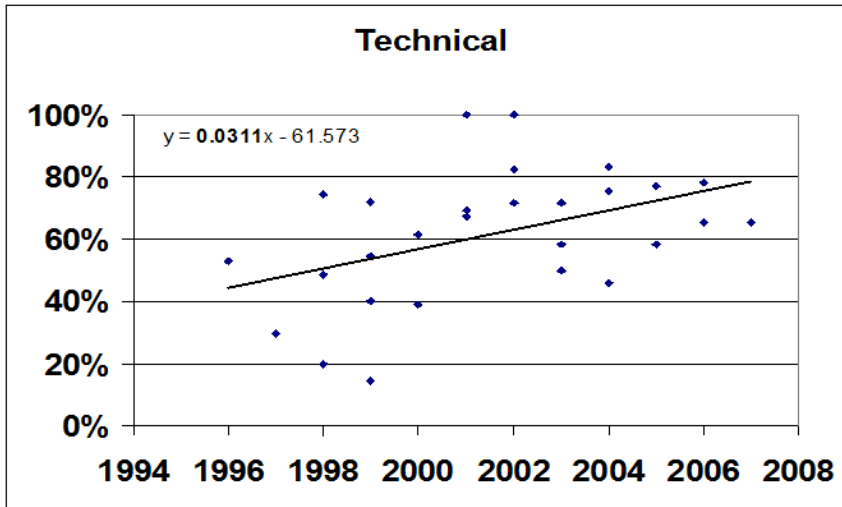


- ❑ Step 2 proposals evaluated between 2006-2008 data suggest a trend toward a more even split between low and medium risk, though the low sample size does not provide conclusive evidence of this.
- ❑ The percentage of Step 2 proposals rated high risk remains steady at about 10%.

The two step evaluation process remains effective in reducing the set of candidate missions to those with acceptable risk



Step 1 Major Weakness Trends by Evaluation Factor



Technical implementation of payload & flight system shows highest % of MW



Step 1 Common Causes of Major Weaknesses (1 of 5)

- ❑ Step 1 findings are based on data from 783 Step 1 proposals
- ❑ **Technical design margins** for flight system and payload
 - Step 1: *Mass*, Power, Data Handling & Communications Links, other concerns
 - 119 with one or more Major Weaknesses (MW) on mass margins – further details next page [= 22% of population]
 - 68 MW on power/energy margins [13%]
 - 53MW on Data Handling & Communications Links
 - 38 MW on propellant margins
 - 26 MW on thermal design margins
 - 6 MW on volume margin
 - 11 MW on radiation protection factor



Reasons for Major Weakness on Margin

Mass

- Insufficient description presented to allow TMC to do an independent verification of the claimed mass margin
 - Heritage masses don't account for potential design modifications
- No clearly stated mass margin
 - None given at all
 - Conflicting statements
 - Confusion between contingency and margin
 - Some of this is failure to follow AO directions which are clear and explicit
 - Some is deliberate proposal puffery
- Margin is clearly stated and verifiable, but deemed by TMC to be too low
- Missing and undersized elements (e.g., launch vehicle payload adapter) create immediate lien on claimed margin

Power

- Similar concerns
- Power margin not always calculated against the most critical or most demanding operating mode



Step 1 Common Causes of Major Weaknesses (2 of 5)

❑ Cost Reserve

- Out of 783 Step 1 proposals – 124 proposals [16%] have a cost reserve-related MW (261 proposals have a cost MW)
- Reserve is below the stated AO requirement
 - Overall level
 - Or by project Phase
- Liens against reserve already identified – e.g., contractor incentive fee
- Reserve is too low to cover cost threats, as identified by proposer or TMC analysis
- Reserves are phased too late in the funding profile to be available when the schedule of activity suggests the need is greatest
 - a recent trend that appears to be partly in response to the 25% rule in recent AOs



Step 1 Common Causes of Major Weaknesses (3 of 5)

❑ Instruments

- Step 1: ~255 proposals [32%] with instrument-related MW some or all of these concerns
 - Complex, new design
 - Inadequate or inconsistent description and detail
 - Weak heritage claims
 - Integration and accommodations: mismatch between stated instrument requirements and known bus capacity
 - Integration and test program; end-to-end verification testing
 - Some issues with pointing performance, detector contamination

❑ Complex Operations

- Step 1: 64 proposals [8%] with complex operational requirements – for payload, observing sequence, landers, etc.



