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Conceptual Design of Near-Earth Asteroid Mining and Utilization of Potential Resources

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Abstract: Asteroid mining represents a groundbreaking endeavor with the potential to revolutionize resource acquisition and pave the way for sustainable space exploration. This conceptual research paper explores the scientific and technological aspects of asteroid mining, focusing on its feasibility, potential benefits, and challenges. By analyzing existing missions, advancements in robotics and spacecraft technologies, and resource prospecting techniques, this paper aims to shed light on the transformative impact of asteroid mining on resource sustainability and the future of space exploration.

Table of Contents

1. Introduction

In the ever-evolving realm of space exploration, where only a select few organizations, including NASA, SpaceX, and ISRO, stand as the vanguards, the landscape has witnessed transformative advancements in technology and cost-effective space travel **[1-4]**. Consequently, these progressions have paved the way for a monumental milestone in human achievement: asteroid mining. While acknowledging the formidable challenges reminiscent of the space race, asteroid mining represents an audacious endeavor that demands unwavering determination and steadfast perseverance. The realization of this ambitious goal may span a considerable timeline, encompassing months, years, or even decades of dedicated effort. However, the ultimate outcome undoubtedly holds tremendous intrinsic and extrinsic value, making the arduous pursuit of asteroid mining an unequivocal testament to the indomitable human spirit and the boundless potential of exploration **[5-6]**.

2. The Conceptual Framework

Asteroid mining involves identifying suitable asteroids in close proximity to Earth and dispatching manned probes equipped with crews capable of extracting valuable minerals. Provisions ensuring crew sustainability are essential, as they operate drills and survive in low-gravity environments. When the asteroid returns closer to Earth, the crew safely retrieves both themselves and the extracted resources, including precious metals like platinum and gold, as well as rare minerals such as lithium and rhodium **[7]**. A typical architecture for near-earth asteroid mining is shown below which includes mission phases such as:

- Launch and Orbital Insertion of Spacecraft
- Directing Spacecraft into Asteroid Orbit using Hohmann Transfer Trajectory
- Spacecraft Landing over the Asteroid
- Resource Extraction and Mining

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- Resources Redirection into Moon for Future Human Civilization on Moon

