ORBITER
Space Flight Simulator
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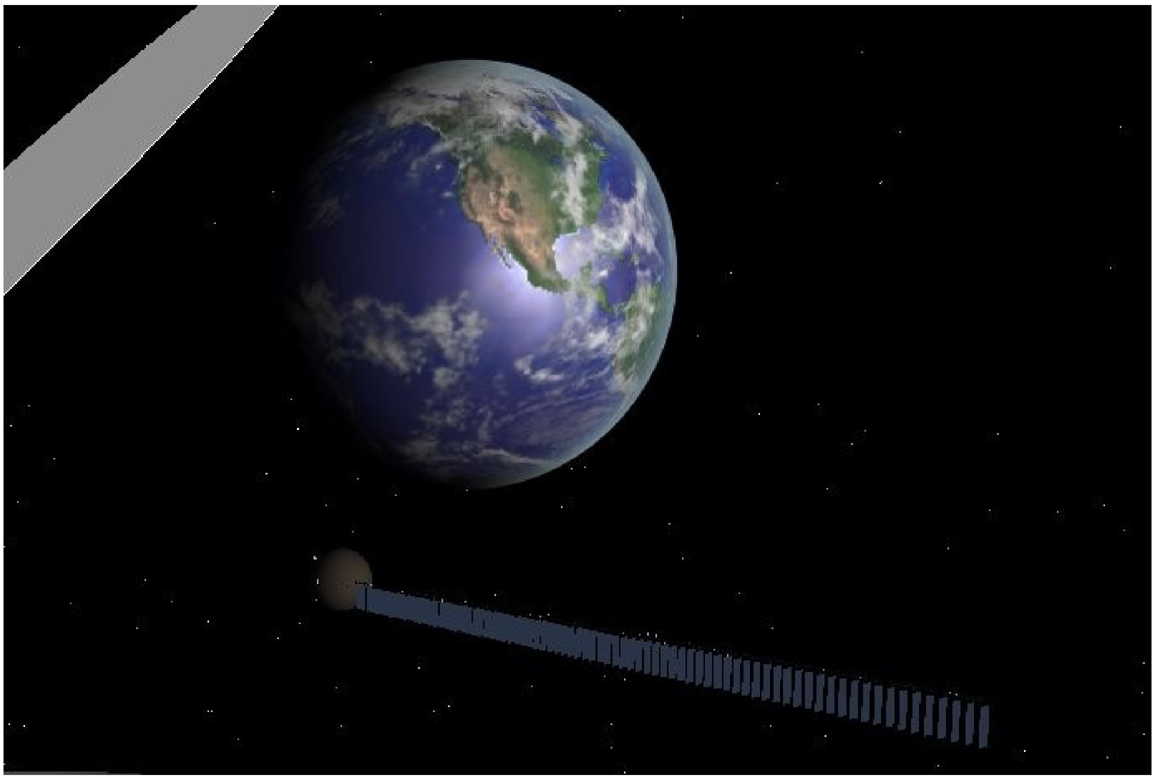
Tsiolkovsky Version 1.01



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Thanks to:
Hendo and Daver, for the CVE-Lite code on which this is based.
Drake, for starting the space colonization craze with his Stanford Torus.

Dr. Gerard K. O'Neill, for the original concept...and of course for all his other ideas.

And, above all, many thanks go to Martin Schweiger, for actually developing the simulator I used to daydream about in astrodynamics classes!

http://www.orbitersim.com

Unpacking:

Use Winzip to put each subfolder in its matching Orbiter folder.
To run most scenarios, you will require Drake's "Stanford Torus" add-on (not included).

Introduction:

Welcome to the Tsiolkovsky add-on! The Robert H Goddard and the Konstantin Tsiolkovsky were described in Dr. Gerard K. O'Neill's book, Colonies In Space. They were a pair of enormous mass-driver-powered shuttles for populating a space colony. Capable of taking on no less than 2,000 colonists at a time, they would spiral outward to L5 over a period of about a week. There, they would take on "fuel" (slag – left-over lunar mining tailings), loading enough for the trip down and back up. Empty of passengers but full of fuel, the ship would take fully three weeks to get back down.

