



# Public Summary of the TMC Phase A Performance Study

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# Introduction and Background

- SMD (Paul Hertz) directed SOMA (Brad Perry) in December 2009 to
  - Compare SMD TMC Phase A evaluation process findings to actual experience of projects selected for implementation and
  - Assess whether the TMC process might be improved to better anticipate and circumvent potential problems encountered in SMD's experience base.
- The study was kicked off January 11, 2010.
- Interim results were presented at an Interim Review (April 23, 2010) using a subset of four projects (OCO, Aquarius, AIM, and MESSENGER).
- All findings, conclusions, and recommendations have been reviewed by SMD.
- This presentation and the associated final report document the study effort's methodology and results. The final report contains more detail and a more comprehensive set of appendices with supporting information.



# Summary of Study Objective, Approach, and Deliverables

Objective: Assess the historical technical/management/cost performance of SMD's portfolio of PI-led missions to determine how they performed at key project milestones versus the TMC findings at the end of Phase A and recommend improvements to TMC and other processes as appropriate.

## Approach

- **Document** the TMC risks for a selected set of 18 SMD projects as reported at the Phase-A TMC CSR Evaluations;
- **Document** the risks and mitigations and impacts of these same missions as reported at each succeeding Key Decision Point (KDP) for each mission as given in the Standing Review Board/Independent Review Team (SRB/IRT) reports and other sources;
- **Interview** the SMD Program Executive for each of these missions to determine whether or not the data collected by the study team accurately reflects the risks and mitigations and impacts reported at each milestone and document the results of these interviews;
- **Integrate** and **analyze** all of the data; and
- **Generate** findings, observations, conclusions, recommendations, and any other considerations for improving SMD TMC mission evaluations based on the study results.

## Deliverables

- Interim Presentation to SMD with preliminary results.
- Final Briefing presentation and Narrative report and presentation to SMD.



# Projects Selection

- This projects used in the study include all mission CSRs that were (a) evaluated by a SOMA-led TMC panel using a standard process, and (b) selected for implementation.
- The resulting 18 missions are shown below. The approach maintained all data points, since even a partially complete data record for a project may yield useful results in a study of this sort. This approach was reviewed and approved by HQ/SMD.

Acq Yr	1996	1998	1999	2000	2001			2002	2003		2006
Program	Discovery	Discovery	SMEX	Discovery	MIDEX	NF	ESSP	Scout	NF	SMEX	Disc
Project	CONTOUR, Genesis	Deep Impact, MESSENGER	AIM	Kepler, Dawn	Swift, WISE, THEMIS	New Horizons	OCO, Aquarius	Phoenix	Juno	NuSTAR, IBEX	GRAIL

NOTE: A set of 20 projects was initially recommended by SOMA for this study. Late in the study, however, it was determined that two Small Explorers, the Reuven Ramaty High Energy Solar Spectroscope Imager (RHESSI) and the Galaxy Evolution Explorer (GALEX) Phase A studies were not evaluated by a SOMA-led TMC panel and, with SMD concurrence, were removed from the study.



# Project PE Interview Questions

1. Does this list agree with your records/recollection of the project's experience?
2. Are there other issues that you recall as being important with regard to the following areas?
  - a. The instrument payload
  - b. The flight system
  - c. Management of the project
  - d. Implementation Schedule
  - e. Cost and cost reserve
3. After selection, did the project respond to weaknesses or comments documented in the TMC review?
4. Were any changes to the project mandated by the Program Office or NASA Headquarters?
5. Were there significant impacts from any external issues beyond the project's control?
6. Did the project respond effectively to the issues it faced during implementation?
7. What change(s) could be made to the CSR Guidelines or downselect evaluation process that might enable an earlier identification of the issues this project encountered?
8. Given the goal of this study, are there any other comments/recommendations that you'd like to make?



# Development of Findings, Observations, Conclusions, and Recommendations

- Findings have been derived from identified project risks and mitigations and associated impacts.
- Observations are based on experiences conducting the study.
- Each Conclusion is supported by one or more Findings or Observations.
- Recommendations follow from the Findings, Observations, and Conclusions.
- Data used for the study has been validated during the PE interviews.