Step 1 Common Causes of Major Weaknesses (4 of 5)

□ Systems Engineering

- Step 1: ~235 proposals with a related MW [30%]
 - Science requirements and flow down to instruments, payload accommodations and flight systems.
 - Note: this concern seems to occur more often in earlier AOs; recent experience suggests improvement in submittals, perhaps in response to firm AO requirements traceability matrix...?
 - Project-wide systems engineering responsibility
 - Credible plans for success
 - Underestimates of the cost of this function



Step 1 Common Causes of Major Weaknesses (5 of 5)

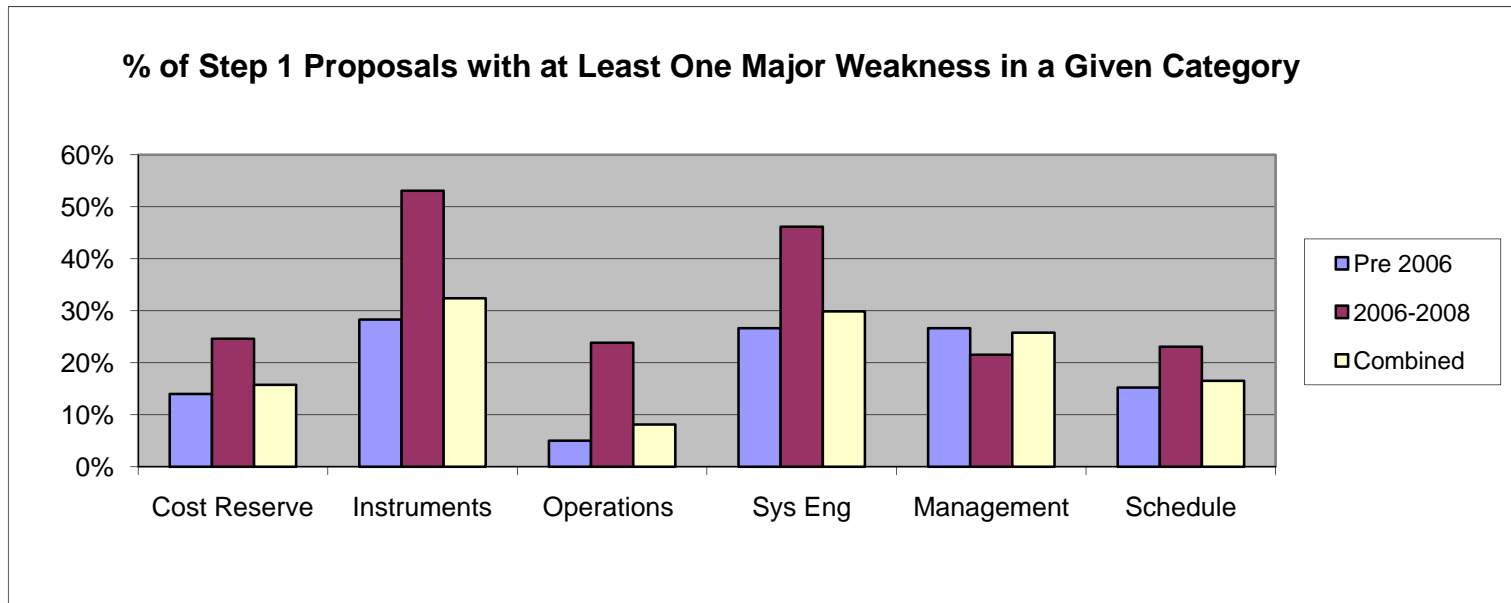
- ❑ Step 1 **Management**– 203 MW [26%]
 - Low time commitments for essential members of the core management team
 - Confusing organization roles & responsibilities
 - Unclear lines of authority
 - Missing commitment letters and/or endorsements from institutions and international partners

- ❑ Step 1 **Schedule** detail and (funded) margins – 130+ with MW [17%]
 - Inadequate detail presented for TMC evaluation
 - No reserve or inadequate reserve
 - Too ambitious or success-oriented for what needs to be done, especially during ATLO
 - Unrealistic timing of key milestones



Trend of Common Causes in Step 1 Proposals

This chart compares data on Major Weaknesses of evaluations conducted in 2006 thru 2008 with earlier evaluations.



While the relative distribution of Major Weaknesses remains approximately the same, the percentage of major weaknesses increased in all categories except Management for the four AOs evaluated between 2006 & 2008

- reflects increased focus of TMC teams & rigor of evaluation process*



Step 2 Common Causes of Major Weaknesses (1 of 4)

79 full mission CSRs (MoOs excluded) were examined.

