Lifeboat Foundation Response to:

NNH13ZCQ001L ASTEROID INITIATIVE REQUEST FOR INFORMATION

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Abstract:

(This abstract *does not* include any proprietary or ITAR information.)

The Lifeboat Foundation is responding to item 6) Partnerships and Participatory Engagement.

The Lifeboat Foundation is a nonprofit nongovernmental organization dedicated to encouraging scientific advancements while helping humanity survive existential risks and possible misuse of increasingly powerful technologies, including genetic engineering, nanotechnology, and robotics/AI, as we move into a very complex future.

The Foundation is pursuing a variety of options, including helping to accelerate the development of technologies to defend humanity and improve its prospects, new methods to combat viruses (such as RNA interference and new vaccine methods), effective nanotechnological defensive strategies, and self-sustaining space colonies in case the other defensive strategies fail and for their contribution to the future of humanity.

We propose three project concepts as our part of this information gathering request.

The first is a joint NASA/Lifeboat Foundation media venture, beginning with public awareness through historical cinema; moving to a video/cinema competition format; concluding with a major effort to create a near-real-time, online gaming effort fed by actual tracking data, while including components of science fiction and competition.

The second is a new competition venue similar to other current NASA efforts. This would be targeted at garage innovators, the Hackerspace/Maker community, and universities. A tiered set of goals would challenge participants to begin with simulated asteroid ore, and eventually produce finished components.

The third activity would leverage many existing NASA pathways into the public, by adding Asteroid Initiative goals into currently sponsored events such as Odyssey Of The Mind; FIRST Robotics, and Lunabotics.

In addition, our members provide overarching comments to the mission as relates to larger societal goals.

This discussion covers aspects of multi-purpose, cooperative missions within and without NASA with the unmanned asteroid retrieval mission as the initiator, with a focus on the later use of the retrieved asteroidal materials as radiation shielding for crew habitats at proposed EM-L1 or L2 logistics stations.

(The remainder of this submittal *does not* include any proprietary or ITAR information.)

Project #1: "Telling The Story"

Engagement Concept (System Concept):

Everything begins as a story. Imagination itself is collection of stories. Imagination is the beginning of creativity, innovation, and positive change. "Tell Me the Story" is a comprehensive cross-media campaign designed to normalize the idea of asteroid mining and planetary defense in the minds of young people. In order to build bridges to community, one must create a destination for the bridge to go to. "Tell Me a Story" creates vision and narrative which brings the future to life now, so we know where we are going. There are three modules to this program: Watching the Story, Making the Story, and Living the Story.

Engagement Approach (Development approach):

1. **Watching the Story**: The goal of this module is to provide an entry point to the campaign via social media, conference presentations, and tying into other NASA public competitions. We propose creating TV and film projects to introduce the concepts and excite interest, in general terms only, for lay viewers. Additional media for elementary and high school will be created to tie into the "Making" module.
2. **Making the Story:** The goals of this module are to educate, raise awareness, normalize the future, mold pop culture, create focus for key ideas, provide a gateway to general education in physical sciences (physics, astronomy, geology, mineralogy, material science, etc.), engineering (robotics, mining etc.), and technology (spacecraft, artificial intelligence, space communication, manufacturing, solar propulsion etc.). Additional goals of this stage are to empower individual voices, create dialogue and community, promote individual original thinking, incubate creativity and innovation, and follow through and sustain focus on the key ideas established in the "Watching the Story" module. This will be tied to overall promotion activities of the NASA brand.

   We propose offering opportunities for the public to create their own media. Possible avenues are: independent films, YouTube/video channels or virtual festivals, actual festivals, social-video-driven asteroid memes, youth programs in film about new science, teaching the concept of "seeing" the future, citizen science journalism, contests, and challenges.

   This stage could also include stimulating interest by re-releasing older science fiction movies, from the 1950s to the present. A "what's scientifically wrong" contest would be a great "make fun of the previous generation" chance for young people.

3. **Living the Story**: The goals of this module are to mold popular culture, engage interest, foster imagination and visualization, and encourage the technological pop sub-culture (space tech entrepreneur gamer).

This should include an elaborate /massively multiplayer online role-playing game (MMORPG) in the asteroid belt. Players move asteroids and mine them. They learn about minerals, mining, robots, spacecraft. The main deployment mechanism for the game uses a client-server system architecture with a specially designed A.I. that keeps "updating" and improving the simulation as new sighting and orbital mechanics data from NASA are acquired. This is the real asteroid belt, or close to it. Players must obey the laws of physics, and resets are neither easy nor painless. Reward should be real, such as launch passes, visits to the nearest NASA center, video game conferences, competitions on site, etc.