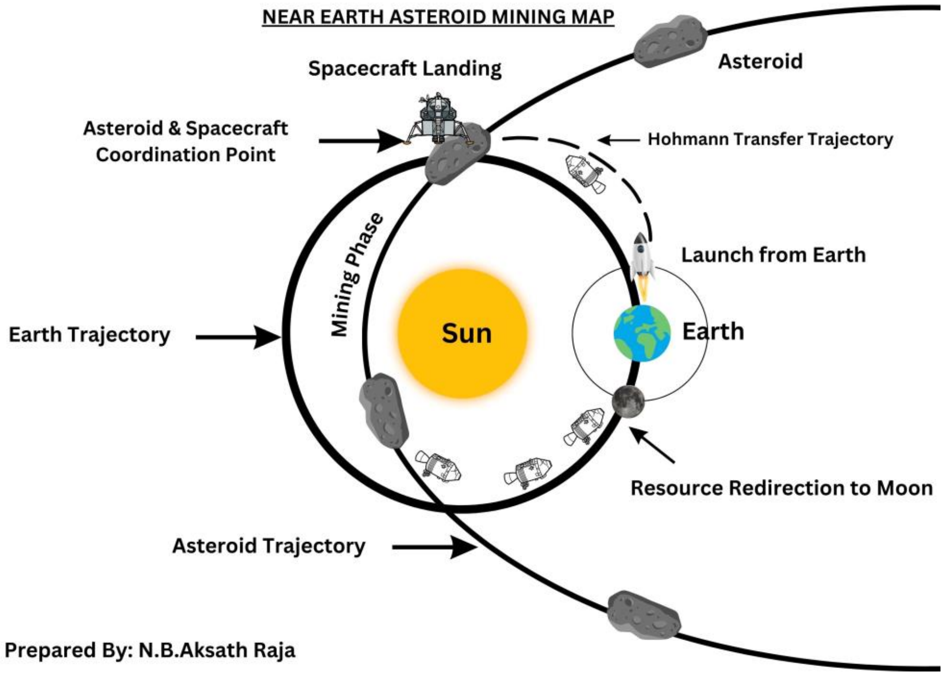

Figure 1 Conceptual Architecture and Roadmap for Near-Earth Asteroid Mining

3. Mission Phases

3.1. Launch and Orbital Insertion of Spacecraft

This phase involves the launch of the spacecraft from Earth and its successful insertion into a desired orbit around the Earth or the Sun. Precise calculations and engineering are necessary to ensure the spacecraft reaches the intended trajectory.

3.2. Directing Spacecraft into Asteroid Orbit using Hohmann Transfer Trajectory

To reach the targeted asteroid, the spacecraft must be directed onto a specific trajectory using a technique called Hohmann transfer. This trajectory optimizes fuel efficiency by utilizing gravitational assists from celestial bodies along the way. Here, we propose to coordinate Asteroid velocity and optimize spacecraft velocity for quick capture and safe-landing.

3.3. Spacecraft Landing over the Asteroid

Once the spacecraft reaches the vicinity of the target asteroid, it must carefully maneuver and land on its surface. This requires precise control and navigation systems to ensure a safe landing. Therefore, we intent to deploy automated landing system for real-time calculation and precision landing.

3.4. Resource Extraction and Mining

After landing on the asteroid, the spacecraft deploys mining equipment and robotic systems to extract resources from the asteroid's surface or interior. These systems may include drills, excavators, and sample collection mechanisms to obtain valuable minerals and resources. In addition, we propose to gather multiple samples from different and potential locations for ground-based analysis and to detect the possible bio signatures to unveil the mystery of life.

3.5. Resources Redirection into Moon for Future Human Civilization on Moon

Once the resources are successfully extracted, the spacecraft can redirect and transport them to a desired destination, such as the Moon. This redirection of resources could support future human settlements or missions on the Moon, providing essential materials and sustenance for human civilization. In addition, this kind of resource redirection will help us to prevent from back-contamination risks [8-10], where we can redirect partial resource to Earth after proper screening.

4. Evolving Technologies for Asteroid Resource Utilization

Asteroid mining represents a significant shift in resource acquisition, granting access to vast reserves of valuable resources that are scarce or costly to obtain on Earth. Beyond the economic benefits, these resources can be utilized in diverse applications, from industrial use to supporting future space exploration endeavors. Furthermore, exploiting asteroid resources lessens our dependence on Earth's finite resources and reduces the environmental impact associated with traditional mining methods.

5. Asteroid Mining Roadmap: Research and Development

To realize the vision of asteroid mining, extensive research and development efforts are underway. Advancements in robotics, spacecraft technologies, and resource prospecting techniques are critical areas of focus. Successful unmanned missions like NASA's OSIRIS-REx **[11]** and JAXA's Hayabusa2 **[12]** have demonstrated the feasibility of reaching and studying asteroids up close, providing valuable data on their composition and structure.

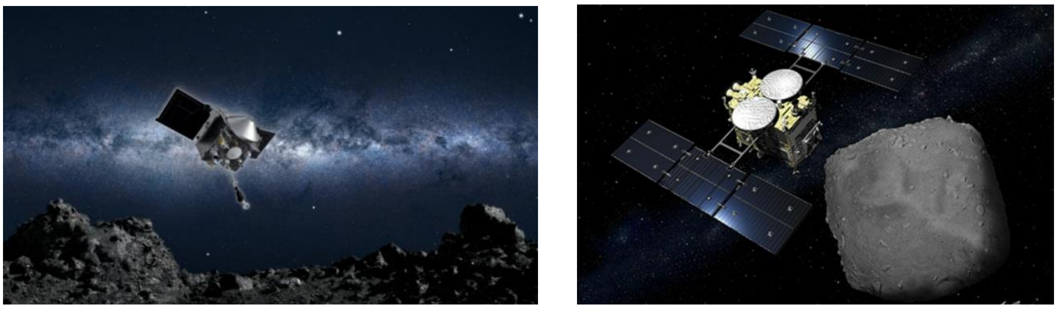

Figure 2 NASA's OSIRIX-REX and JAXA's Hayabusa-2
[Image Courtesy: NASA and JAXA]

