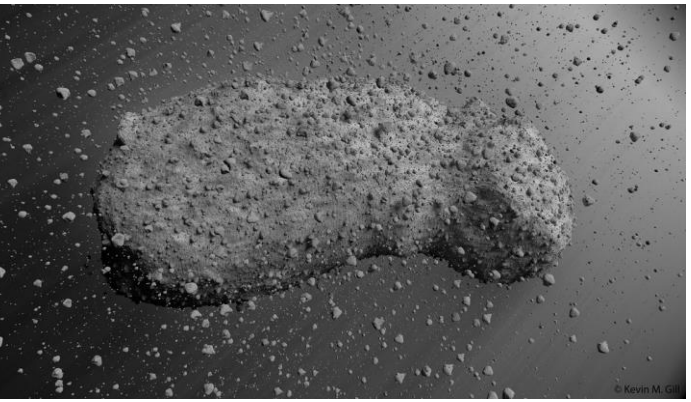
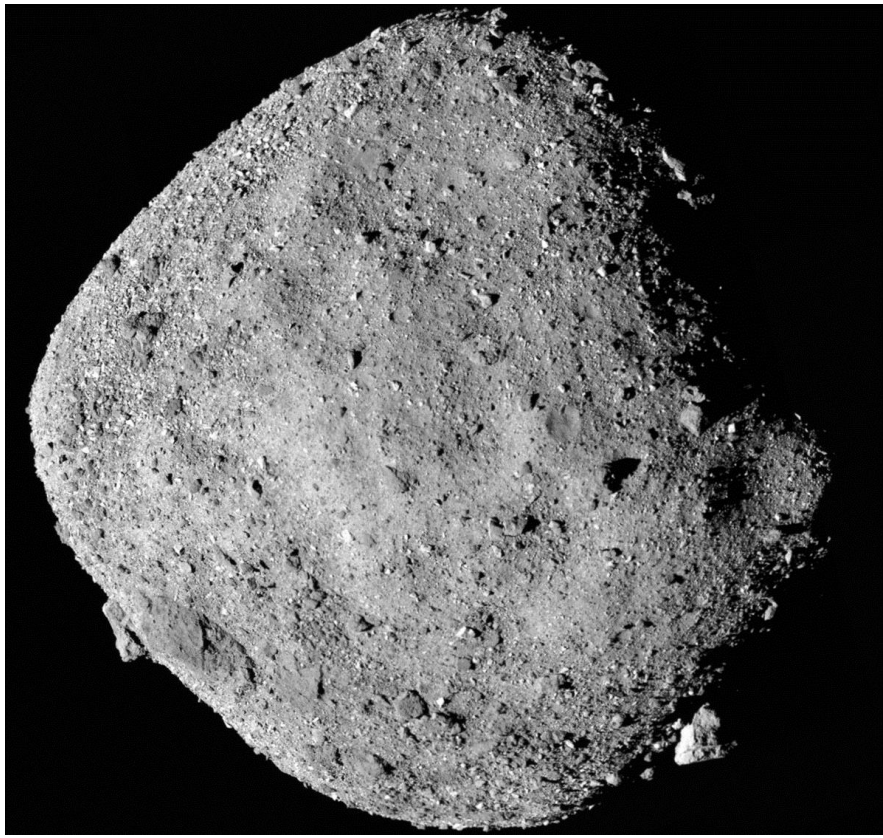
Asteroid VR/AR Simulator