To avoid the perception of a boring, "nerds only" environment, we propose including alien intelligences, fuel caches, etc. However, the non-fantasy scientific parts of the game are true to data and become more true as the simulation evolves over the years. The simulation and user base will mature over years, then the A.I. may eventually use player-generated data as input for useful calculations and concepts.

The talent base for the video/gamer side of the "Tell The Story" campaign can be drawn from the Lifeboat Foundation's extensive membership. Working in partnership with NASA's technical and Public Affairs community, this integrated approach will provide access to world famous names to assist the NASA Asteroid brand.

The first two modules of this approach use mature, proven markets, techniques, and approaches, requiring only a project management approach with objectives, timeline, and appropriate budget (or industry partnerships). The gaming environment is well understood, but the Lifeboat Foundation recognizes that this requires a significant investment in resources by NASA, the Lifeboat Foundation, and partners to develop the tool. It is fully feasible that association with a NASA activity of this magnitude would be attractive to either game technology education (e.g. Full Sail University) or large game manufacturers.

This project meets the NASA intent of using NEA observations, citizen science, and public–private partnerships to increase the resources for tackling the planetary defense problem and for broadening participation.

Project #2: "Space Fabrication Challenge"

Engagement Concept (System Concept):

Asteroid capture is exciting because it offers a source of matter that does not have to be shipped from Earth at enormous expense. There are various concepts for processing that matter. There are various methods of mining; techniques for refining by heat and chemical processes; and techniques for fabrication by molding, extrusion, machining, and 3D printing.

The approach for this challenge is to engage the "hackerspace" and "maker" communities, as well as more conventional academic venues like NASA's "Lunabotics" event.

Engagement Approach (Development approach):

This project leverages on the thirst for creativity combined with mechanical ability embodied by garage inventors, Hackerspace members, and team of students and faculty advisors. The extreme popularity of the Maker events could also be leveraged.

Use of competitive prizes, especially “no cost to NASA” types such as Center visits, launch passes, free tickets to Visitor Centers, and publication in NASA journals can be powerful awards. The possibility of developing sounding rocket or orbital “picosat” type payloads as follow on, sponsored projects, is another motivator.

Possible competitions are:

- Separating simulated asteroid ore into basic elements and compounds
- Converting these components into useful fabrication stock
- Turning the stock into finished, formed product autonomously

This progression follows typical “Challenge” type protocols. Each step takes a few years to master, while NASA learns what works and adjusts the rule set. Once a particular technique is conquered by the community, the next level of goal is set.

Once designs for fabrication equipment are available, NASA can direct the goals towards designs of hardware to be manufactured by that equipment. For example, tubing and wire are natural products for in situ manufacturing, and more complex products can be contemplated.

Once earth-bound manufacturing has been achieved, the next step of micro gravity flights aboard sounding rockets, then ISS experiments or free flying picosats, follows NASA’s normal technology progression.

This project, while directly addressing the “Public Engagement” aspect of the RFI, cross correlates to several of the other five requirements.

Project #3: “Leveraging The Excitement”

Engagement Concept (System Concept):

NASA is already engaging the public, especially students, in many space-related competitions and venues. This project would add parallel goals to these already highly successful venues.

Engagement Approach (Development approach):

1. NASA currently sponsors an “Odyssey of the Mind” problem each year. By directing one or more years towards the five desired technical goals, the public outreach mission is achieved.

2. The Lunabotics and NASA Centennial Challenge Sample Return mission are natural partners to a Space Manufacturing competition as detailed in Project #2.

3. NASA already has a significant public affairs outreach in the social media, video, and television mediums. The Lifeboat Foundation will survey our more than 2,000 members, using information about current outreach efforts supported by NASA, to continue a dialog on using our “name recognition” members and deep, broad talent base to continuously add outreach efforts.

4. The FIRST and NEXT robotics competitions are also natural parallel pathways to introduce the asteroid awareness and creative energy desired by NASA.

Specific Responses to NASA RFI Item #6

a. How can NASA encourage commercial and international partnerships to leverage the Asteroid Initiative to advance human exploration goals such as in-situ resource utilization, and to strengthen planetary defense?