6. Conclusion

Asteroid mining stands as a significant milestone in the ongoing saga of space exploration. While acknowledging its formidable nature, this research underscores the attainability of this endeavor through unwavering determination and perseverance. The timeline for success may span considerable durations, but the ultimate outcome promises to yield immeasurable benefits. By embracing the challenges and committing to the long-term vision, humanity can unlock the transformative potential of asteroid mining, ushering in a new era of sustainable resource acquisition and propelling us further towards the frontiers of space exploration.

7. References

[1] Whipple, F. L. (1947). Meteorites and space travel. The Astronomical Journal, 52, 131.
[2] Landis, G. (Ed.). (1991). Vision-21, Space Travel for the Next Millennium: Proceedings of a Symposium Held at the NASA Lewis Research Center, Cleveland, Ohio, April 3-4, 1990 (Vol. 10059). National Aeronautics and Space Administration, Scientific and Technical Information Division.
[3] Chen, H., Lee, H. W., & Ho, K. (2019). Space transportation system and mission planning for regular interplanetary missions. Journal of Spacecraft and Rockets, 56(1), 12-20.
[4] Venkateswaran, T. V. (2017). Scramjet: ISRO's futuristic technology to reduce costs of space travel. i wonder..., 24-28.
[5] Shaw, L. E. (2013). Asteroids, the new western frontier: applying principles of the general mining law of 1872 to incentive asteroid mining. J. Air L. & Com., 78, 121.
[6] Ursul, A., & Ursul, T. (2019). From planetary to space mining: prospects for sustainable development. In MATEC Web of Conferences (Vol. 265, p. 06015). EDP Sciences.
[7] Hamilton, V. E., Simon, A. A., Christensen, P. R., Reuter, D. C., Clark, B. E., Barucci, M. A., ... & Lauretta, D. S. (2019). Evidence for widespread hydrated minerals on asteroid (101955) Bennu. Nature Astronomy, 3(4), 332-340.
[8] Ross, S. D. (2001). Near-earth asteroid mining. Space, 1-24.
[9] O'Leary, B. (1988). Asteroid mining and the moons of Mars. Acta Astronautica, 17(4), 457-462.
[10] Shreya Mane, A. (2022). Asteroid Mining: Opportunities and Challenges. Eduzone: International Peer Reviewed/Refereed Multidisciplinary Journal, 11(1), 13-16.
[11] Bos, B. J., Ravine, M. A., Caplinger, M., Schaffner, J. A., Ladewig, J. V., Olds, R. D., ... & Lauretta, D. S. (2018). Touch and Go Camera System (TAGCAMS) for the OSIRIS-REx asteroid sample return mission. Space Science Reviews, 214, 1-23. **https://doi.org/10.1007/s11214-017-0465-2**.
[12] Watanabe, S. I., Tsuda, Y., Yoshikawa, M., Tanaka, S., Saiki, T., & Nakazawa, S. (2017). Hayabusa2 mission overview. Space Science Reviews, 208, 3-16. **https://doi.org/10.1007/s11214-017-0377-1**.

8. Biography

Aksath Raja, a passionate advocate for space exploration, became captivated by the concept of asteroid mining as a means to advance humanity and achieve enlightenment. Through extensive research, collaboration, and public engagement, he emerged as a prominent voice in the field. Aksath's multidisciplinary expertise and unwavering commitment led him to address the challenges associated with mining asteroids. Recognized for his clear communication and vision, he continues to inspire others with his belief in using space resources to propel humanity forward. Aksath Raja's journey epitomizes the transformative power of passion and the potential of asteroid mining for the betterment of mankind.

9. Acknowledgement

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10. Conflict of Interest

The author have no conflict of interest to report.

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