□ Step 2 Technical Major Weaknesses

Issues with requirements definition & flow down, overstated heritage, and inadequate plans for verification dominate the technical category

- Requirements - 17% of Technical major weaknesses are due to problems with requirements definition, traceability, & flow down
 - Program size and profile don't seem to matter; a SMEX CSR and a Mars Scout CSR are equally likely to have a requirements major weakness
- Verification – 15% are due to issues with inadequate plans for verification
 - CSRs with this weakness also often had a major weakness related to requirements, system complexity, or design maturity
- Heritage – 15% are due to issues with the implementation of heritage elements
 - Overstatement of the benefit of the heritage
 - Modifications to the heritage element is required but not adequately accounted for



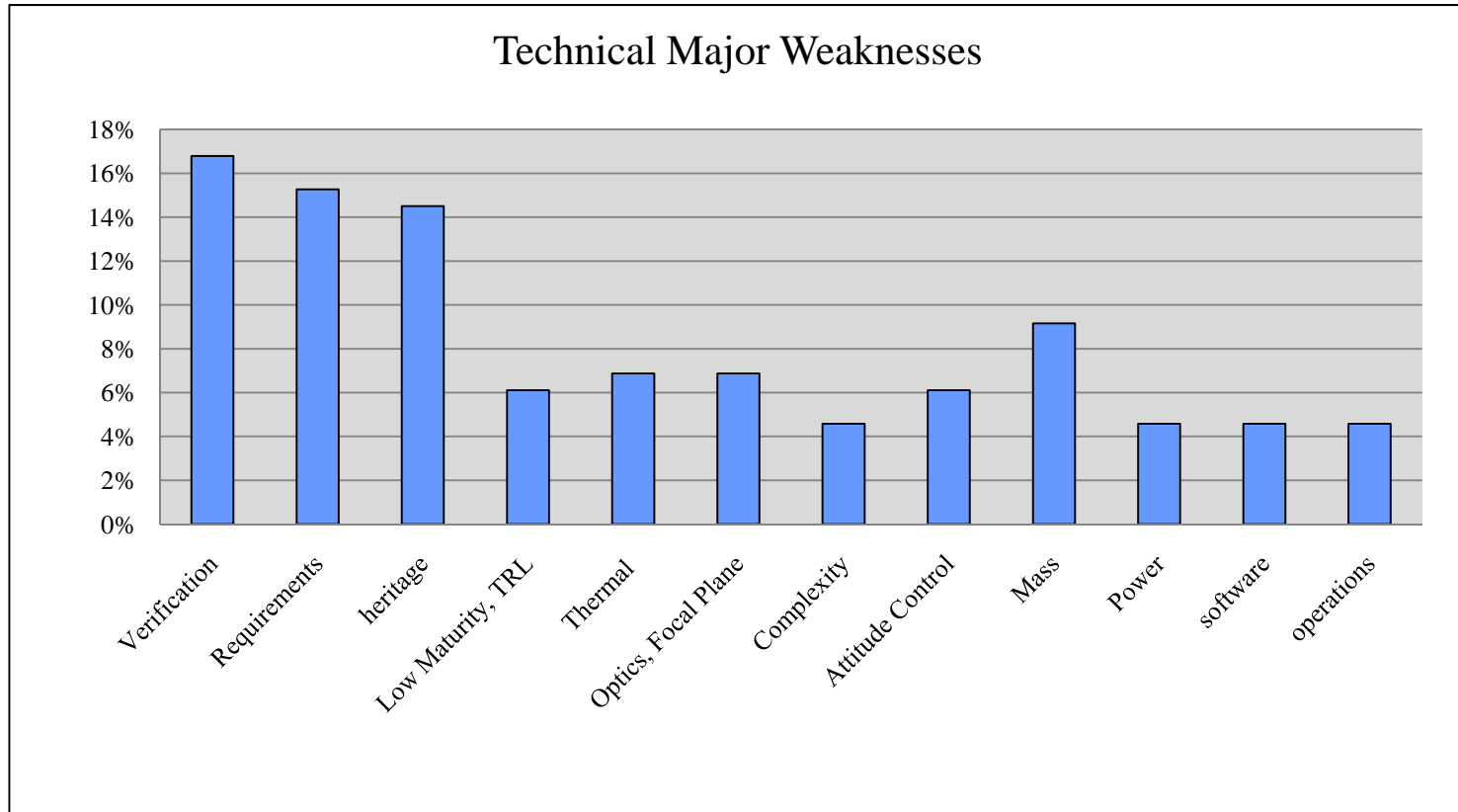
Step 2 Common Causes of Major Weaknesses (2 of 4)

❑ Step 2 Technical Major Weaknesses

- Mass Margin – 9% are issues with mass margin in some aspect of the design concept
 - Mass margin major weaknesses still occur but much less frequently than in Step 1
- Thermal – 7% are due to inadequate thermal design
 - Many of these are at the instrument level
- Optics/Focal Plane – 7% are related to the design & development of the instrument instrument optics and focal plane
 - Overstatement of performance is often cited
- ACS – 6% are issues with attitude determination & control
 - Inadequate understanding of pointing budget
 - Mismatch between hardware capability and required performance
- Low Maturity/TRL – 6% are related to dispute of the claimed TRL
 - These are more often related to instrument implementation



