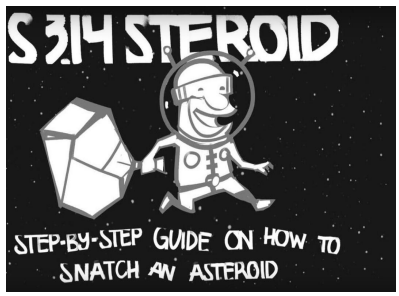


NASA's International Space Apps Challenge 2016

Project «S3.14STEROID»

BELARUS MINSK

Cathegory:
Solar System & Beyond. Asteroid Mining

#spaceappsby #BringMeARock #SolarSystem #OutThere #S3.14STEROID

Short summary: roadmap for serious challenges of humanity

1 Key questions

- search and further survey to produce unified database for asteroids;
- unified classifier of spectral classes of asteroids, based on existing dataset of "Tholen classifier", SMASS classifier;
- detailed database\classifier of asteroid according to geological data, to extend "The MPC Orbit (MPCORB) Database" up to mining catalogue
-
- roadmap for future use of asteroids, according to step-by-step concept of space expansion
- determine factors important for asteroid-for-purpose selection
- key rules for automatic selection, based on our complex criteria:
- transportation (changing orbit)
- resources
- mining potential
- time window

- rational, logical and elegant way of transportation of: selected asteroid; compound made of resources extracted on-location; or even a couple of synergetic asteroids (resource/propellant).
- selection tree for transportation engines and complex roadmaps for transportation
- vision of asteroid use on different steps of space expansion

2 To whom it is useful?

- Asteroid mining developers
- Asteroid search and survey developers
- Homo Sapiens Sapiens;
- Space logistics companies;
- Space truckers and Flibustiers :)

3 What problem is solved?

“....I’m a young and inexperienced Flibustier. What should I do? How will I snatch my first asteroid? Where’s that damned step-by-step guide - that’s what he said, that young guy in a fur hat on top of the spacesuit we met ten minutes before NASA Space Apps Hackathon.

We have to help him!

4 Uniqueness

Hey, You! You, I mean! Where is your step-by-step Flibustier guide on asteroid mining?

5 Implementation

- First attempt of prospective design of flexible, modular multi modal system for asteroid transportation, including physical models with planned extension for orbital maneuvering and gravity assistance.
- Python module for The MPC Orbit (MPCORB) Database, additional modules for database filtering according to selected asteroid properties;
- User friendly interface for **“asteroid-to-purpose”** selection with complex selection criterias

6 Preparatory steps

1. Detailed database (orbit, class, preliminary assessment of the composition) developed by orbital telescope array.

2. Close exploration and radar geomapping by multiple “a-hive” (asteroid hive) probes in the asteroid belt. Each a-hive is equipped with a huge set of cubesat-type drones (atomic battery, EHF georadar, gamma-spectrometer, EHF transmitter). A-hive seeds prospective (according to database) asteroids with orbiting (for larger ones) or “anchor three microspine paws and crawl” (for smaller) cubesat-like drone explorers to determine their potential according to following purposes.

7 Asteroid selection criterias according to general purpose

Mission/ purpose	**General purpose changes according to step-by-step space expansion**
1	Mine valuable resources for Earth, use metal and propellant for orbital construction
2	Resources for Mars, possible Mars terraforming
3	Orbital habitat
4	“Sent in advance” propellant and resource “storages” for interstellar mission

8 Integral criteria of the asteroid attractiveness to “snatch” it

A. Transportation (changing orbit):

Criteria	Weight (for missions from point 7)			
	1	**2**	**3**	**4**
Ability to be synergistically partnered with another asteroid	6	6	5	2
Elements of orbit and position according to Sun, Earth, Mars etc.	5	6	7	9
Ability to use gravitational assist of major asteroids and other bodies	4	4	3	2
Presence of substances suitable to be used as propellant	6	7	8	9
Mass, size	8	8	10	3
Energy needed for changing orbit to smaller heliocentric, areo- or geocentric	9	8	0	7
Orbital speed	7	7	3	5

Total for current purpose	45	46	36	37

B. Resource:

Criteria	Weight (for missions from point 7)			
	1	**2**	**3**	**4**
Reliability of survey data	8	8	9	10
Metals for construction purpose	6	8	8	4
Rare earth element	10	8	8	5
Hydrogen, water, hydrocarbons	2	10	8	10
Other mineral resources	1	2	5	1
Total for current purpose	27	36	38	30

C. Mining potential:

Criteria	Weight (for missions from point 7)			
	1	**2**	**3**	**4**
Occurrence depth	4	4	6	9
Aggregate state, structure, chemically bound state of resource	5	5	6	8
Equipment needed for extraction	5	5	7	9
Total for current purpose	14	14	19	26

D. Orbital window:

Criteria	Weight (for missions from point 7)			
	1	**2**	**3**	**4**
Interposition of potentially synergetic asteroids	6	5	5	2
Orbital window according to potential gravity assist bodies	7	7	8	10
Total for current purpose	13	12	13	12

Complex value of asteroid:

(Price of resource per unit)*(amount of X resource)*(complex coefficient of value of asteroid (A*B*C*D))

9 Changing the orbit of chosen asteroid

We’ve explored some scenarios, based on actual and prospective technologies and our logistic assumptions. Different combinations of such drives as direct nuclear heating of propellant, plasma engine, solar sail, sail with laser/maser pumping from mediating platform and gravity assist can be used according to criteria of time/price ratio.

