New materials, processes, devices or systems to support mission operations for robotic deep-space exploration

PROBLEM STATEMENT

You are contacted by a science working group that is conducting a preliminary analysis of the goals, requirements and feasibility of a robotic deep-space exploration mission. Of particular interest are onboard subsystems for telemetry, tracking and command, electrical power and distribution, and thermal control. Material and electronic componentry of such subsystems are subject to harsh, highly-variable operational conditions. Beginning at launch, extreme noise, vibration and shock test the physical durability. Decreasing atmospheric pressure can induce outgassing and recrystallization. Extreme temperature fluctuations may result from positioning relative to solar radiation. Cumulative effects of the radiative environment of space vary widely depending on orbit, mission environment, and mission life cycle. Innovative solutions for materials, processes, and devices that compose subsystems for telecommunications, electrical power, data handling, and temperature control are sought. To be viable, the envisioned material, process, device and/or system must perform reliably over a seven-year deep-space mission while meeting the extremely demanding, highly variable stresses anticipated in the harsh space environment. Questions to consider might be: What critical aspect of an onboard subsystem for telemetry, tracking and command, electrical power and distribution, or thermal control would provide the greatest return on investment from an innovative design for a material, process, device or system? What are theory, material, system, and performance aspects of the design? By what metrics should the design be validated? What software, equipment, or methods would be required to validate the design? Why is the design better than alternatives? What attribute(s) make the design likely to disrupt or penetrate the market for deep space exploration and be adopted by a highly-visible program subject to careful scrutiny and strict technical oversight?

You are the Chief Technology Officer of a company that has specialized in creating innovative microelectronic/photonic materials, processes, devices and/or systems. Your CEO believes that the company's expertise in micro to nanoscale elements could provide a research and development path for a material, processes, device and/or system to meet a critical, demanding need for robotic deep space exploration. Your job is to identify, design, and propose development of an element or suite of elements that draws from the specific expertise and resources in your organization to provide an innovative platform that contributes in a meaningful way and has significantly enhanced properties and performance relative to competitors' state of the art capabilities. Your job as CTO is to deliver a complete proposal with your plan for the company to compete in this area to your CEO by your Monday morning, January 14, 2019 deadline.

YOUR DELIVERABLE

Your task is to write an internal proposal for your corporate officers describing your idea for research and development. The proposal should include the following:

- Executive summary (one page)
- Risk assessment roadmap form (one page)
- Full proposal (15 pages maximum)
- Appendix A: List of references (no page limit)
- Appendix B: Ranked list of intellectual property documents examined (no page limit)

Most Importantly – The significance and novelty of your creative solution, one that moves the boundaries of knowledge outward, will be the primary assessment focus of your review panel. The list below is just a minimum list of issues you might consider. There may be many more. The point is that your proposal ***should contain the evidence*** needed to make an effective and compelling case to your CEO in order to insure that she/he makes the right decision.

At a minimum, be sure you address all of the following:

Current Science and Technologies - What is already being done in this area by other researchers, companies and governmental institutions? Describe the current state-of-the-art for both the science and the implementation. Use diverse resources such as science literature, journals, conference proceedings, the internet, patents or other sources of existing public knowledge. ***Cite all references you use and use quotes for any word-for-word transfer to your report.***

Your Design Approach – What is the basis for your design approach to the problem? Why is your technology better than existing technologies? What technology attribute(s) make it likely to penetrate the market and be selected by the space community for deep space robotic exploration? Address scientific *and* engineering aspects of these questions.

Testing and Qualification - Describe a set of tests you will use to demonstrate that your approach is effective and that your implementation of the solution will launch successfully.

Cost Analysis – Identify cost and market issues that will impact the pricing strategy of the solution you have proposed. Consider such things as: the major cost items that would impact the implementation; which elements of your implementation solution would be handled in-house versus externally-sourced; major risk elements that could drive up costs if the primary path item fails; costs of IP licensing needed, etc. Provide justification and/or reasoning behind your decisions. Estimate manufacturing cost as the technology reaches mature stage, so the marketing team can determine potential for penetrating other markets. Avoid subcontracting manufacture or assembly of any proprietary component outside the company, because the CEO is concerned with potential IP leakage.

Intellectual Property – In Appendix B, list in rank order of importance ***all*** commercial, academic, and governmental IP sources that were consulted while formulating the answer, including reference data. For instance, include the patent number; title; inventor name; and assignee name for a patent. Discuss the 3 most significant IP documents affecting your approach to your solution in the 15-page document. Compare strengths and weaknesses of these approaches relative to your own. Recommend how these IP threats should be handled.

Hint – Clearly state your hypothesized solution. Identify its innovation(s) and advantages relative to state of the art. Describe both existing data, and work needed to support each aspect of the hypothetical solution. Consider theoretical, fabrication, and characterization aspects: for each, identify software/equipment and methods to use, parameters to vary, anticipated outcomes, and possible alternatives in the event of unsatisfactory results. Discuss material, process, device, and systems aspects of your solution. *Refine* your hypothesized solution as you accumulate information and prepare the manuscript. **Remember**: clearly distinguish what is known from what is hypothesized or not known. What is needed to distinguish the important things to know?

Reference the 2019 PhD Candidacy Exam Guidelines document for general instructions.