Step 2 Distribution of Technical Major Weaknesses*



* Includes only the most common technical major weaknesses,



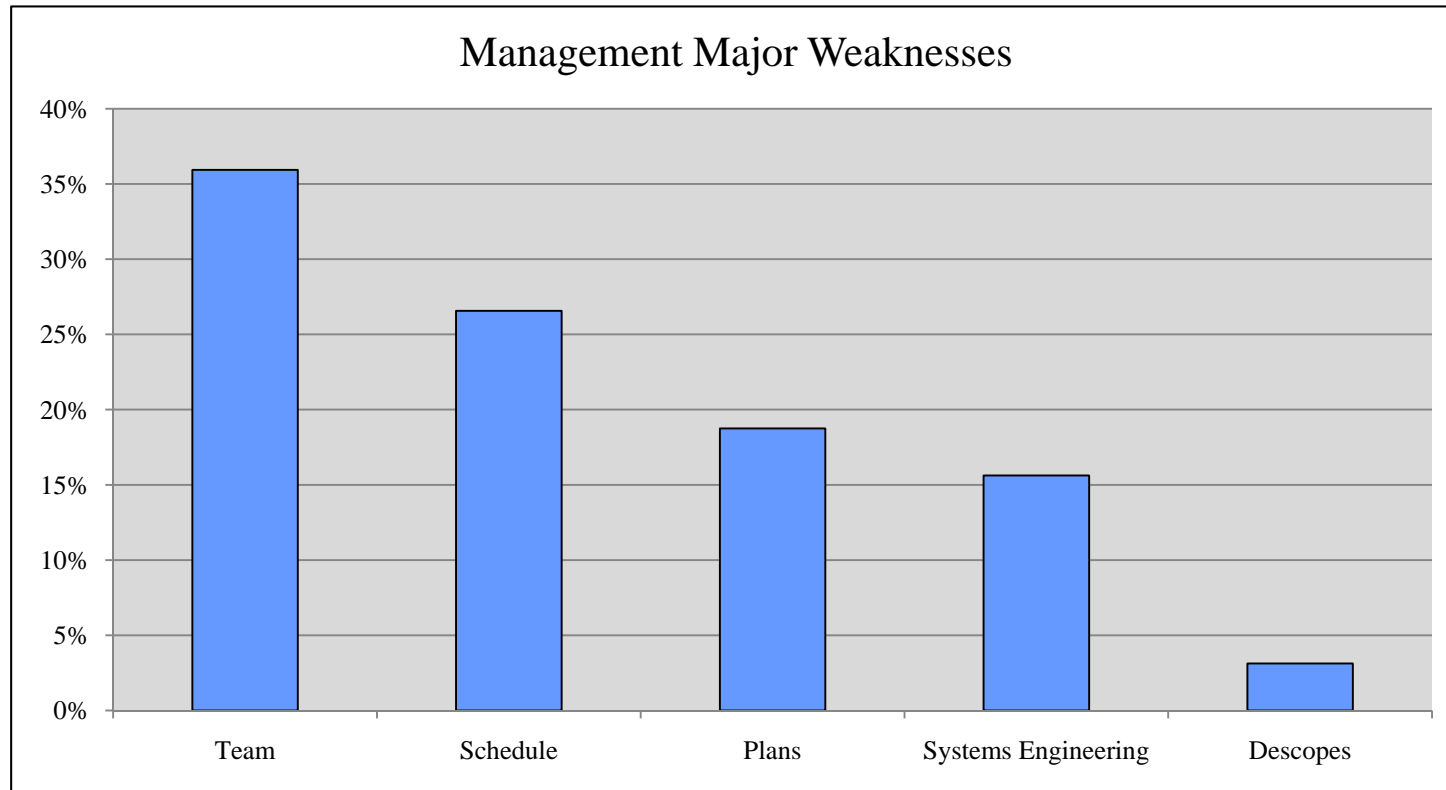
Step 2 Common Causes of Major Weaknesses (3 of 4)

❑ Step 2 Management Major Weaknesses

- 36% are issues associated with key individuals
 - Lack of relevant experience among core team
 - Many recent PM candidates proposed have good management credentials, but limited/no history of flight project accountability
 - Low time commitments for key members of the core team: Project Manager, Systems Engineer, Flight System Manager, Key Instrument Engineer, etc.
- 27% are schedule related major weaknesses
 - Inadequate /inappropriately placed schedule reserve
 - Missing key elements
 - Inadequate definition or complete lack of critical path
- 19% are related to management plans
 - Key elements such as risk management, are inadequate
- 16% are due to systems engineering
 - Often reflects lack of consistency among project elements
- 3% are due to definition of descopes
 - Often associated with overstatement of heritage or TRL



