MicroSatellite Miner (MICROMIN)

M. Sevket Uludag, M. Erdem Bas, I. Eray Akyol, M. Deniz Aksulu, Mustafa Karatas, Cansu Cenik, Amin Mirzaie, Fatih Ince, I. Omer Evranos, Alper Çiftçi, A. Rustem Aslan

Istanbul Technical University, Faculty of Aeronautics and Astronautics, ITU Ayazaga Campus, Maslak, Sariyer, 34469 Istanbul, Turkey

Phone: +90 212 258 3197, E-Mail: meseulu@gmail.com

Introduction

To live in space, to send colonies to explore the space, and to maintain space vehicle with its subsystems', the main requirement is energy. For economic purposes the efficient way is to produce the energy/equipment needed at space instead of sending those equipment from Earth. Compared to the cost of having the resources in space rather than transporting from earth is much more feasible and cost efficient.

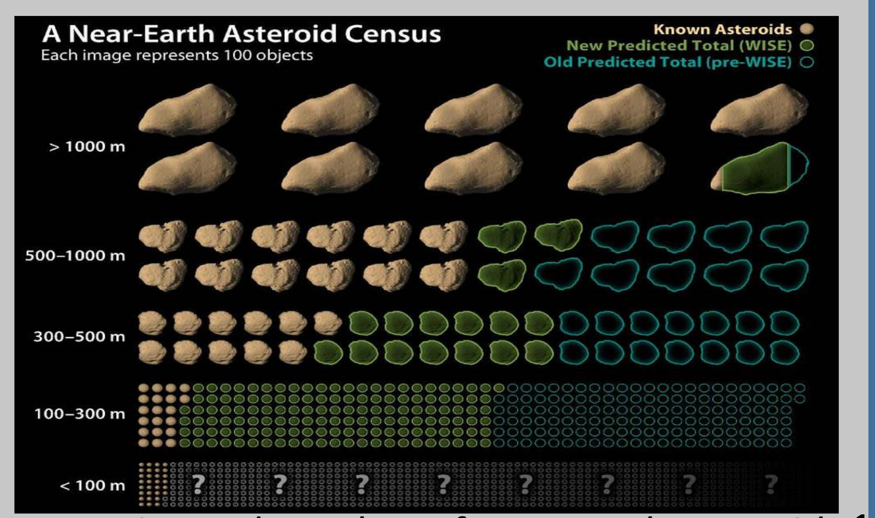

Figure 1: Estimated number of near-Earth asteroids [1]

Mission Objectives

- Exploring the possibility of using microsatellites for meteorite detection and investigation
- Using of infrared sensor to detect composition of meteorites
- Exploring capacity of electric propulsion for microsatellites
- Launching and operating of microsatellites to high earth orbits
- Inter satellite communications