## NOTES

- This study explored only a subset of missions evaluated by TMC and does not include hundreds of mission concepts that were not selected for implementation.
- Since the study focused on traceability of issues encountered by the project, there is a greater emphasis on TMC identified major weaknesses. The TMC identified strengths reported are limited to only those that were in conflict with project experience.
- For this report, the Findings, Observations, Conclusions, and Recommendations focus on traceability of project experience to TMC findings from Phase A. However, the data collected for this study could be used to support many other findings that have been reported in prior SOMA studies for SMD.



# Technical Issues

**Spacecraft Maturity/Complexity/Heritage.** These issues include overly optimistic assumptions for the spacecraft hardware/software design and complexity, often related to issues adapting heritage elements for a different application. Issues were identified for 11 of the missions.

**I&T Scope & Planning.** These issues include cases where deficiencies were discovered with the I&T plan. In project implementations, I&T planning results directly from the systems engineering effort: integration activity is based on system level drawings, and verification requirements are derived from environments definition and requirements flow-down. Issues were identified for 5 of the missions.

**Subsystem/Hardware Development.** These issues capture problems with specific subsystems and/or critical components. Issues were identified for 4 of the missions.

**Instrument Development.** These issues include significant problems encountered with development of the science instruments. Issues were identified for 10 of the missions.

**Systems Engineering (SE).** These issues cover identified deficiencies with the early systems engineering effort and associated processes. Issues were identified for 2 of the missions.

**Operations Planning & Testing.** These issues involve problems with planning for operations and/or operations testing. Issues were identified for 2 of the missions.



# Management Issues

**Organizational Experience.** This covers problems encountered with organizational roles and commitments. Issues were identified for 3 of the missions.

**PM & Key Person Experience & Time Commitment.** This covers problems encountered with the experience and/or level of commitment for key people. Issues were identified for 8 of the missions.

**Team Dynamics/Communication.** These issues include problems identified with communications within the project teams. Issues were identified for 2 of the missions.

**International Partners.** This category captures problems with delivery of major elements from an international provider. Issues with international partners had significant impact on only one of the missions in this study (Aquarius), but the issue was brought up by several PEs.

**Contractor/Subcontractor Oversight.** These issues include problems with lack of oversight of the contractor and/or major subcontractors. Issues were identified for 4 of the missions.



# Cost and Schedule Issues

## COST

**Cost Related Descopes.** These issues cover occurrences where descopes were necessary to reduce cost and/or cost risk. Issues were identified for 4 of the missions.

**Inadequate Basis of Estimate.** These issues cover problems/deficiencies in the original basis of estimate that are discovered during development. These issues include unintended omissions of cost elements and inaccurate assumptions related to design maturity, complexity, and heritage. Issues were identified for 12 of the missions.

## SCHEDULE

**LRD slip (> 2mo) due to development issues.** These issues include instances where the LRD was delayed due to internal impacts affecting development. Issues were identified for 7 of the missions.

**LRD slip (> 2mo) due to LV issues or conflicts.** These issues include instances where the LRD was delayed due to technical issues with the LV, weather anomalies (hurricanes) at the launch site, and conflicts with other mission launches. Issues were identified for 4 of the missions.

**LRD slip (> 2mo) driven by HQ redirection and/or funding issues.** These issues include instances where the LRD was delayed due to external impacts other than the LV. These are typically related to funding availability. Issues were identified for 8 of the missions.



# Other Issues

**NIAT Standards Imposed.** This covers projects that received funding augmentation to respond to NIAT recommendations. Issues were identified for 5 missions.

**Full Cost Accounting Imposed.** This covers projects that experienced increased cost due to adding full cost accounting requirements. Issues were identified for 4 missions.

**Launch Vehicle Changes/Issues.** These issues cover HQ-directed LV changes, technical problems with particular LVs, and/or problems with launch vehicle analysis or processing at the launch site. Issues were identified for 6 missions.

**Errors & Mishaps.** These issues cover errors and other issues with analysis, fabrication, or testing for a key element. Issues were identified for 6 missions.

**Termination Considered.** This captures missions that went through one (or more) termination reviews. This includes 3 missions.

**Project Changed After Selection.** This captures missions that were significantly changed due to external impacts, mostly SMD-directed. There are 9 missions with this issue.



