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MANAGING THE PERCEPTION OF ADVANCED TECHNOLOGY RISKS IN MISSION PROPOSALS

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I. Introduction

Through my work in the project proposal office I became interested in how technology advancement efforts affect competitive mission proposals. Technology development allows for new instruments and functionality. However, including technology advancement in a mission proposal often increases perceived risk. Risk mitigation has a major impact on the overall evaluation of the proposal and whether the mission is selected. In order to evaluate the different approaches proposals took I compared the proposals claims of heritage and technology advancement to the sponsor feedback provided in the NASA debriefs. I examined a set of Discovery 2010 Mission proposals to draw patterns in how they were evaluated and come up with a set of recommendations for future mission proposals in how they should approach technology advancement to reduce the perceived risk.

II. Background

Based on initial reads of the Discovery 2010 proposals, I observed that technology development is often coupled to discussion of heritage. While one would expect the presentation of heritage to reduce perceptions of technology development risk, this was not always the case. Therefore, this research investigates the interactions of technology development and heritage in competitive mission proposals.

III. Research Objectives

To accomplish my research I set the following objectives:

- Explore the approach different proposals take in presenting technology advancement and the involvement that heritage takes in those approaches
- Determine how these proposals mitigate the perceived risk
- Use sponsor feedback to determine the effectiveness of each approach

IV. Approach

The criteria for the sample set were to have a significant number of technologies of unique nature to evaluate while maintaining a consistent set of conditions under which the proposals operated. I analyzed 8 proposals from the Discovery 2010 call. From these proposals, 22 different technologies, most of which were instruments were identified. Each technology represented a unique case.

Discovery 2010 is the most recent large portfolio for JPL, with high potential for the non-selected missions to be proposed again. Therefore this sample is highly relevant to JPL. By limiting the sample to a single call, external conditions were the same across the portfolio. The evaluation team remained similar for the set; thus both the criteria they were looking for, as well as the type of comments they provided were consistent. The starting cost cap for the call was the same for all proposals, though within a proposal teams could choose how the available funds were allocated. Finally, each proposal selected which science goals to respond to from the same overarching set identified by NASA, were consistent for each proposal. While each proposal may have addressed a different set of these goals, the sponsor would evaluate them similarly.

Once the sample set was well defined, it was possible to begin to search for connections between the approaches that the proposals took in the technology development. Through the examination of each proposal, two inter-connected factors became apparent. The first being whether the proposal claimed any heritage for its technologies. The second being whether the proposal claimed any advanced technology development. Based on these criteria I evaluated the proposals approaches to both aspects and categorized them into one of four sections.

		Does the proposal claim technology heritage?	
		Yes	No
Does the proposal claim that technology development is required?	Yes	• Proposal claimed heritage from one or more existing technology(s) • Proposal claimed that the technology required advancement	• Proposal claimed that the technology was entirely new with no heritage • Proposal claimed that the technology would be created(or is in development)
	No	• Proposal claimed heritage for the technology • No technology advancement required based on either small improvement to technology or claims of simple process	• Proposal claimed that the technology was new with no existing heritage • Proposal claimed simple design so development isn't necessary

Figure 1: Initial categorization method based on claim of heritage and claim of technology development requirement

Once these technologies were categorized into sections, they were then compared to NASA debrief feedback in order to evaluate if the approach the proposal took was effective. This was done by

examining the proposal debriefs and extracting comments that related to technology development and maturity. Comments that fit the following criteria were included:

- Did the review board believe the heritage claims?
- Did the review board believe that the development plan was reasonable? (cost and schedule)
- Did the review board believe that the development plan would lead to the desired result? (performance)
- Did the review board believe the technology maturity claims(Technology Readiness Levels)?
- Did the review board believe that the advanced technology requirements were clearly expressed?

These comments were then connected to the individual technologies that were associated with them from the proposal:

Proposal Name	Claim Heritage?	Technology Advancement Required	Name of Technology	Strengths and Weaknesses	Sponsor Rating
Proposal 1	Yes	Yes	Technology 1	Major Strength 1	Low, Medium, High Risk
				Major Weakness 1	
				Major Weakness 2	
				Major Weakness 3	
				Major Weakness 4	
				Minor Weakness 1	
				Minor Weakness 2	
				Minor Weakness 2	

Figure 2: Table demonstrating a sample technology associated with its strengths and weaknesses from the NASA debiefs (Details removed due to competion sensitive information)

Figure 2 contains one example of the 22 technologies selected to be evaluated with an average of 4 strengths or weaknesses per technology. By creating this table it allowed for the individual approaches toward technology advancement to be evaluated as effective or ineffective. This evaluation was based on number of strengths and weaknesses as well as how pertinent the comments were to the initial categorization. Using these assessments, the technologies could be broken down further from the original categorization (Figure 1), into sections based on their effectiveness (Figure 3).