Step 2 Distribution of Management Major Weaknesses*



* Includes only the most common major weaknesses



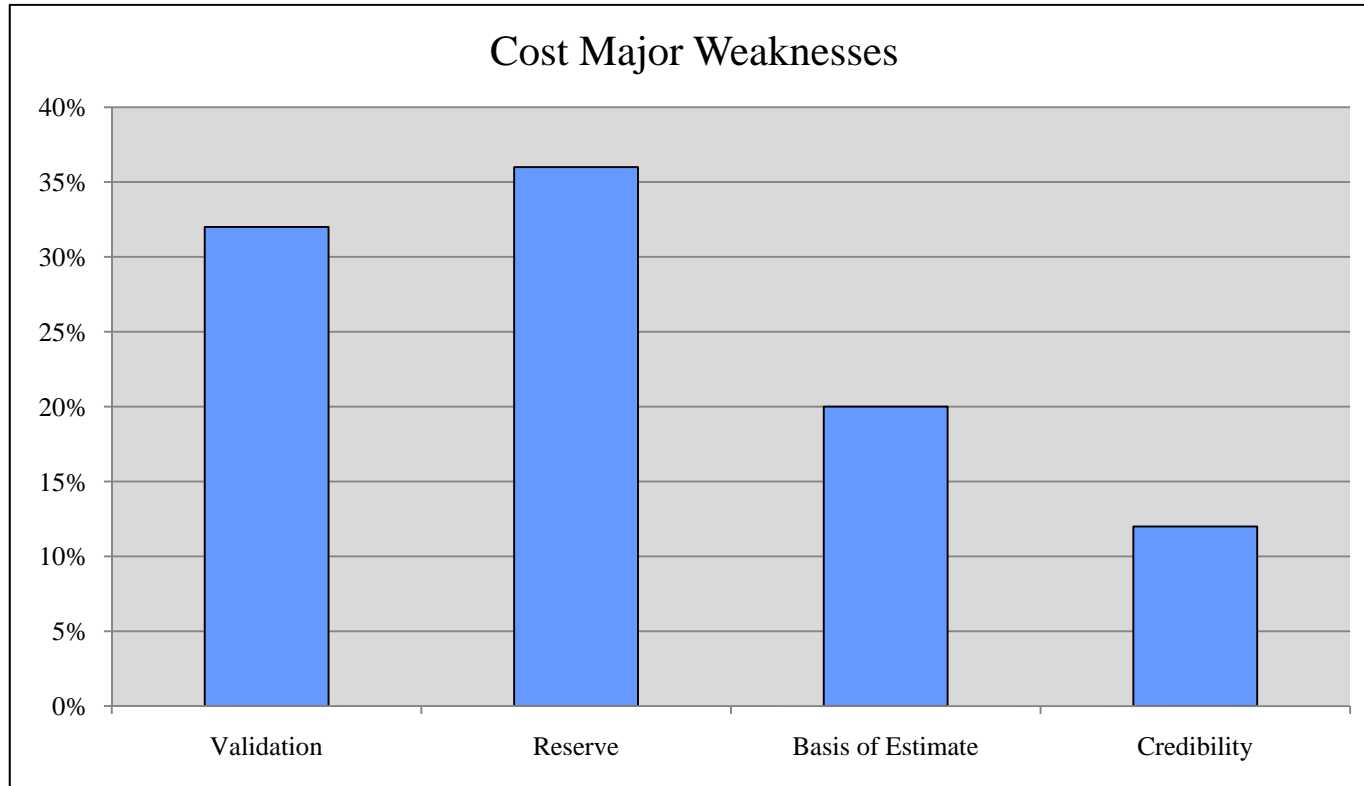
Step 2 Common Causes of Major Weaknesses (4 of 4)

❑ Step 2 Cost Major Weaknesses

- 36 % are due to inadequate cost reserve
 - Increased definition in the design and implementation in Phase A often results in erosion of cost reserve
 - Cost reserve is often an issue in proposals where low maturity and/or issues with heritage are also cited
- 32 % are related to significant and unreconciled differences between the proposed cost and the independent cost estimates.
 - This is often associated with a dispute in the proposer's underlying assumptions in areas such as technical performance, TRLs, heritage, etc.
- 20% are due to an inadequate basis of estimate
- 12 % are related to the credibility or relevance of the supporting cost data



