AO Lessons Learned Workshop

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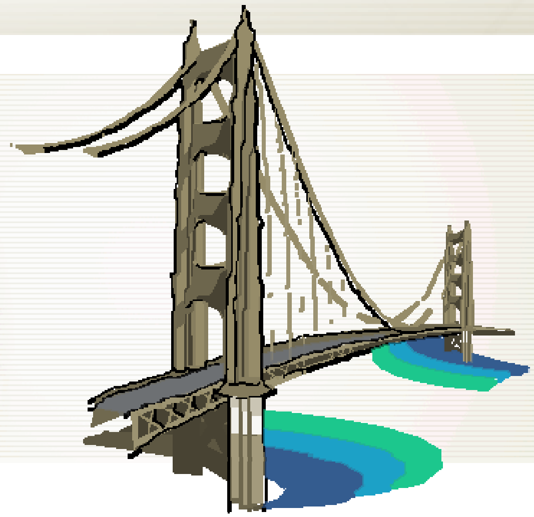
What we believe are the expectations

AO Developers | **Responders**



AO Development

- Clear and concise AO
- Reasonable constraints
- Responsive, clear, and concise answers to questions

Responders

- Compliant proposal
- Written clear and concise
- Compelling science
- Experienced team
- Innovative cost effective approach
- Low/No risk
- Low cost

AO Evaluation

- Flawless evaluation of science, technical approach, cost, and associated risk
- Detailed debriefs

Core Telecom Issues

Amount of information requested vs. return

- The requirements listed in previous AOs have required a significant level of detail of questionable value especially for a step one proposal.
  - Many requested parameters are not needed to evaluate mission feasibility
  - Many of the parameters requested would not be finalized until Phase B.
  - Requires effort to determine the details required that might be better spent on areas of higher risk

APL

Telecommunications Requirements example from step 1 SMEX AO

- Downlink Information

Data volume (Mbytes/day), bit error rate, onboard storage (Mbytes), transmit frequency, power available for communications (Watts), downlink data rate, effective isotropic radiated power (dBW). transmitting antenna type and gain (dBi), modulation and coding [e.g., Binary Phase Shift Keying (BPSK), Consultative Committee for Space Data Systems (CCSDS), Reed-Solomon], number of data dumps per day, spacecraft data destination (e.g., mission operations center), science data destination (e.g., science operations center), and maximum time lag between data dump and data arrival at destination, if relevant to science needs.

- Uplink Information

Number of uplinks per day, number of bytes per uplink, bit error rate, receive frequency, uplink data rate, receiving antenna type and gain (dBi), modulation and coding (e.g., BPSK, CCSDS, Reed-Solomon), and approach and schedule for obtaining license(s) for use of proposed frequency bands.

- Modes of Communications Operations:

- For transmit-only mode: Mode timeline, data rate(s), and duration;
- For receive-only mode: Mode timeline, data rate(s), and duration;
- Antenna Tx and Rx patterns (if available); and
- For Rx and Tx modes simultaneously: Mode timeline, data rate(s), and duration.

Telecommunications Parameters Requirements example from step 1 Mars Scout AO

Table 3-1: Telecommunications Parameters and Definitions

Parameter	Units	Description
Maximum S/C Distance	Km	Maximum spacecraft-earth station distance during primary mission.
1st Encounter Distance	Km	Maximum spacecraft-earth station distance during first encounter.
2nd Encounter Distance	Km	Maximum spacecraft-earth station distance during second encounter.
Nth Encounter Distance	Km	Maximum spacecraft-earth station distance during Nth encounter.
Uplink Transmitter Power	Watts	Earth Station Transmitter Output.
Uplink Frequency Band	GHz	Proposed earth-to-space frequency band expressed in GHz.
Uplink Command Mod. Index	Rad	Earth Station Uplink Command Modulation Index (Peak Radians)
Uplink Ranging Mod. Index	Rad	Earth Station Uplink Ranging Modulation Index (Peak Radians)
Uplink Transmit Antenna Gain	dBi	Gain (or name) of earth stations transmitting antenna (e.g., 34M BWG).
S/C HGA Receive Gain / Loss	dBi/dB	Gain of spacecraft's high-gain receive antenna / Circuit loss to LNA.
S/C MGA Receive Gain / Loss	dBi/dB	Gain of spacecraft medium-gain receive antenna / Circuit loss to LNA.
S/C LGA Receive Gain / Loss	dBi/dB	Gain of spacecraft low-gain receive antenna / Circuit loss to LNA.
Telecommand Data Rates	b/s	Maximum and Minimum desired telecommand data rate (Max / Min).
Telecommand Bit-Error-Rate	-	Required telecommand Bit-Error-Rate (BER).
S/C Receiver Noise Temperature	K	Total spacecraft receiver system noise temperature.
S/C Receiver Bandwidth	Hz	S/C Receiver's phase-locked-loop threshold bandwidth (2 Blo).
Turnaround Ranging	Yes/No	Statement whether turnaround ranging is required.
Required Ranging Accuracy	Meters	Specify project's required range measurement accuracy.
SC Transmitting Power	Watts	S/C Power amplifier output.
Downlink Modulation Format	Name	Format name (e.g., PCM/PM/Bi-ϕ, PCM/PSK/PM, BPSK, QPSK, etc.).
Downlink Frequency Band	GHz	Proposed space-to-earth frequency band expressed in GHz.
S/C HGA Transmit Gain / Loss	dBi/dB	Gain of spacecraft's high-gain transmit antenna / Circuit loss from PA.
S/C MGA Transmit Gain / Loss	dBi/dB	Gain of spacecraft's medium-gain transmit antenna / Circuit loss from PA.
S/C LGA Transmit Gain / Loss	dBi/dB	Gain of spacecraft's low-gain transmit antenna / Circuit loss from PA.
Downlink Receive Antenna Gain	dBi	Gain (or name) of earth station receiving antenna (e.g., 34M BWG).
Telemetry Data Rates	b/s	Maximum and Minimum desired telemetry data rates (Max / Min).
Downlink Telemetry Mod Index	Rad	S/C Downlink Telemetry Modulation Index (Peak Radians)
Telemetry Coding & Code Rate	Name & Rate	Telemetry code (e.g., convolutional, Reed-Solomon, concatenated, Turbo etc.).
Telemetry Frame Length	Bits	Total telemetry frame length, if Turbo encoded.
Frame Deletion Rate	Rate	Acceptable Transfer Frame deletion rate from bit errors.
Telemetry Bit-Error-Rate	-	Telemetry Bit-Error-Rate (BER) required for desired frame deletion rate.
Ground Station Implementation Losses	dB	Total losses including phase jitter, demodulation loss, and waveform distortion.
Downlink Ranging Mod Index	Rad	S/C Downlink Ranging Modulation Index (Peak Radians)