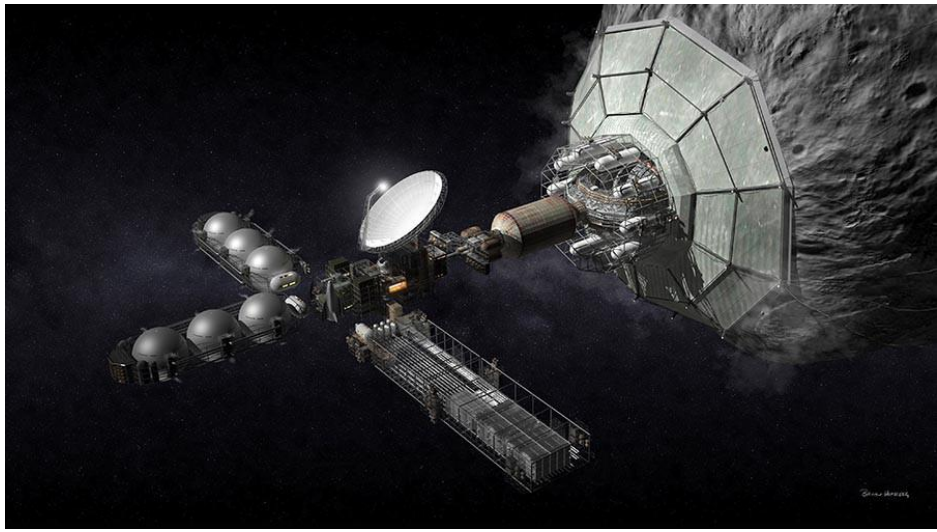
Glenn Johnson with Akorren Johnson



If people are to visit and explore asteroids and eventually develop methods of mining an asteroid, we will need to come up with technologies for getting close to, setting down on and removing material without creating big dust clouds or pushing ourselves off the asteroid. Zero-g or micro-g can be very difficult to work in when there are many small particulates that need to be controlled. Development of a VR simulator would allow researchers and designers a window into the difficulties ahead and maybe a platform for testing ideas for the mining of an asteroid and eventually a platform for how to manufacture materials at an asteroid.

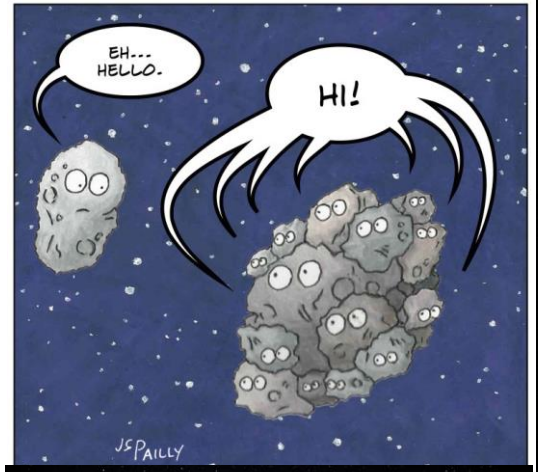
Develop a VR simulator for translating a person or a space craft around an asteroid for the purpose of learning how to get close and to the surface without being enveloped in a cloud of dust and rocks that could be dangerous to the person and/or the space craft.





Simulator for asteroid

- Asteroids that are rotating on an axis or tumbling through space tell us that they are more solid and have less surface debris and dust. The faster they rotate the less rocks will stick to them from gravity (like how a spinning, wet tennis ball sprays water from its surface). Although there are some asteroids that are one very big rock or a solid mass of iron and nickel. The current theory is that many asteroids between Mars and Jupiter are more like a jumble of big rocks, gravel and dusts—these are the ones that are not tumbling or rotating.
- Think of the asteroid as a few very large rocks that are probably at the center of the asteroid. Then there would be several slightly smaller rocks that would be another layer around the central bigger rocks. As you go outward from the center of the asteroid the rocks would get smaller. There would be dust and gravel that would go all the way to the center and fill any voids but for the most part, the bigger rocks would be near the center and the smaller dust and gravel would be on the outside of the asteroid. Since there isn't very much gravity, the dust, gravel and bigger rocks are not held together very tightly and so bumping into an asteroid could result in a big cloud of dust and rocks surrounding the space craft or floating astronaut. This could be dangerous since that person now has to maneuver themselves out of the dust either to find their partner or find their ship.
- What would it be like to do a virtual reality program so that astronauts and engineers could practice working up close with a simulated asteroid? This would give them time and experience to learn some of the many difficulties and the skills needed to maneuver around and near a large gravel pit of an asteroid before actually visiting the place.