Satellite Constellation

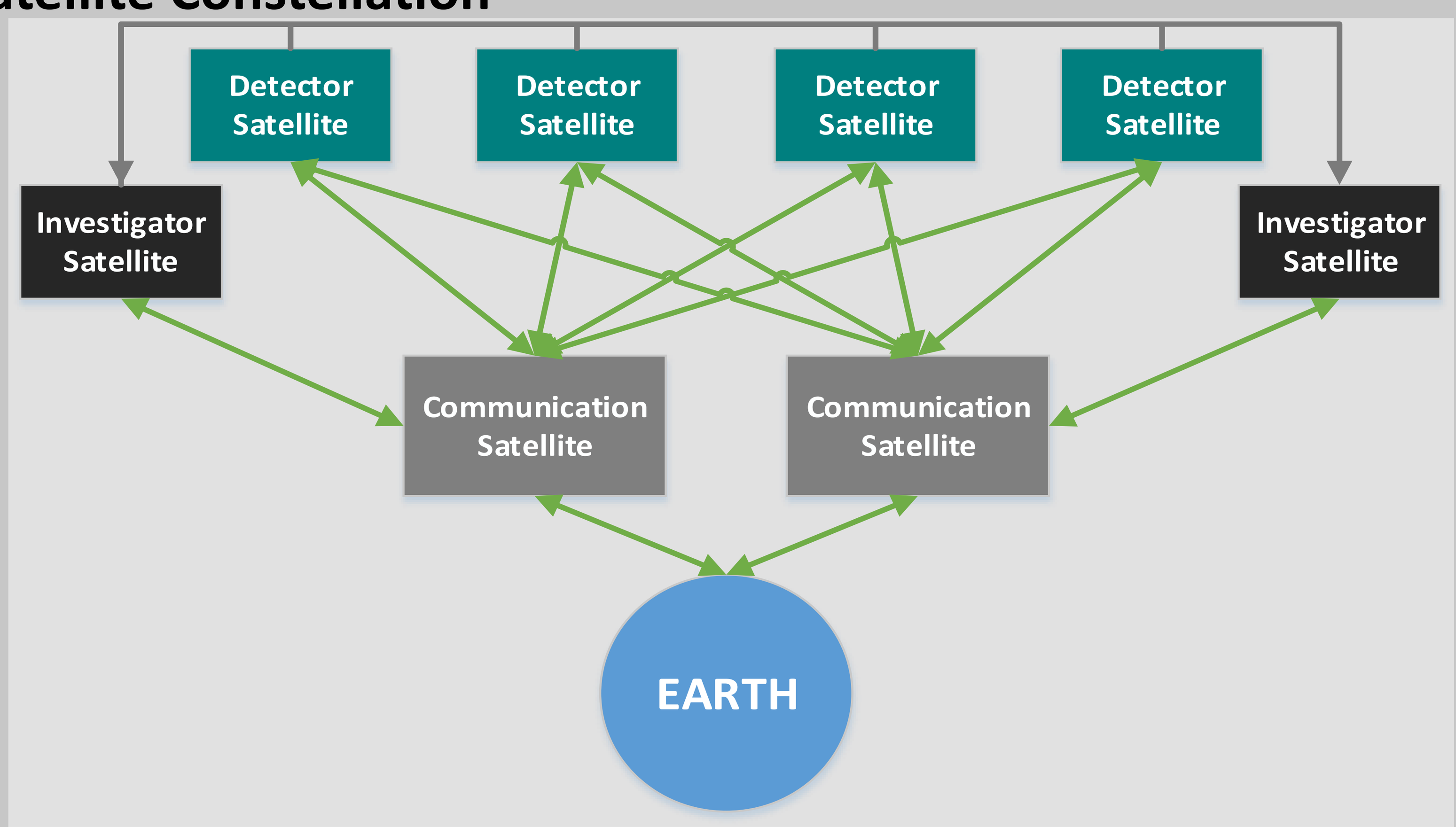

Figure 2: Satellite Constellation

Satellite constellation will be consisted of 8 satellites with 3 group:

- 4 detector satellites will monitor space and detect meteorites using their cameras
- 2 investigator satellites will approach to meteorite upon detection signal from detector satellites. NEOCam infrared sensor will be onboard for investigation
- 2 earth communication satellites will work as a relay which will help communications between the earth and satellites.

All satellites will be in highly elliptical orbit except communication satellites which will be in circular orbit for efficient communication. Each one will not exceed 50 kg of mass and 20 cm x 20 cm x 40 cm of size.

Implementation and Time Plan

Phase 1 : This phase will include launching of one satellite per group with a total of three satellites. Testing of detectors, sensors, propulsion systems and approach system will take place on this phase.

Phase 2 : System review based on precursor flight on phase 1, improving systems and launching actual systems of 8 satellites