In our projects above, we address three ways to engage a variety of industry: entertainment, educational, and technical.

b. What organizations are potential partners, and how can we involve a broad community?

We suggest in our Project #3, a number of existing, NASA supported information and interaction streams. Projects #1 and 2 also identify types of partners. We propose the Lifeboat Foundation as a potential partner.

c. What would make participating in the Asteroid Initiative highly desirable for your organization or agency from financial, strategic, technological, and cultural perspectives?

The Lifeboat Foundation is a nonprofit nongovernmental organization dedicated to encouraging scientific advancements while helping humanity survive existential risks and possible misuse of increasingly powerful technologies, including genetic engineering, nanotechnology, and robotics/AI, as we move into a very complex future.

The Foundation is pursuing a variety of options, including helping to accelerate the development of technologies to defend humanity and improve its prospects, new methods to combat viruses (such as RNA interference and new vaccine methods), effective

nanotechnological defensive strategies, and self-sustaining space colonies in case the other defensive strategies fail and for their contribution to the future of humanity.

The Asteroid Initiative is 100% in line with the goals of our diverse and forward-thinking organization.

d. How can we generate momentum with near-term goals?

We suggest the following timeline:

Year 1: "Watching The Story" rollout, aligning existing competition goals (e.g. FIRST) with the Initiative; and building the beginning of an organizational structure for the large, fabrication challenge and the "Making The Story" process.

Year 2: Run a pilot competition for the fabrication challenge and the "Making" event.

e. What do we need to know with more certainty to expand planetary defense capabilities?

Lifeboat doesn't feel this question is pertinent to our submittal, as public outreach. It certainly will serve as input information in the event NASA chooses to partner with us in the future.

f. What other applications may result from investments in technologies to support the Asteroid Initiative?

Our massive online gaming project would leverage into a variety of tools, which can't be fully predicted at this time. However, the ability to simulate operations with a variety of users would provide a method for developing and testing scenarios.

g. How do you see the Asteroid Initiative contributing to our nation's future role in space?

Lifeboat sees this as a societal driving motivator especially if the entertainment media becomes fully engaged in a productive manner. The American public reacts strongly to a challenge. Here there are two challenges, the threat of asteroid impact, and the value of industrialization and settlement of space. While the likelihood of the former is low, the mere threat, coupled with today's awareness of our limited natural resources, could bootstrap innovation in the private sector. The latter could be the next stage in the development of our species.

Further Discussion

The Lifeboat Foundation has prepared additional thoughts and considerations for the requesters. This information is submitted under item 6g; and shares our vision for the usefulness of pursuing an asteroid encounter scenario in a larger context.

Asteroidal materials can be used by extracting water for direct use or for fuel, used to make structural materials, and used for radiation shielding. NASA can best encourage commercial use of asteroids by buying processed asteroidal materials from a newly developed market entity, asteroid mining companies; or having cooperative arrangements with them to provide such materials in support of near term space development initiatives. This model would be similar to, and an expansion of, NASA's current Commercial ISS Cargo and Crew initiatives.

NASA has sometimes proposed a "gateway" base at the Earth–Moon L1 or L2 points. Such a logistics station must be able to support docking of cargo and multiple vehicles in addition to crew modules, and support the accumulation of propellants, so that rapid-paced base-buildup campaigns can be mounted from the base.

The branch of NASA that wants to build this base is part of the manned program section. The group that wants to capture the asteroid is linked to both the science and manned sections, due to the interest in having a crew visit the asteroid after it is captured. Irrespective of what logistics capabilities this gateway might have once built, the rubble from an asteroid, or even slag from asteroid rock that had metals or water extracted from it would make a good cosmic radiation buffer. The layer of asteroidal material would need to be at least several feet thick to provide sufficient radiation protection for a crew. Bringing this much mass, or a more highly sophisticated shielding system, from Earth could be prohibitively expensive. The hundreds of tons of available asteroidal material could thus mean the difference between a practical station proposal and an impractically expensive one.

In addition, it is feasible that asteroid-derived materials could be processed into propellant to be accumulated at depots such as the L1/L2 station. Fuel derived from the asteroid depends critically on its composition, with *carbonaceous chondrites* typically having the largest amount of water.

This then calls for coordination between several future initiatives:

1. The group planning the initial crewed visits
2. The group planning the asteroid capture mission
3. The group planning the construction of the base itself
4. Asteroid mining companies providing asteroid materials

Asteroid-derived materials could additionally be used to build large structures in space, such as solar power satellites, large space telescopes, and eventually large space habitats. In situ, asteroid-derived fuel can be used to access other locations in space without paying the energy deficit needed to launch fuel from Earth.