Bennu is a Near Earth Orbit asteroid that has been visited by the NASA OSIRIS REx. Bennu's orbit around the sun crosses the Earth's orbit. It is possible that Bennu could impact Earth but it is a very small likelihood—1/2700 in the year 2175.

Psyche rotates once every 4 hours and is expected to be mostly one solid mass. NASA has a mission for Psyche planned to leave Earth in 2022.

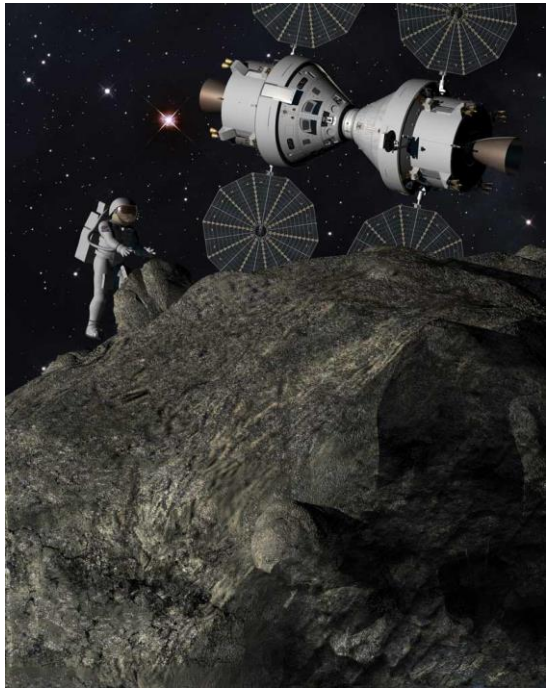
Problem:

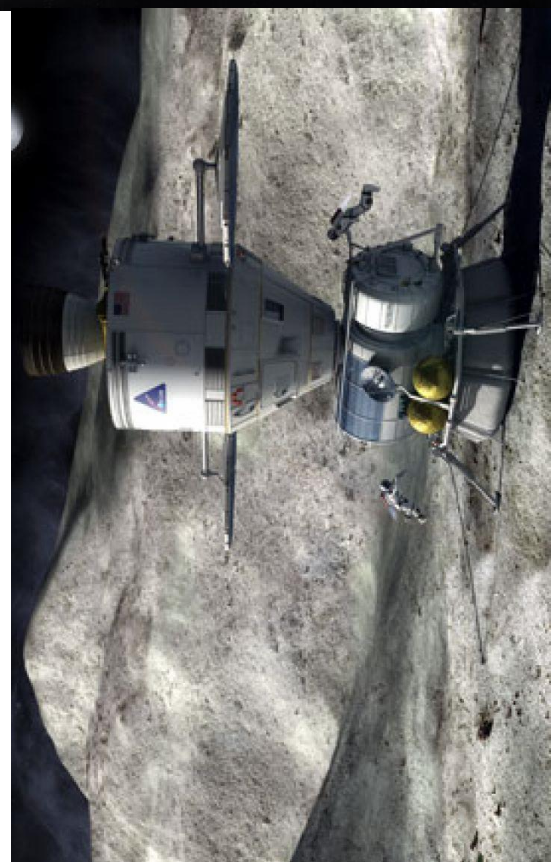
If people are to visit and explore asteroids and eventually develop methods of mining an asteroid, we will need to come up with technologies for getting close to, setting down on and removing material without creating big dust clouds or pushing ourselves off the asteroid. Zero-g or micro-g can be very difficult to work in when there are many small particulates that need to be controlled. We will need a method of testing ideas that can't really be done with solid objects on Earth.

Objective:

Develop a VR/AR program that simulates what it would be like for an astronaut to bump into Bennu and what methods could be used to minimize an expanding dust cloud that has been stirred up by small maneuvering thrusters.