We’ve made two simplified physical models of two opposite transportation algorithms: one using nuclear propulsion and another using solar sail as the lowest energy with the minimum price.

10 Short run

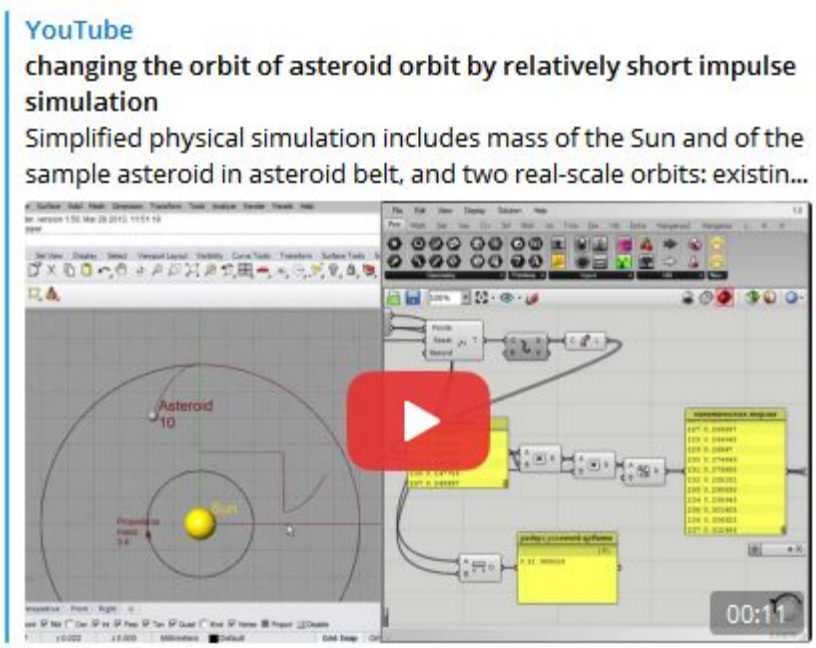
Simplified physical simulation includes mass of the Sun and mass of the sample asteroid in asteroid belt, and two real-scale orbits: existing and target one, which is approximated to the orbit of Earth to perform an orbital switch from heliocentric orbit to geocentric one.

The first, relatively short impulse with significant mass of propellant and the second one, although short but with less mass of propellant, are made by two separated automatic "tugboats" (one in the asteroid belt and another one on the earth-like orbit), to avoid senseless transportation of equipment and propellant on the asteroid's inertial route from one orbit to another.

"Tugboat" in the asteroid belt (larger impulse) operates by using easily melting parts of the asteroid itself or body of another asteroid with high percentage of easily melting substances on similar orbit as a propellant for nuclear engine to achieve powerful impulse.

Similarity of orbits of the asteroid with good industrial, constructional or habitat potential and other one with meltable substances, which could be used as a propellant, is included into the algorithm of target selection.