Step 2 Distribution of Cost Major Weaknesses*



* Includes only the most common major weaknesses



Summary

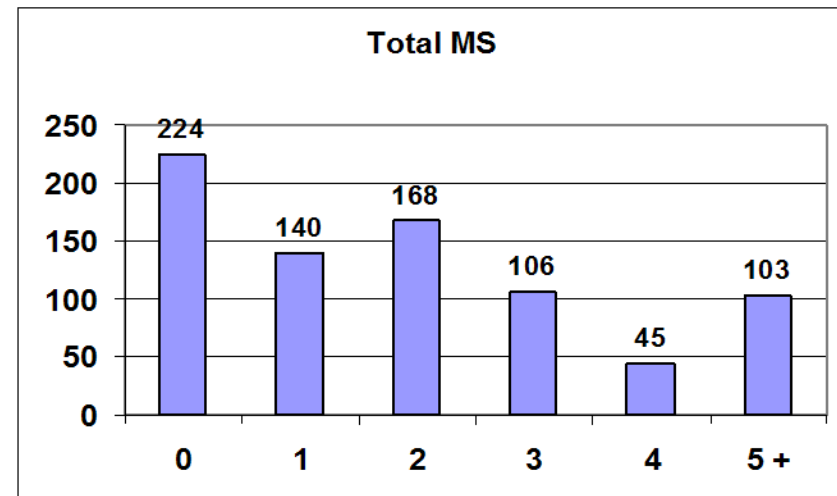
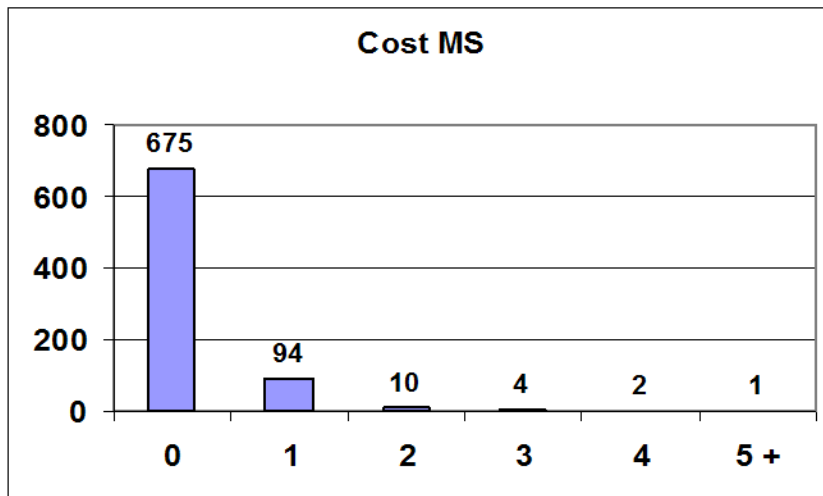
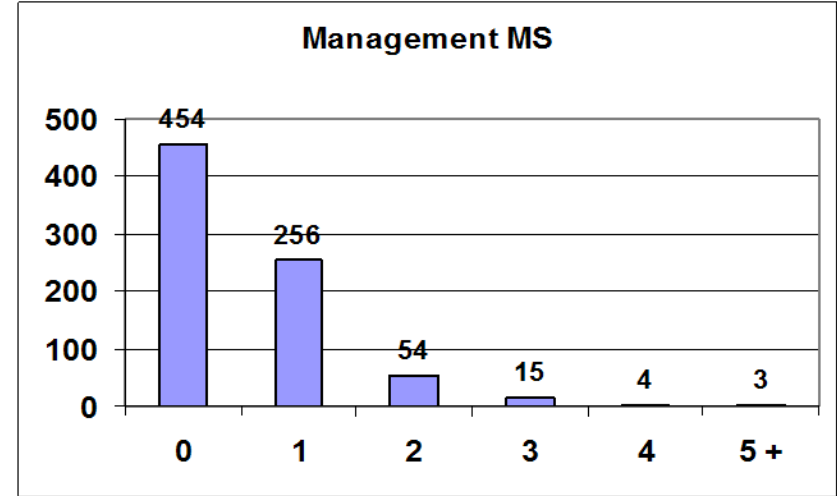
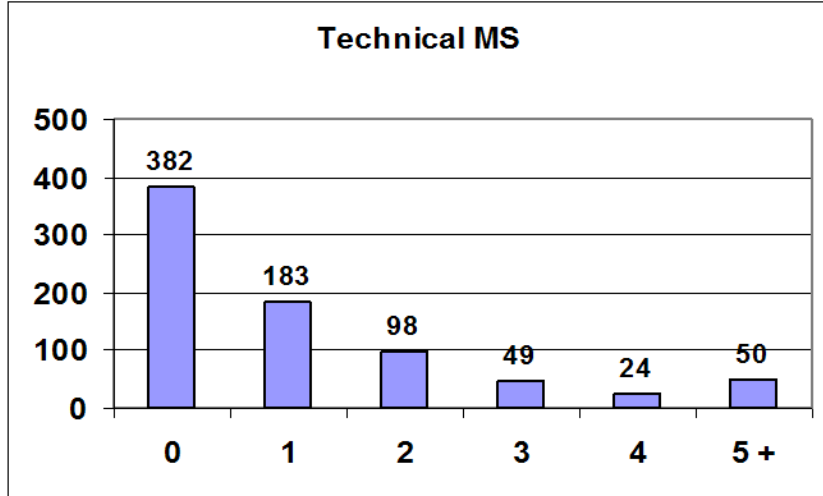
- ❑ SOMA has directed evaluation of more than 800 proposals and concept studies submitted by PI-led teams since the office was formed
- ❑ Review of specific strengths and weaknesses indicates that most successful proposers respond to TMC findings by attempting to fix identified weaknesses
- ❑ Certain types of weaknesses such as requirements definition and flow down persist in Step 2
- ❑ Are there common causes of major weaknesses in TMC reviews? Yes!
 - Overstatement of heritage and maturity
 - Inadequate definition, traceability and flowdown of requirements
 - Technical margins – especially mass margin
 - Less frequent in Step 2 than Step 1
 - Cost reserve
 - Instruments: complexity, over-reaching development
 - Attitude control and pointing
- ❑ Looking at overall risk ratings shows a relatively small percentage of proposals had improved risk ratings in Step 2. An equal number stayed the same or got worse
 - May be explained in part by more detailed review and with less “benefit of the doubt” given to proposer at Step 2