Obviously, all program ideas that NASA, industry, and the scientific community create must include a logical, practical, and fiscally reasonable plan and schedule to build such a station if it wants to use the asteroid's valuable mass as radiation shielding for that station.

The synergistic use of asteroid mining technology with other space-based programs, Earth-based industry, and greater societal good is a fertile area for study. This would be a natural tie in to our proposed Project "Space Fabrication Challenge."

The L1/L2 logistics base has a further progressive use, providing a cost-effective point of departure for expeditions to the Lunar surface, to asteroids, and to low Mars orbit, allowing establishment of a duplicate Mars orbital (or Phobos/Deimos based) station for access to the Mars surface. It would provide a place to accumulate expeditionary vehicles and lunar-derived propellant free of the risk of artificial space debris impacts. This would provide what can be described as an on-demand generalized in-space operational capability such as the Navy has to go to a designated point on the ocean, perform a mission, and return safely. This type of capability is similar to what would be needed to respond quickly to an asteroid threat detected too late to deal with in a slow manner, such as a gentle orbit shift over a year or two. It would also make practical dealing with some asteroids in the slow manner since the mission could possibly leave very soon after detection.

The Earth/Moon L1/L2 logistics base would make the mounting of expeditions (manned or robotic), to any inner solar system destination much easier in addition to facilitating a more rapid response to an asteroid threat. The Mars base would, being higher in the gravity well, possibly be able to provide quicker response to an Earth intersect asteroid threat. These pre-positioned capabilities are the epitome of an on-demand generalized in-space operational capability.

Specific Observations on Current Program Planning

- These missions should be analyzed in the context of both overall human spaceflight and space development program and supporting research. The constraints and interconnections between various NASA programs with the Asteroid Initiative should be indicated on a map or format that displays the overall strategic vision of the Federal government.

- Most NASA-specific mission designs and plans are too narrowly focused on the needs and benefits of a specific mission. We advocate more public visibility and input to technology-driven, versus mission-driven, programs. An example would be publicizing the government supported current budget, R&D path, and TRL of the higher-powered electric propulsion mentioned in this RFI; the perceived costs (funding scale) of both asteroid crew visit and capture missions; and the asteroid mining equipment if any that is being developed by or in coordination with NASA.

- We need a more generalized capability in space than Apollo demonstrated.

- Near and midterm asteroid missions are heavily dependent on the availability, capacity, and capability of the SLS booster and Orion capsules. These are limiting constraints to all proposed activities.

Thoughts on Mission Boundary Criteria

- We need decisions on what type of asteroid is the best for the near-term use and for its scientific value.

- We advocate early identification of specific carbonaceous asteroid targets of the right size in the right orbit before mission planning.

- We advocate modeling the probability of finding the right asteroid within a specified time period that meets national budget ability, technology development curves, and the public interest. Based on the Keck study, the asteroid chosen would not be accessible to astronauts until the early 2030s. This would put the manned asteroid mission in direct funding competition with a Mars mission.

- We need to be able to maintain an asteroid in the selected orbit once captured, requiring another mission planning and control function, including station-keeping propellant.

- The level of public concern and reaction to perceived risk from an asteroid capture mission will need to be addressed.

Thoughts on Asteroid Visit Missions

- The currently proposed crew visit allows for little actual testing of equipment, only science sample taking.

- There is a need for coordination with asteroid mining companies for use of asteroid as a test site for company equipment.

- Current NASA studies and plans for use of the asteroidal material after science samples are taken and mining tests are completed should be placed on a library site as part of this RFI. This includes use of materials on the ISS, should it still be functional at the time of these missions.

Comments on the Keck Report

The Keck report indicates that the missions to retrieve an asteroid would take place after 2020 and that the total mission time would be between 6 and 10 years. More recent discussions indicate that the second SLS mission might be directed toward such a retrieved asteroid. Due to the length of the unmanned retrieval mission indicated in the Keck report, such a mission would have to be mounted very soon for the asteroid to be in place in time for the manned mission. If a liquid fueled upper stage was used to speed up the mission, there would be insufficient xenon left to return the asteroid to Earth orbit. This discrepancy needs to be resolved so that the different groups participating in the overall project can coordinate.