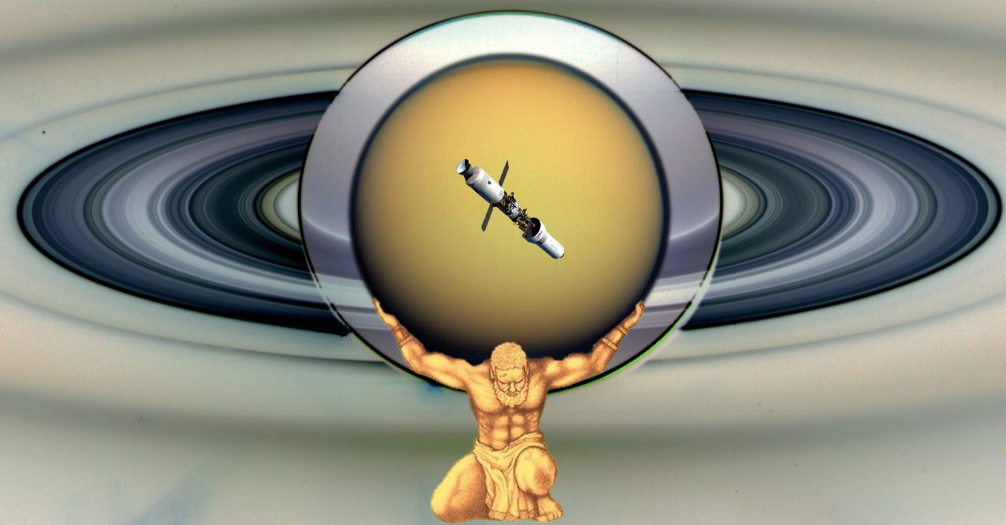
ATLAS



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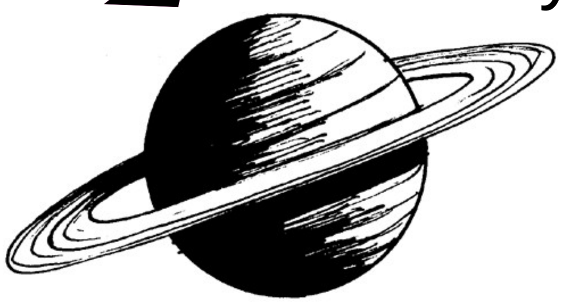
<github.com/ASU-CompMethodsPhysics-PHY494/final-atlas-mis

Prelude

Saturn is **10 times** farther from the Sun than Earth

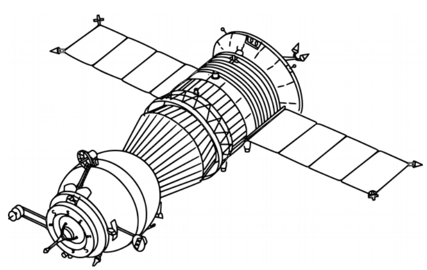
It orbits once about every **10,000** days



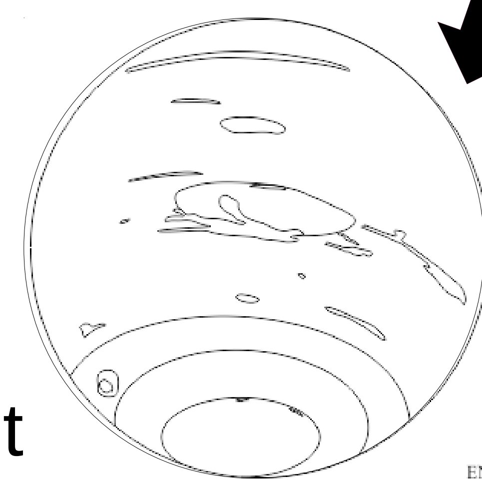
Titan orbits Saturn

It has **lakes of methane** and a dense atmosphere

Astrobiologists hypothesize that **life** could form here



ATLAS is a robotic scientific **explorer** made for Titan



It's up to us to figure out how to get **ATLAS** there!

The Mission

Titan represents an incredible opportunity to explore a potentially habitable world outside our own. ATLAS will gather evidence that could answer the question of whether or not we're alone in the universe.

The Problem

Getting a spacecraft all the way out to Saturn is no easy feat. Launch vehicles burn vast amounts of fuel, and even then it can be close to impossible to attain the velocities necessary to reach the outer solar system. If we could utilize gravitational assists from planets to accelerate our spacecraft, that would reduce the need for powered propulsion.

The Solution

We set out to create a dynamic simulation of the solar system based on gravitational interactions between bodies. This required calculating, iteratively,

$$F = \frac{GMm}{r^3}\vec{r}$$

for all masses and their relative distance from each other and plotting the system as it evolves over time.

With that done, we were able to then model ATLAS. The spacecraft is treated like any other body in the simulation, but with additional functions to control aspects of its launch, as well as retain data of its motion throughout the trajectory.

Epilogue

Through careful analysis of many ATLAS trajectory simulations, we were able to project initial conditions that lead to a successful intercept with Titan.

We didn't fulfill all of our hoped for objectives, but with more time, the ATLAS mission would have liked to place ATLAS in a stable orbit at a Lagrange point.

Exposition

Implementation of the velocity Verlet algorithm was the key component in modeling the movement of all bodies in the solar system (including ATLAS).

There were a total of 34 simultaneous equations being solved for the force calculations in the velocity Verlet, making optimization of the Verlet function necessary.

```python
    if i < int(launchday/dt):
        r[i+1, 6] = r[i+1, 1]
        v[i+1, 6] = v[i+1, 1]
        Ft_6[:] = 0
        Ft_next_6[:] = 0
    if i == int(launchday/dt):
        r[i+1, 6] = r[i+1, 1] + .01*r[i+1, 1]
        v[i+1, 6] = v[i+1, 1] + velofrac*v[i+1, 1]
        Ft_6 = (F_gravity(r[i+1, 6], mass['Atlas'], mass['Sun']) +
        F_gravity(r[i+1, 6]-r[i+1, 0], mass['Atlas'], mass['Venus']) +
        F_gravity(r[i+1, 6]-r[i+1, 1], mass['Atlas'], mass['Earth']) +
        F_gravity(r[i+1, 6]-r[i+1, 2], mass['Atlas'], mass['Mars']) +
        F_gravity(r[i+1, 6]-r[i+1, 3], mass['Atlas'], mass['Jupiter']) +
        F_gravity(r[i+1, 6]-r[i+1, 4], mass['Atlas'], mass['Saturn']) +
        F_gravity(r[i+1, 6]-r[i+1, 5], mass['Atlas'], mass['Titan']))

        print('launch', v[i, 6])

    if i == int(t_max/dt):
        #v[i+1, 6] = [-0.4*v[i+1,6][0],v[i+1, 5][1]]
        v[i+1, 6] = [0.80866*v[i+1,6][0],2.21166*v[i+1,6][1]]
    #if i == int(2535/dt):
        #v[i+1, 6] = [0.2*v[i+1,6][0],0.2*v[i+1,6][1]]
return r, v
```