Result Is Not In Best Interest Of All Parties

This level of required detail drives proposers:

- **To reuse existing designs rather than include incremental changes that might optimize the science return**
- **To expend effort on a subsystem that is usually well-understood and may present only typical engineering challenges**
- **Requires extra TMCO effort to evaluate and verify**

Some Suggestions For Telecomm

- Limit required parameters to the minimum required to estimate the data return/emergency link and what can reasonably be expected at pre-Phase A
- Request a single number science volume for a simple feasibility check of the telecommunications system
- Require an integrated mission or daily trajectory (e.g. average Range) which, with the minimal link parameters, provides a quick check on data rate and volume
- Specify explicit margins for science downlink and the emergency links for consistent evaluation
- Apply engineering judgment
  - A 2 Mbps S-band link from LEO does not require a high degree of scrutiny
  - A Ka-band link from Mars with Turbo encoding does

NASA AO Comments

- In general, instructions of the AO are clear, and SMEX Appendix B is particularly useful, although it could be further developed to become even more useful.
- We are concerned that the current excessive AO requirements limit the number of institutions capable of responding to the AO.
- We are further concerned with the emphasis on risk limitation. This promotes proposals with long heritage proven techniques/instrumentation rather than new visionary ideas. Given the choice does HQ prefer a mission with low risk incremental science over a mission with higher risk but breakthrough science?

Mission Comments

Cost cap
Investment of B&P funds during Step 1 and government plus B&P for Step 2 (aka Phase A) amounts to small fraction of total mission cost. The immaturity of the design leaves key technical risks unexposed, such that cost estimates at this point have a large uncertainty bar therefore forcing less than optimum science well below the cap to be proposed if you want to win in the current environment.

Communications prior to AO
At AO release an established scientific, technical, programmatic, and cost baseline shoud be in place. We need a stable environment with major AO constraints and scope one year in advance.

Risk - Catch-22.
You can't propose it if you haven't built it, and you can't build it if you haven't gotten the money to do so and IRAD can only pay for so much. There has to be a way to make new designs acceptable especially for SMEX proposal where the missions themselves are considered more risky.

Mission Comments

AO Requirements (perception and reality) - There seem to be a general inconsistency between the perception and reality of the AO requirements. For example please make it clear if the MAR is a guideline or a requirement. The AO need to be more specific.

Cost exhibits - Confusion in the SMEX AO for cost exhibits. Specifically, the calculation for effective direct costs for table B-8 and B-13. Populating the exhibits with a set of numbers as an example might help.

Submissions - In an age of electronic NSPIRES submittals, 50 hard copies of proposals seems excessive

EPO - Suggest that in both Step 1 and Step 2 that the team just acknowledge that they will provide an EPO proposal after the mission is awarded. Then once awarded, provide a comprehensive proposal by the winning team that is reviewed as it currently is with a panel and revise, if needed, per NASA instructions.

Appendices - strict page limits to the written sections and then encourage you to put all kinds of information in the appendices without page limits. So, while that helps, if there is some specific theme to expand on (cost or heritage, for example), it really means effectively writing a 400+ page proposal with BOEs

MoO Comments

Descope Options - For instrument proposals, we continue to struggle to come up with credible descopes, i.e., million-dollar cuts, considering we have usually trimmed the proposed instrument down to the bare essentials to make the instrument cost competitive.

There was language in the SMEX AO that suggested MOOs didn't have to provide descope options, but the posted response to a question regarding this issue on the website said the opposite (also a familiar problem). Guidance/clarification/simplification from NASA would be helpful.

Risk - There are different types of risks: technical, cost, schedule, etc. Again, guidance and clarification would be helpful.

Costing - level the playing field a bit here so that costs are comparable across proposals from different institutions. A more explicit statement saying the proposed cost w/o reserves is X on the ICE S curve would be helpful.

Heritage - SMEX AO requested basically the same information in different sections, which creates extra work and hardship when given strict page limits. Were different authors putting together the AO?

Appendices - strict page limits to the written sections and then encourage you to put all kinds of information in the appendices without page limits. So, while that helps, if there is some specific theme to expand on (cost or heritage, for example), it really means effectively writing a 100+ page proposal

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