# Mapping of Findings & Observations to Conclusions to Recommendations

## FINDINGS/OBSERVATIONS

- F1: Data suggests that alignment of TMC findings and project experience has improved over time, but many issues are still unanticipated by the TMC process
- F2: *Spacecraft* issues – underestimated complexity, overstated heritage
- F3: *Instrument* issues – underestimated complexity, overstated heritage
- F4: Common management issue – PM & key personnel experience & time commitment
- F5: Common cost issue – Inadequate BoE
- F6: Only 3 projects implemented TMC-suggested mitigations, and many TMC findings are ignored during implementation
- F7: LRD slips for 14 of the 18 missions driven by development issues & HQ-directed changes
- O1: No single repository of project-specific IRT reports exists
- O2: No standard for PE turn-over of responsibilities and files
- O3: CADRe data is an excellent resource for cost, schedule and technical data
- O4: Insight into some project issues was evident in TMC minor weaknesses and indirect references embedded in major weaknesses

## CONCLUSIONS

- C1: The significant analysis and assessment effort expended in the TMC process is not adequately captured as projects proceed into Phase B and implementation.
- C2: Unattained design heritage and underscoped complexity are common causes of significant development issues.
- C3: The experience and time commitment of the key management are critical factors in successful project implementation.
- C4: Issues with the CSR cost BoE tend to persist in development if not addressed in Phase B.
- C5: There is a high degree of interrelationship among common issues that is difficult to account for in the current TMC cost estimating process.
- C6: Maintenance of historical files for future access and usage by SMD can greatly assist the acquisition process.

## RECOMMENDATIONS

- R1: SMD should develop a standardized process for TMC debriefings to Program Offices and PEs and require that each selected project provide a formal response to findings reported by TMC.
- R2: SMD should consider including post-selection participation by TMC members in reviewing project formulation and implementation.
- R3: The TMC review process should review heritage claims with greater scrutiny and SMD should ensure claims are valid early in development.
- R4: The CSR guidelines and TMC's evaluation criteria should emphasize the requirement of relevant experience and time commitment for key personnel.
- R5: SOMA should further explore potential modifications to CSR guidelines to better capture applicability of claimed heritage and qualifications of the management team.
- R6: SOMA should direct thorough TMC panel discussion of all important cost assumptions prior to generating TMC estimate results.
- R7: SMD should continue to support the CADRe efforts but further require that all IRT/SRB review milestone reports be entered and maintained a similar repository.



# Recommendation 1

**SMD should develop a standardized process for TMC debriefings to Program Offices and PEs and require that each selected project provide a formal response to findings reported by TMC.**

- The intent is to ensure TMC findings are fully communicated and to create an audit trail for findings that is similar to the Request For Action (RFA) process used by projects and standing review boards at milestone reviews. This recommendation might be facilitated by a subset of experienced TMC reviewers convened after selections are announced to review the Form C and to write an RFA for each finding determined to require one. Under direction by SOMA and the PE, each Form C entry would be reviewed to determine whether it should be the basis for an RFA. The project would then be expected to respond to and disposition each RFA as part of its Phase B activity. *[Contributing Conclusion: 1]*



## Recommendation 2

### **SMD should consider including post-selection participation by TMC members in reviewing project formulation and implementation.**

- SMD should consider including that senior members of the SOMA TMC evaluation process are included in the membership of the project's Standing Review Board or as consultants to ensure continuity of reporting and attention to TMC analysis and assessment throughout the project's life. Such participation, together with Recommendation 1, establishes a more structured transition from acquisition to implementation, and would also ensure that current project experience is fed back into future acquisition cycles as AO process improvements.

*[Contributing Conclusion: 1]*



## Recommendation 3, *pg 1 of 2*

### **The TMC review process should review heritage claims with greater scrutiny and SMD should ensure claims are valid early in development.**

- Given that a high percentage of projects experienced significant erosion of resources due to heritage claims that did not materialize, TMC should be cautious in awarding benefit of the doubt for heritage. Although the degree of applying benefit of the doubt is significantly reduced during CSR down-select site visits, the time and level of interaction is limited which precludes fully resolving all benefit of the doubt issues. This is particularly true in cases where the TMC has issues with the basis of estimate or cannot validate the proposed cost estimate. In the CSR evaluations this implies that a) all claims of heritage should be carefully scrutinized and cross checked with the proposed implementation and cost estimates, and b) given the typical (for Phase A) lack of detail and mature planning needed for validation, a proposed strength for design heritage should be held to a high standard of proof to be considered as a TMC finding.
- SMD should remain skeptical of heritage claims after selection. A project claiming significant cost and schedule advantages from design heritage should be expected to perform a rigorous heritage review at the start of Phase B to further refine the project baseline and reserves and verify heritage applications are credible and properly accounted for. Currently, many projects perform these reviews, but there is no standard practice or requirement for when the review should occur or the expected level of detail.