Backup Material

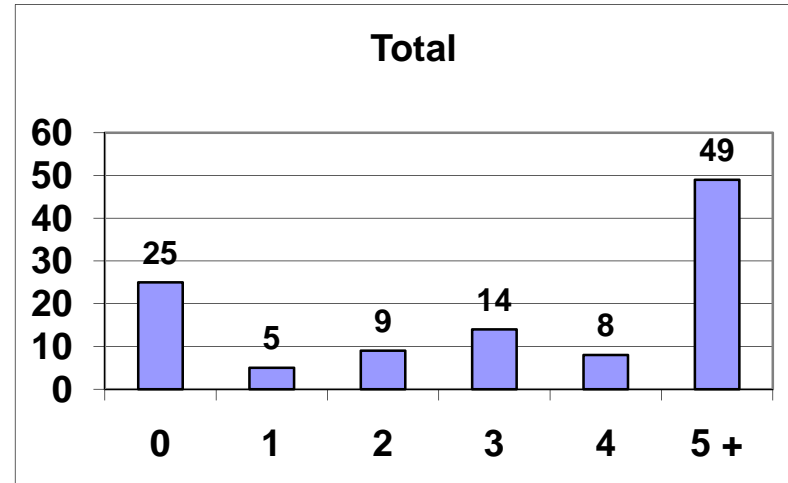
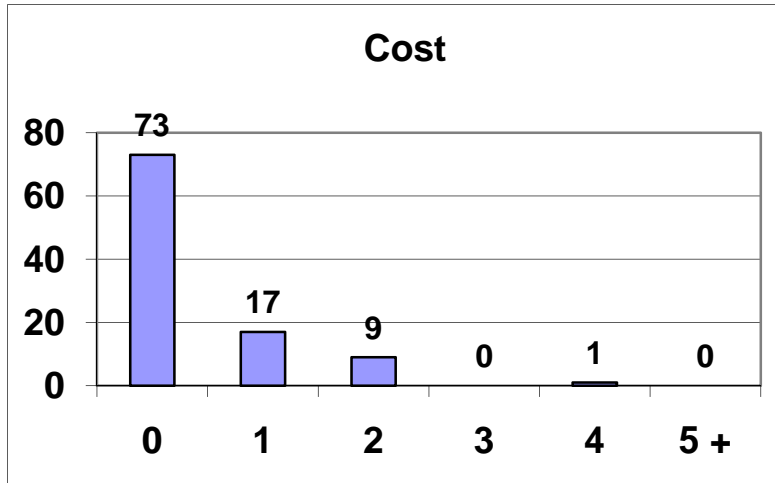
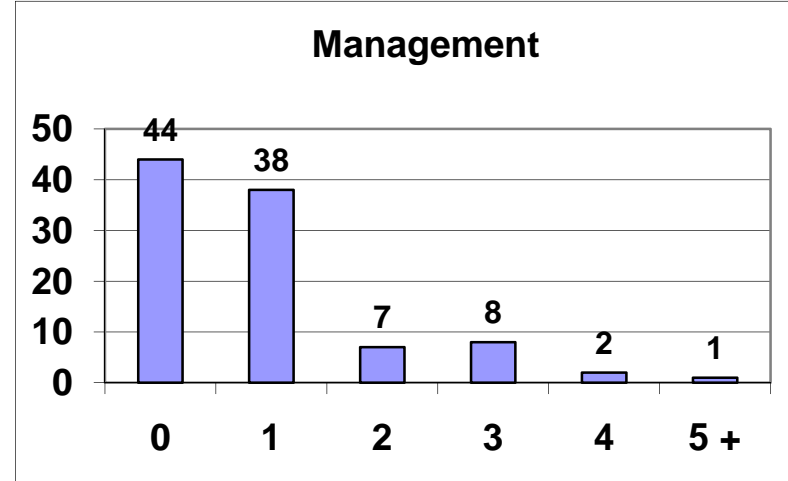
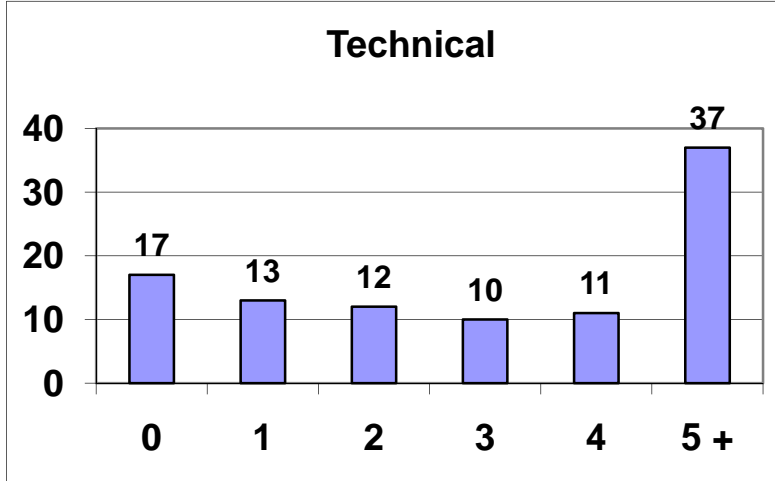