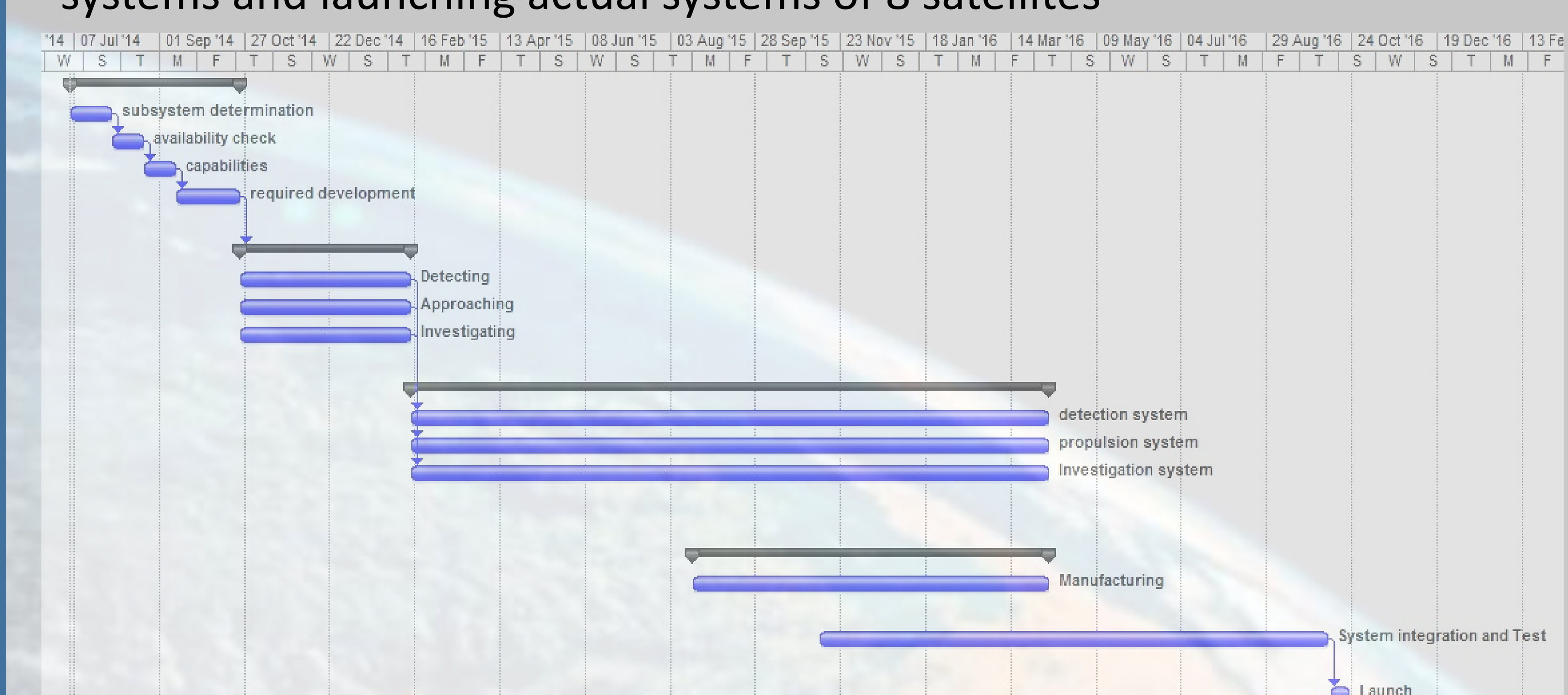

Figure 3: Time Plan for Phase 1

Required Thrust and Propellant

Miniature Xenon Ion (MiXI) thruster is ideal for precision repeat path, orbit control and precision formation flying missions. Predicted Xenon propellant mass for 4 years mission duration for each investigation satellite is about 15.84 kg.

Engine average specific impulse can be determined from table below, minimum value of I_{sp} is taken into consideration, hence exit velocity is determined as $V_e = 2.4525\ x10^4\ m/s$. Next step is to calculate thrust using input power and power efficiency (with 50 watt power input and 40% thrust efficiency):

$$T = \frac{2\, p_t\, \eta_t}{V_e} = 1.6309\ mN$$

Name	Thrust	Mass	Diameter	I_{sp}	Power
MiXI	0.01-1.65 mN	0.2 kg	3 cm	2500- 3000	20-50 w


Figure 4: Miniature Xenon ION (MiXI) thruster [2]


Figure 5: MiXI's Miniature Hollow Cathodes [3]

Infrared Sensor

The Near Earth Object Camera (NEOCam) sensor is a new infrared light detector to improve the performance and efficiency of the next generation space based asteroid hunting telescopes. The sensor will send multiple beams and then collect the reflected ones in order to understand the material of meteorites.

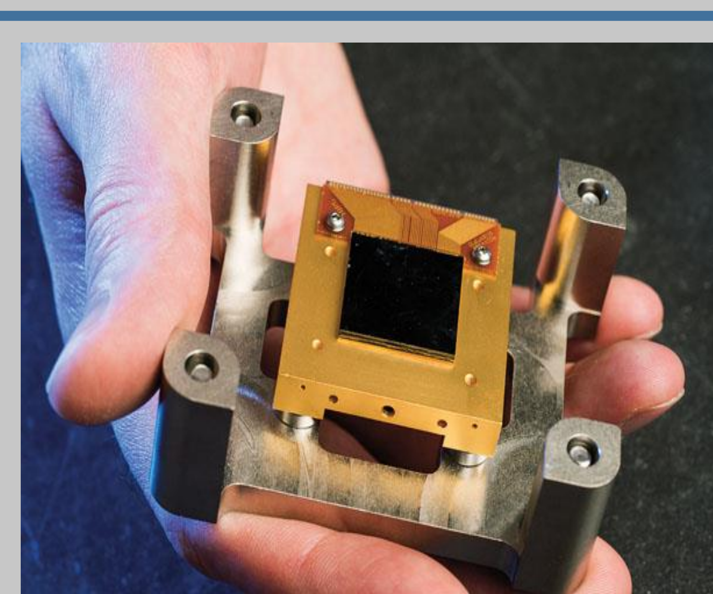
Figure 6: NEOCam Sensor [4]

Concept of Operations

Detector satellites will continuously scan space for a suitable meteorite to investigate. Following detection, the satellites will communicate with investigator satellite through communication satellite or directly, to give the position of the meteorite. Then, based on a travel plan, the investigator satellites will use their electric propulsion system to approach the meteorite. Planned orbit will probably be a spiral trajectory due to propulsion system's low thrust. Having sufficiently approached the meteorite, they will use their sensors to examine the meteorite. The results then will be sent to the Earth through communications satellites.

Budget

Predicted budget for phase 1:

- Engineering 3 years, 20 Member, $1.5 million
- Equipment procurement, $2 million
- Development, $2 million
- Launch costs, $2 million
- Total $7.5 million

Possible Risks

- Some technologies may not be ready to use
- Sensor size may be too large
- May cost more than expected
- May take much longer to realize
- Difficulty of Approaching a Meteorite
- Achieving a successful formation flying

References

[1] http://www.nasa.gov/mission_pages/WISE/multimedia/gallery/neowise/pia14734.html
[2] http://sec353ext.jpl.nasa.gov/ep/img/microprop/mixi_2.jpg
[3] http://authors.library.caltech.edu/11954/1/WIRijpse08.pdf
[4] http://www.rochester.edu/pr/Review/V76N1/0402_asteroids.html