https://www.youtube.com/watch?v=mwSNx3kNXdc



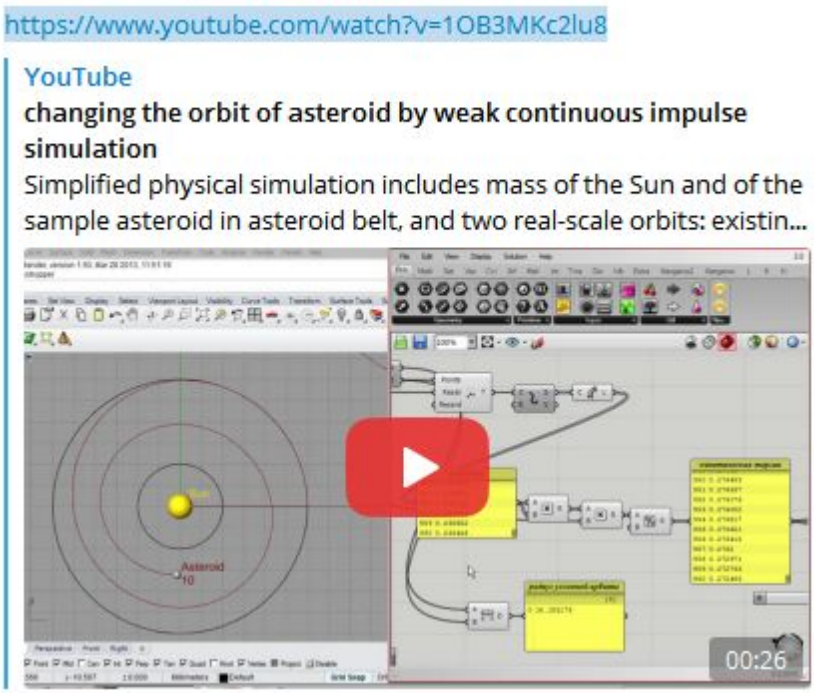
11 Long run

Simplified physical simulation includes mass of the Sun and mass of the sample asteroid in asteroid belt, and two real-scale orbits: existing and target ones, which is approximated to the orbit of Earth to perform an orbital switch from heliocentric orbit to geocentric one.

Relatively weak but continuous impulse in this simulation could be made by solar sail, solar sail with laser/maser pumping or plasma engine, which uses some concretions in asteroid shell, transported by small anchored bots to the thruster, as a propellant.

Simulation is based on Grasshopper tool with Kangaroo plugin.

https://www.youtube.com/watch?v=1OB3MKc2lu8



12 Solved Hackathon Tasks

Platform for search, evaluation and selection of asteroids for mining. Solutions for resource transportation.

We've set it a bit wider: selection of asteroids for the **current purpose** (resources, terraforming, habitats, etc) based on integral criteria mentioned above (see p.8) and economical value (algorithms of transportation, time window, etc).

13 Reflection

Opportunities to mine resources in space, as far as knowledge and technologies dedicated to it, should be the heritage of humanity. And our attempt to show the seriousness of asteroid mining process in unserious way proves it.

In our submission we've developed a draft for complete roadmap of Asteroid Mining.

The application, that we have created during the hackathon, allows to choose an appropriate asteroid automatically for a given stage of human development or for a specified mission taking in account geological analysis of each asteroid, modelling of the energetically profitable way of asteroid transportation and availability of the asteroid according to required time frames.

List of prototypes, developed during hackathon:

- draft for complete roadmap of Asteroid Mining.
- first attempt to prospective design of flexible modular multi modal system for asteroid transportation, including physical models and further exploration on gravity assistance.
- -Python module for The MPC Orbit (MPCORB) Database, additional modules for database filtering according to selected asteroid properties ;
- User-friendly interface for "asteroid-to-purpose" selection with complex selection criterias.

http://theghostbel.github.io/capture-asteroid/

Working on the project, we have raised questions, which have to be answered to make full-performance technological cycle of Asteroid Mining possible for the next generations. We

believe that all these questions can be solved in the nearest future by the global community of scientists, technicians and enthusiasts who will not be left without support of NASA experts.

Here is the list of open questions and obstacles on the way to magnificent implementation of the roadmap:

1. Lack of complete, reliable and accessible (for a wide range of multidisciplinary experts) database of asteroids and comets, classified by their consist and composition and bind of a foreign key with the MPC Orbit (MPCORB) Database IDs.
2. Lack of reliable and efficient methods for evaluation of valuable minerals in composition of asteroids and comets, based on instrumental measurements, and unified data format for such kind of data.
3. Low efficiency of known hardware complexes for searching and geological exploration of mineral resources on asteroids and comets.
4. Lack of database of optimal near-Earth (near-Mars) orbits and of calculation methods for calculating these orbits for the purpose of transportation of the asteroids or its parts to further exploration.
5. Lack of international regulatory documents dedicated to space resources exploration.

We dare you to create the future together with NASA!

Go to - https://github.com/theghostbel/capture-asteroid/

14 Technology

Tools:

- jQuery
- Kangaroo Physics v0.099
- Grasshopper 0.9.0076
- Rhinoceros 5 (SR2)
- Phyton
- Android Studio
- JavaScript
- Piratepad
- Brackets
- WebStorm
- Adobe Acrobat XI Pro 11.0.7
- Adobe Premiere Pro CC 2014 8.0.0.169
- Photoshop CC 2014
- Google drive
- three.js
- Twitter Bootstrap

Links:

- http://dawn.jpl.nasa.gov/technology/GRaND_inter.asp
- http://www.minorplanetcenter.net/iau/MPCORB.html
- http://www.fakel-russia.com/research/
- https://en.wikipedia.org/wiki/Asteroid_spectral_types
-http://www.nikiet.ru/index.php?option=com_content&view=article&id=245%3Aspace-creation&catid=3&Itemid=50
- https://light2015blogdotorg.files.wordpress.com/2015/07/fig1.png
- http://www.techtimes.com/articles/110935/20151127/president-obama-signs-pro-asteroid-mining-bill-into-law.htm
- http://www.thespacereview.com/article/2910/1

15 «S3.14STEROID» TEAM

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