- How long will it take for different sized particles (1mm, 5mm, 10mm, 20mm, 40mm, 100mm) to be pulled back to the surface after being dislodged by force of 10N. What kind of path with the particles take?
- Assume the astronaut hits the asteroid with their fist with 10 N of force.
- Assume density of rocks to be 1.190±0.013 g/cm^3
- How much debris will be scattered by a 20Newton thruster that is 10m from the surface?
- How much gravity does a Bennu have? Will it be the same everywhere since it isn't spherical?
- How might people move around on the surface?
- What kind of software do you want to use--Unity, Unreal Engine, other?
    - Are there some that are better for this application than others?
- How do we capture an asteroid without being in a cloud of dust?

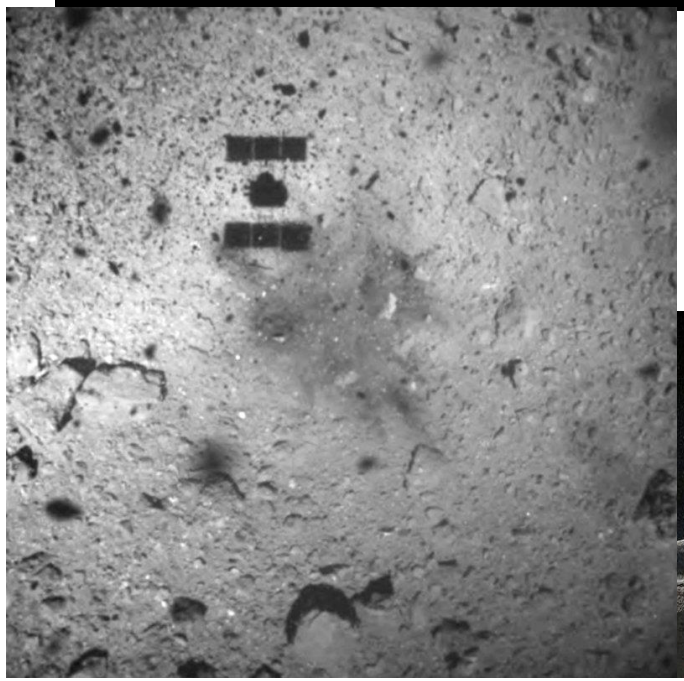




Pointers:

- A key question is how to represent this problem in a virtual reality program? Trying to model billions of small and large particles would quickly crash your computer to do all the calculations for their collisions and paths as the weak gravity slowly pulls them back toward the bigger body of the asteroid.
- It may be helpful to start with an asteroid made with only one big rock and then work into several bigger rocks and see how they behave. Then once you have something that is working well, add more rocks that are smaller and see how they behave. As you add smaller and more rocks to the collection, your computer will work harder and harder to model the particle paths and this means it will get slower and slower. However, you will also begin to see patterns where you can simplify the calculations.
    - The bigger rocks are not really moving all that much. Is there a need to do calculations on them?
    - If the asteroid is 1000 m across, do I need to do calculations for anything beyond 2 m away from my astronaut?
    - Maybe at first we don't need to do calculations on dust particles as much as we could do everything with baseball sized rocks.
    - Would it be valuable to divide it up between
        - One team creating a simulation to get the player to stand on an asteroid and see what happens when you try to walk on it
        - Another team does the calculations for the particles and their path as numbers are described above
    - https://www.youtube.com/watch?v=M9NrzyTKaCE

Asteroid Itokawa as photographed by Hayabusa 2



Shadow of JAXA's Hayabusa 2 on the asteroid Ryugu before returning to Earth with samples from the surface.