		Does the proposal claim technology heritage?			
		Yes		No	
		Mostly Strengths	Mostly Weaknesses	Mostly Strengths	Mostly Weakness
Does the proposal claim that Technology Development Required?	Yes	Technologies which claimed heritage and a development plan and were effective in their approach	Technologies which claimed heritage and a development plan but were ineffective in their approach	Technologies which were entirely new and presented an effective development plan	Technologies which were entirely new but were ineffective in presenting their development plan
	No	Technologies which claimed heritage with no technology development and were effective in their approach	Technologies which claimed heritage with no technology development but were ineffective in their approach	Technologies which claimed no heritage and no development plan but were effective in their approach	Technologies which claimed no heritage and no development plan but were ineffective in their approach

Figure 3: Second level categorization method based on proposal claims and NASA debrief comments

V. Results

The research objectives were presented in order to find patterns between heritage, technology advancement, and their effectiveness as determined by the NASA debrief feedback. Each step of the methodology was designed to follow each of these objectives while building upon the previous steps, to determine if and where the patterns exist. In addition to the final connections, each step individually presented results. The first categorization table (Figure 1) when applied to the sample yielded the following:

		Does the proposal claim technology heritage?	
		Yes	No
Does the proposal claim that technology development is required?	Yes	(11) A - 1 A - 2 B - 3 B - 4 B - 5 C - 7 D – 13 D – 12 E – 12 F - 15 E – 13	(2) H - 19 B - 6
	No	(7) C - 8 D - 11 C - 10 C - 9 G - 16 G - 17 H – 18	(2) H - 20 E - 14

22 total cases

Figure 4: Initial categorization based on claim of heritage and claim of technology development requirement (22 total technologies evaluated)

While all the quadrants contained some technologies, the majority of proposals put out by JPL included technology heritage. However, there was a divide in the number of proposals which claimed technology advancement. This lead the research toward trying to determine if one method was more effective or if both had merit. Thus the debrief comments were correlated to the technologies and using those determinations, the second categorization was made:

		Does the proposal claim technology heritage?			
		Yes		No	
		Mostly Strengths	Mostly Weaknesses	Mostly Strengths	Mostly Weakness
Does the proposal claim that Technology Development Required?	Yes	41% 9/22 A - 1 A – 2 B - 3 B - 4 B - 5 C - 7 D – 13 D – 12 E – 12	9% 2/22 F - 15 E – 13	9% 2/22 H - 19 B – 6	0%
	No	9% 2/22 C - 8 D – R11	23% 5/22 C - 10 C - 9 G - 16 G - 17 H – 18	0%	9% 2/22 H - 20 E - 14

Figure 5: Second level categorization based on proposal claims and NASA debrief comments (22 total technologies evaluated)

While technologies fell into six of the eight categories, two capture the majority of the sample; the mostly strengths for the claim of heritage and technology advancement, and the mostly weaknesses for heritage without any technology advancement. Combined these two quadrants contain 64% of the total technologies and are the focus of the remaining discussion.

An important observation from the data is that certain proposals (e.g., H, D) contain technologies in different categories, both in how they were evaluated and the nature of the advancement themselves. This indicates that the technologies were evaluated independently of each other and the proposal as a whole, allowing the technology advancement conclusions to remain mostly independent of the proposal evaluation.

VI. Discussion

a. Heritage with Technology Advancement

The inclusion of heritage with technology advancement resulted in a majority of the technologies receiving strengths from the NASA debriefs. In order for technology advancement to be effective in proposals, an examination of the common strengths demonstrates what information NASA was looking for. The first common strength was a proper evaluation of the technology maturity. The proposals received a strength when they stated the technology readiness levels in a clear manner (usually either in the instrumentation section, the advanced technologies section or both), and explained why the technologies were at said levels. This included details about the capabilities of the technology, what lab demonstrated values it had produced, as well as what testing the technology had undergone. Most of the technologies were at minimum technology readiness of 4, however only clearly demonstrating the current level of technology was not enough.

