

Concept Design and Operation of an Asteroid Mining Vehicle

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Abstract

The objective of this extended abstract is to provide an outline of the space activities undertaken within the aeronautics group at Kingston University, before moving on to the current asteroid mining research.

1. Introduction – Space Activities at Kingston University

The space activities undertaken at Kingston University range from mission and launch vehicle design to small scale rocket engine testing. Over the last 20 years the aeronautics group at Kingston have been involved in a wide variety of projects. Previous projects have included:

- Re-entry vehicle decelerator studies
- Application of three-dimensional printing for space applications
- Launch vehicle design
- Rocket engine research

The aim of the aeronautics group at Kingston is to apply the experience and knowledge gained from these projects so that the future needs of the space community can be addressed. The aeronautics group has a keen interest in launch vehicle design, especially the design of low cost launchers. The main driving factor behind this is their potential to provide a reduction in the associated cost of future space missions. This would allow further development of future missions such as asteroid mining and deep space exploration making these more attractive for future funding.

In order to enable future missions a number of test facilities are available, one of which features heavily in the current research activities within the group. The two primary test facilities are the rocket laboratory and the microgravity drop tower (which is due to be commissioned in the late summer of 2014).

The aeronautics group has a number of current projects under investigation which are applicable to asteroid or deep space missions. These projects are:

- Project Trident a spacecraft design for a proposed mission to Neptune
- In-orbit and Planetary Manufacturing

2. Introduction – Asteroid Activities

Asteroid mining is a new concept for the aeronautics group at Kingston. This is the first year that such a project has been undertaken the resulting study is in the form of an individual project [1] which is part of the Bachelor of Engineering (BEng) Degree course.

3. Concept Design of an Asteroid Mining Vehicle Design (AMV)

The aim of the research was to investigate the concept of asteroid mining and determine suitable mining targets through the application of a series of project criterion. Presented in the following sections is an outline of the project.

The aim of the AMV study was to design a cost effective asteroid mining vehicle and associated operational facilities which would enable mining on asteroids within the main asteroid belt and on Near Earth Asteroids (NEA). In order to determine which asteroids are suitable for mining, research was conducted into asteroid characteristics and associated mineral content. From the selection process two asteroids were selected: Eros (NEA) and Ida (located within the main asteroid belt). Figure 1, shows the Eros asteroid with its associated orbital parameters presented in Table 1.



Figure 1: Near Earth Asteroid Eros [1]

Table 1: Eros Orbital Parameters [1]

Orbital Parameters		
Eccentricity	(-)	0.226
Semi-major axis	(AU)	1.457
Perihelion	(AU)	1.13
Aphelion	(AU)	1.78
Inclination	(°)	10.8
Mean anomaly	(°)	119
Orbital Period	(Years)	1.76
Mean Motion	(°/day)	0.56

During the project the trajectory and propulsion elements were investigated in order to size the final vehicle design.

The design phase of the AMV project went through several iterations. The final design included a processing stage which is contained within the rear of the mining vehicle. The proposed AMV concept resulted in a vehicle 15m in length with a height and width of 4.5m. Further conceptual work would be undertaken as part of a follow on study. The AMV would carry additional sensors and equipment, with the possibility of conducting further scientific experiments on the mined asteroid samples. The selected payload for the AMV is shown in Table 2.

Table 2: AMV Payload Selection

AMV Payload
High Resolution Camera
Alpha-Proton Spectrometer
X-ray/Gamma – Ray Spectrometer
Tungsten Carbide 0.5m drill bit
Infrared Spectrometer
Asteroid Capture Bag
M900Ia/600 Fanuc Robotics Robot Arm

4. Summary and Conclusions

The AMV project was the result of the first asteroid mining project undertaken at Kingston. The output from the project has provided an initial conceptual design for a mining vehicle. As a result this project will run over the next academic year to focus on the mission design, mining and potential scientific applications. Areas of further study include the development of a processing and refuelling station as well as a detailed analysis and design of an attitude control system for the mining vehicle. Further research would also be conducted on robotics as Kingston has some previous experience in this area, with research undertaken on the design of mobility systems for Mars rovers [2]. These aspects combined with potential experiments using the Kingston University drop tower for studying the behaviour of fluid (fuel) under microgravity conditions. Additional mining applications would also be investigated as part of the asteroid mining roadmap which will form part of the research strategy with the aeronautics group.

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References

[1] Kumanan, D.: Concept Design and Operation of an Asteroid Mining Vehicle and Processing Station, Kingston University, Final Year Project Thesis, 2014

[2] Patel, N., Ellery, A., Welch, C., and Curley, A.: Preliminary Analysis of Mobility and Suspension Systems for a Mars Micro Rover, IAC Paper, IAC-02-U.2.08, 2011.