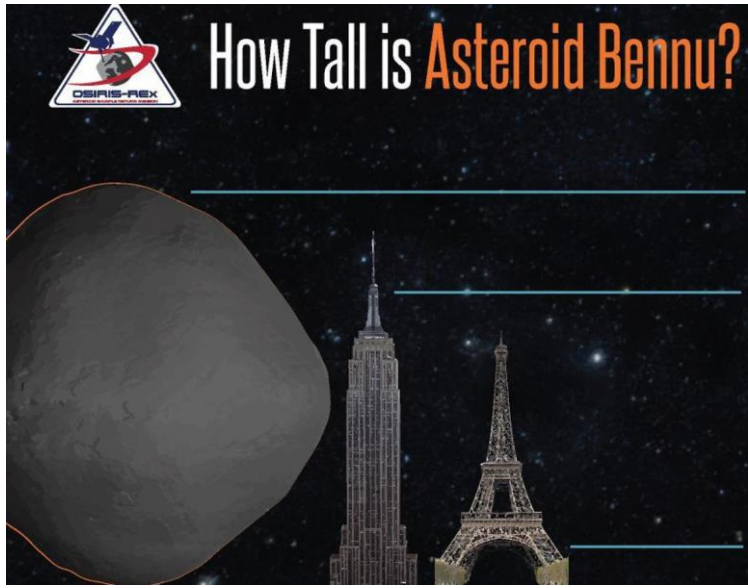
Bennu

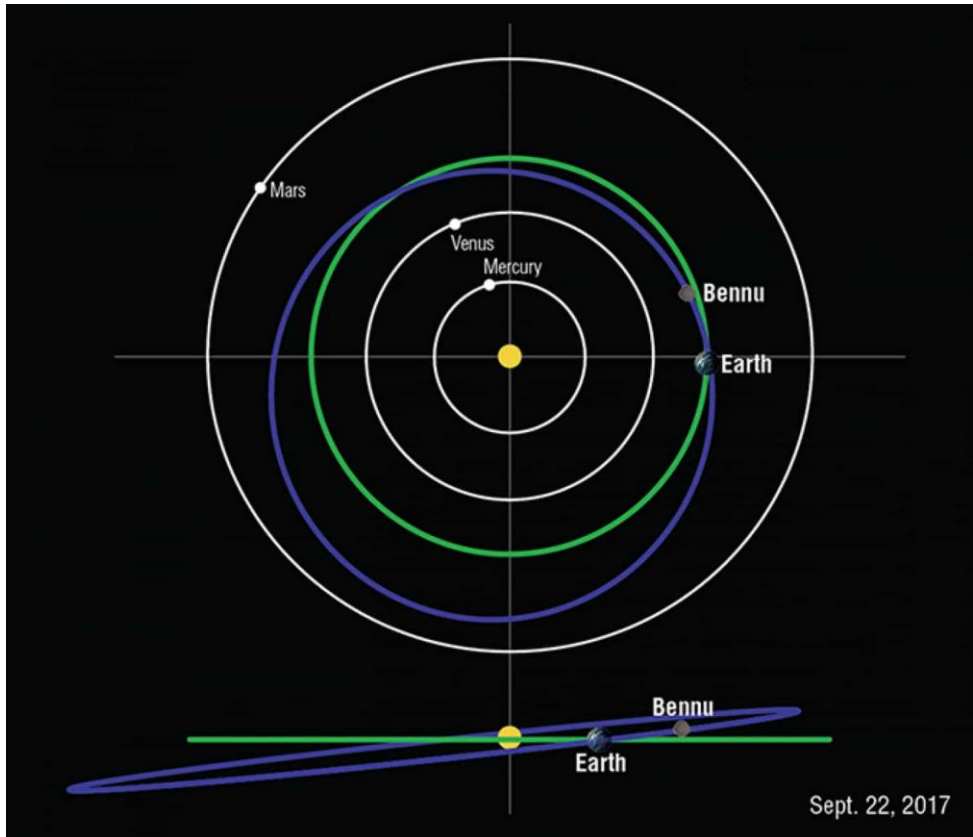
- Bennu was chosen because there is much more information about it but you may find it easier to start with starting with something much smaller and more simple like a few large rocks.