These technologies also received strengths for presenting an effective development plan for advancing the technologies to TRL 6 by the end of Phase B. These development plans contained several key components to receive a good rating. As stated they demonstrated the current level of their technology, however beyond that they stated the necessary requirements that the technology had to meet. These requirements pertained to the measurements they were taking or required performance as well as the environmental constraints. If the development was specific to one or multiple parts of the technology, (i.e. sensor, mirror, mobility) then each part's development was explained. An effective development strategy finally included the projected time frame that the technology would reach new stages of development, in addition to a cost constraint for the development. When combined the cost and schedule formulate the constraint space within which the development will occur in. This constraint space provides a believable development window which the advancement will occur.

Finally, these claims were further supported with the careful use of heritage. The technologies leveraged heritage in order to demonstrate two concepts. That the measurements were possible at a less developed manner, and that they provide a back-up option if the advancement is not successful. The former ties directly in with the technology maturity level. While heritage is not a substitute for current technology readiness, it does provide a basis for the evaluation. Heritage level can support the evaluated technology readiness if the changes that must be made can be accounted for, typically new environment and better measurement resolution.

The technologies that claimed heritage and a development plan but received mostly weakness occurred when they failed to present these strategies. Their development plans were either missing key scheduling milestones and cost constraints, or the stated values weren't realistic enough for the amount of development planned. The TRLs were stated but not supported, and the heritage was mentioned but the relevance wasn't explained.

b. Heritage without Technology Advancement

The inclusion of heritage without claiming technology advancement resulted in the majority of the technologies being evaluated with mostly weaknesses. The main difference between the two approaches comes from how the heritage was utilized. When technology advancement was included, the development plan was comprehensive while being supported by the heritage claims. Without the advancement discussion, the heritage became the main supporting evidence for the technology. The discussion of the technology became a defense of the heritage while implying that the change to the new technology was modest. However, the perception that the change was modest, from the proposers standpoint often wasn't confirmed by the NASA feedback. Many of the weakness presented were related to the lack of a development plan for such technologies. This demonstrates that even if small changes to technology are present, they should be claimed as advancement. However, it is not only the statement of whether there is or isn't advancement that is important. If a clear development plan is presented explaining what changes must be made to the existing technology and how they are to be accomplished, then the advancement will receive strengths. The one example of this is C-8, which claimed no technology advancement however received strengths because they did present a complete development strategy.

In addition, claiming modest change received weaknesses because technology maturity was often considered to be overstated. Many of these proposals stated the TRLs of the flight proven heritage and extrapolated to form the maturity level for the new technology. While this can be considered a strength, it must be done carefully so as not to over state the heritage. This often occurred when a flight proven TRL 9 instrument was given as the heritage, and the proposal then presented their version of the technology as TRL 6. While this is a reduction in the maturity this is only effective if the instruments are identical (flight spare or build to print). Otherwise, if there is a change in the technology or environment the maturity of technology should be more conservative.

c. Technology Development with No Heritage

While there aren't many entirely new technologies they do demonstrate an extreme for Technology Development. The two technologies that appeared in this category both contained mostly strengths. Through the comments, they were evaluated similarly to the technology development with heritage, including a clear development plan and proper evaluation of technology maturity. This stems from the acknowledgment that the technology is entirely new, thus a lot of measures were taken to ensure that the development was clearly described. This demonstrates that new technologies can receive strengths and further enhance the strengths given for the other advancement strategies.

VII. Conclusion

Comparing 22 technologies from a subset of Discovery 2010 JPL mission proposals to the NASA debrief feedback I determined a set of recommendations for including advanced technology development in competitive mission proposals. I concluded that including three factors reduces the risk associated, and leads to more strengths. The first is a careful evaluation of your technology maturity; clearly stating the current level of development, incorporating heritage while accounting for design changes, and the testing performed. The second is providing a clear step by step development plan, demonstrating each individual step toward development, the cost of the advancement, and the planned schedule. This should be included for any changes to design even if they are considered slight. Finally, avoid substituting heritage discussion for development discussion. While they can supplement each other lacking one can be detrimental to the proposal. Overall, presenting a complete story of how your technology will reach maturity for the mission in a reasonable time frame will lead to strengths.

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