Step 1 Major Strengths





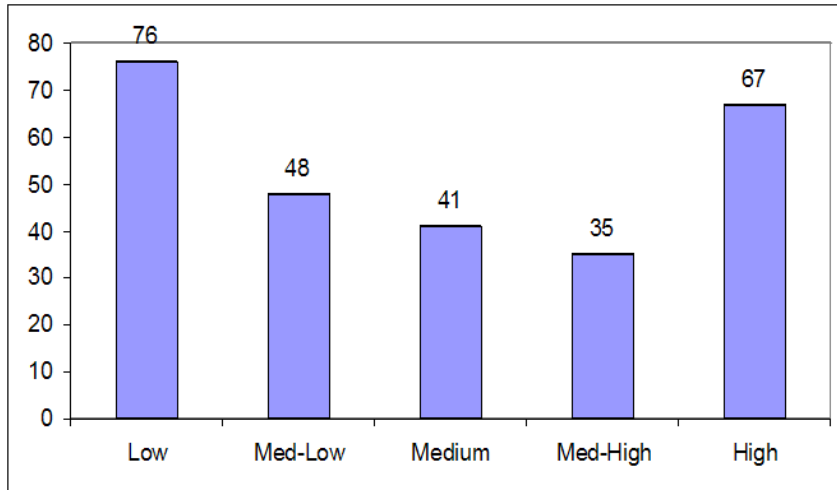
Step 2 Major Strengths



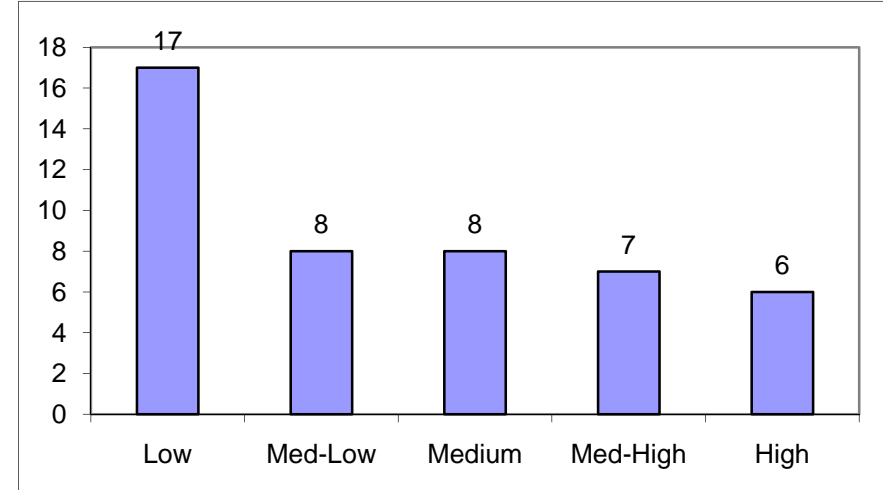


TMC Risk Evaluations

Step 1 Cost Risk



Step 2 Cost Risk



- ❑ Smaller totals than for TMC risk, because cost risk has not always been reported separately, and the number of reporting categories has evolved from three to five
- ❑ Cost risk distributions for both Steps follow the overall TMC risk distributions