- Bennu was recently visited by JPL's OSIRIS-REx probe and is currently heading back to Earth with samples from the surface. This is an important accomplishment as the maneuvering around and making contact with this size object is very difficult. https://www.youtube.com/watch?v=NYGHbl_esgw
- https://www.nasa.gov/feature/goddard/2020/bennu-top-ten
- https://www.youtube.com/watch?v=j_hSNBmpuqY

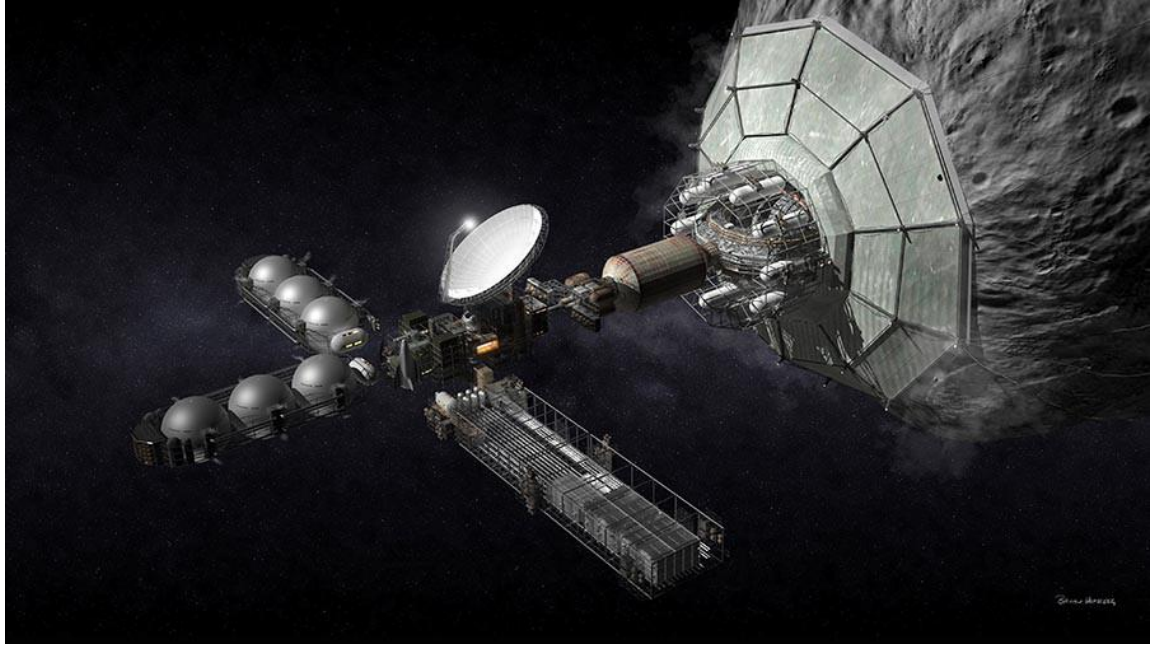
Touch down

- https://www.youtube.com/watch?v=YIsPTcfltcs





A longer, bigger picture



Mining

- It has been said that the first Trillionaire will be someone who mines the asteroids. This is just speculation but it seems reasonable considering that some asteroids have more gold and platinum than all of the gold and platinum than has been mined in all of human history.
- Just because a bucket full of rocks has some gold in it doesn't mean it has enough gold to pay the price of sending a couple of astronauts or robots there to bring them back. The mission may cost several million or even a billion dollars to bring back gold and platinum that is only worth $100,000.
- However, the real money may not be in mining the gold and platinum but maybe in the water that could be turned into fuel for the space craft, oxygen for breathing or water for the astronauts.
- Since it currently costs around $2500 per kilogram to get things off Earth and into space, there could be a lot of value to having water available already in orbit on the way to different destinations like Mars or being able to send water from one asteroid to rendezvous with a space craft that is traveling to another asteroid.
- The difficulty with all of this mining speculation is finding a way to remove the material that is desirable. How can work be done on the surface or close to the surface and be able to remove the rocks and dirt that we want without making a dangerous cloud that damages the space suits, the robots or the space craft that brings back all the material? How do we hold our equipment to the surface and remove the ore that we came there for? This is the long term goal.