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Introduction: The study and utilization of asteroids will be an economical way to enable exploration of the solar system and extend human presence in space. There are thousands of near-earth objects (NEOs) that we will be able to reach. They offer resources, transportation, and exploration platforms, but also present a potential threat to civilization.

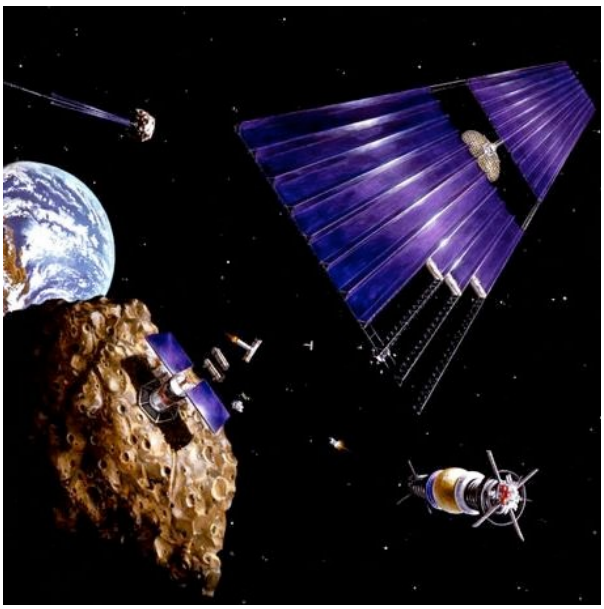
Asteroids play a catastrophic role in the history of the Earth. Geological records indicate a regular history of massive impacts, which astronomical observations confirm is likely to continue with potentially devastating consequences. Study and exploration of near earth asteroids, however, can significantly increase advanced warning of an Earth impact, and potentially lead to the technology necessary to avert such a collision. Efforts to detect and prevent cataclysmic events would tend to foster and likely require international cooperation toward a unified goal of self-preservation. Exploration of asteroids will help us to understand our history and perhaps save our future.

Besides the obvious and compelling scientific and security drivers for asteroid research and exploration, there are numerous engineering and industrial applications for near-term asteroid exploration.

We have strong evidence that some asteroids are metal rich. Some are water and organic material rich. They can be reached with a very low fuel cost compared to other solar system destinations. Once we reach them, there are efficient, simple extraction technologies available that would facilitate utilization. In addition, the costs of returning extracted resources from asteroids will be a fraction of the cost to return similar resources from the Moon to Low Earth Orbit (LEO). These raw materials, extracted and shipped at relatively low cost, can be used to manufacture structures, fuel, and products that could be used to foster mankind's further exploration of the solar system.

Asteroids also have the potential to offer transport to several destinations in the solar system. In addition to Mars and the Asteroid belt, it is possible to nudge the orbits of NEOs to provide convenient transport to other destinations. Resources to support life on these long voyages may be gathered from the host asteroid itself. As asteroids travel over a wide range of inclinations and ranges, they offer possible platforms to perform scientific investigations. These include unique vantage point observations of the sun and planets. These observations can help us to understand solar activity and space weather. They also afford us an opportunity to see how the earth looks from afar with different perspectives. When we look for planets outside of our solar system, these observations will help us to calibrate our data. Asteroids may also be used as platforms to support very long baseline interferometry with unprecedented angular resolutions.

Themes: [1]. Utilize the unique attributes of Near-Earth Objects (NEOs) to enable and enhance sustainable robotic and human space exploration into the solar system. [2]. Pursue scientific activities to address fundamental questions about Asteroids, the solar system, the universe, and our place in them. [3]. Characterize and mitigate the risk asteroids pose to life and infrastructure. [4]. Supporting Themes for Objectives Categories.



Photograph: Study & Utilizations of Asteroids

Objectives: [1]. Astronomy and Astrophysics. [2]. Use asteroids as a platform for VLBI astrophysics. [3]. Study Zodiacal Dust. [4]. Heliophysics : Observe the Sun , Observe and characterize the solar wind .[5]. Geology : Understand the origin, composition, and structure of asteroids , Gain a better understanding of the history of the Moon by studying impact craters on asteroids , Study water and other volatiles on asteroids , Characterize potential resources on asteroids , Characterize the impact process. [6] Life Support and HabitatL: Provide safe and enduring habitation systems to protect individuals, equipment, and associated infrastructure, Improve upon existing biologically based life support system components to support long duration human exploration missions, Provide agriculture services to support life support systems , Provide health care services to aid life support operations. [7] Materials Processing: Provide the capability to beneficiate asteroid materials , Provide the capability to dig regolith , Provide environmental sealing , Develop processing techniques , Provide the capability to sieve minerals , Provide the capability to collect materials , Provide the capability to store materials. [8] Communication and Navigation : Provide an interplanetary Internet , Provide autonomous and expert communications and navigations systems [9] Power : Utilize solar energy , Define and characterize power requirements.[10] Surface Mobility : Implement surface mobility systems to support both crew and cargo traverses in reduced gravity, Provide surface mobility capabilities for the purpose of constructing and operating an outpost. [11] Operational Environmental Monitoring : Monitor space weather to protect inhabitants and gather data about our solar system , Monitor real-time environmental variables affecting safe operations. [12] Crew Activity: Develop teleoperation capabilities to support human operation of equipment on the asteroid's surface. Implement human interaction systems (telepresence) to support automation technologies required for asteroid operations, Provide arts, entertainment, recreation, and leisure activities for the well being of the crew. [13] Asteroid Resource Utilization : Characterize asteroid resources , Collect and return representative asteroid samples , Fabricate structural elements , Develop resource- and environment-appropriate refining technologies .[14] Commercial Opportunity: Create a business plan for asteroid resource utilization , Develop an asteroid tourism industry , Establish insurance coverage for asteroid activities , Establish a legal regime for asteroid activities , Establish environmental requirements for asteroid activities , Develop commercial technologies for energy production. [15] Public Engagement and Inspiration: Extend awareness of space activities to diverse, non-traditional communities, utilizing non-traditional means, to enhance public engagement. [16] Transportation : Provide redundant transportation services to and from asteroids , Develop reliable methods of transporting materials to and from asteroids , Develop methods of using an asteroid as a spacecraft to more distant exploration destinations , Optimize transportation methods to minimize thrust and delta v requirements. [17] Global Partnership [18] General Infrastructure : Provide finance and insurance services to support businesses operating on NEOs , Provide warehousing services on NEOs , Develop infrastructure and utilities systems on NEOs to aid NEO operations.[19] Operations Test and Verification : Engage in operations testing to understand the effect of the NEO environment on basic working tasks (with timescales applicable to early crewed Moon and Mars missions).[20] Guidance, Navigation and Control : Establish beacons for interplanetary navigation, communication, and threat assessment , Investigate and develop methods for orbit modification.

References: [1] Space Generation Congress [2] Lee. P., et al. (2005) Space Resources Roundtable VII [3] Hindustan Copper limited (Mines) [4] Chadwick, W. J. III., et al. (2004) Advances in Astronautical Sciences, 119, 1, pp. 509-528. [5] Dr. S.K. Bhave, PhD, Gujarat University, India