## Recommendation 3, pg 2 of 2

**The TMC review process should review heritage claims with greater scrutiny and SMD should ensure claims are valid early in development.**

*continued*

- Because of the significant and overarching impact that systems engineering has on successful project development, SMD should require that all projects be subject to a standard review of systems engineering plans. In addition, for any TMC CSR review that identifies specific systems engineering threats, the project should be expected to address the TMC concerns as part of the standard review. The systems engineering review could be conducted concurrently with the heritage review. To minimize impact to the project, these activities could be part of the SRB's SRR charter, or could be directed by the cognizant Program Office, and scheduled early in Phase B to cause the least disruption to the project's work. *[Contributing Conclusion: 2]*



## Recommendation 4

**The CSR guidelines and TMC's evaluation criteria should emphasize the requirement of relevant experience and time commitment for key personnel.**

- SMD should continue to promote training for new PI's, PMs, and SEs. TMC should continue to evaluate experience and qualifications and time commitments of key personnel proposed, and should ensure that this experience has direct relevance to each individual's proposed role. *[Contributing Conclusion: 3]*



## Recommendation 5

**SOMA should further explore potential modifications to CSR guidelines to better capture applicability of claimed heritage and qualifications of the management team.**

- Recognizing that Recommendations 3 and 4, if adopted, are likely to result in more conservative evaluations by TMC, guidelines for CSR preparation should be reviewed to ensure that proposers are preparing the right information for the TMC review of the CSR, and that the proposers are not over-burdened by submitting unnecessary information. The detailed heritage appendix, now required for all CSRs, does a much better job of communicating to TMC a complete picture of the heritage elements and their claimed impact on the project's plans, but many issues still arise during TMC regarding heritage. *[Contributing Conclusion: 2]*



## Recommendation 6

### **SOMA should direct thorough TMC panel discussion of all important TMC cost assumptions prior to generating TMC estimate results.**

- Early discussion (during panel or sub-panel teleconferences) should focus on clear and complete description of the key assumptions, cost threats, and related issues – the Basis of Estimate – instead of an early comparison of numbers against proposed costs. This redirection of focus would: (1) improve efficiency of the TMC cost estimating process, and; (2) make best use of the combined panel’s expertise to direct cost analysts to the most important driving assumptions. This effort can help focus TMC initial findings and site visit interactions on the key technical and programmatic issues with the greatest potential for significant cost and/or schedule impact. [*Contributing Conclusions: 2, 3, 4, 5*]



## Recommendation 7

**SMD should continue to support CADRe efforts but further require that all IRT/SRB review milestone reports be entered and maintained in a similar repository.**

- CADRe reports are a valuable asset for technical, schedule, and cost data, but there is no comparable effort to collect IRT/SRB milestone review reports with the NASA-sponsored independent assessment review findings, which contain valuable insights for lessons-learned and other SMD studies. These should be collected from each project's SRR, PDR, CDR, System Integration Review (SIR), and MRR. SMD should consider implementation of a system to ensure project histories are carefully documented from the SMD oversight perspective and maintained in a location that provides ready access by SMD. It is recognized that various program offices maintain this information for their missions, but this data could not be shared for use in this study. This data could be included in the SMD Science Works Data base or a similar repository. Improved procedures for project turnover when a Program Executive succession occurs would be needed to support this. (This is not intended to duplicate in any way records maintained by a project office at the lead Center.) *[Contributing Conclusion: 6]*



## Concluding Remarks

- This report has presented Findings, Observations, Conclusions, and Recommendations, which the Study Team believes can be used to improve the TMC process.
- Some Recommendations are already in SOMA's domain, so it is planned (with SMD concurrence) that SOMA will immediately proceed to develop recommended changes for the acquisition process that address these issues.
- Other Recommendations may require further investigation to determine the most effective and feasible approach.
- SOMA stands ready to assist SMD with the development and implementation of these changes.