Using all lunar materials, the ships featured an 80-meter-diameter spinning-gravity passenger section covered by two meters of slag for radiation shielding. A mass-driver, like the one shooting payloads up from the moon, served as the main propulsion system. Solar panels, like the sails of a square-rigger, powered the the mass-driver.

While the Goddard and Tsiolkovsky were to transfer between a giant LEO station and an O'Neill cylinder at L5, a Stanford torus in GEO works as well. The ISS will have to stand in for what should be a much bigger station in LEO; it looks a bit silly, but it works.

I have also taken the liberty of inventing a variant class, the Oberth. This is a modified vessel that sacrifices some passenger space in order to double the fuel bunkerage. It also includes landing gear (on the nose!) and provisions for wilderness refueling (shovels and drills). Oberth carries "only" 500 personnel at a time on multi-year voyages to Phobos, Deimos, and main belt asteroids.

Tsiolkovsky Operation:

General rule: do everything at 100x time compression (or more). Tsiolkovsky and her sister ships are huge; nothing happens quickly with them.

The "big ships" are propelled by a solar-powered mass-driver. This will make flying it a bit unusual.

The mass-driver produces an impressive amount of thrust...but it's on an enormous spacecraft! So the thrust/weight ratio is actually very low. So low, in fact, that it doesn't fly like impulsive-burn rockets like the DeltaGlider. Instead, you'll have to thrust for a long time, spiraling gradually outward.

To do this, point prograde (or retrograde, to spiral in). Engage full thrust, and crank up the time compression to 100x. Depending on the speed of your machine, you may be able to judiciously increase to 1000x...that will help a lot.

The big ships have 80 or so solar panels in a line along the mass-driver, looking a bit like an old-fashioned suqare-rigger. Why there were no panels on the "top" side of the mass-driver is beyond me. At any rate, this add-on calculates the relative sun angle, and reduces the pellet firing rate for low-power situations like having the spacecraft bow- or stern-on to the sun, which puts most of the solar panels in shadow. This will slow you down slightly, but won't be critical in most cases. However, when spiraling in, you do make sure you don't place your perigee at a place with a bad sun angle, because then it will take forever to circularize. It will take long enough with good sun angles!

Your solar power (as a percentage of what is available) is shown in the HUD in the upper right. Once pointing the way you want, you may want to experiment with a roll about that heading to improve sun angle and power.

As you spiral out, you will eventually come to the “edge” of the gravity-well shelf. You will know this because the trajectory becomes quite elliptical. This “edge” is not a defined point the way the Sphere of Influence is, but it's simply where local gravity is low enough that you suffer fewer gravity losses and start to make real headway. At this point, you can treat the ship much like a normal impulsive-burn ship. Use the planning tool of your choice (although the Shift-X “what-if” tool is as precise as is useful), fine-tune your perigee, and raise apogee until you're headed for the Stanford Torus. Once at apogee, burn to circularize; you're in relatively “flat” space and it works pretty much normally, except that you'll need to be on 100x time compression for anything to happen.

Attitude “jets” are rotary pellet launchers, also firing lunar slag out the ends of rapidly spinning arms. This pulverizes the rock in the process, so it comes out as a rock-dust “puff”. Their efficiency is less than the mass-driver's, but they're much easier to point! The mass-driver attitude jets are my own invention; O'Neill didn't specify how the big ships made attitude changes or rendezvous.

Once rendezvous with the station is achieved, docking is straightforward if ponderous. Try to get your position set while outside the rim of the colony, and move in straight and smooth without adjustments. Your pellet-launching “attitude jets” are spewing high-speed sand; try not to scratch the colony's big mirror. It seems likely that approaches with these ships would only be permitted to the “bottom” end of the colony.

To descend to the ISS is a bit trickier. Lowering perigee is easy to start with because you're in “flat” space. As you get lower in the gravity well, though, you become a “spiralling” craft again. Ensure you don't lower perigee somewhere where the sun angle is bad, because it can be incredibly hard to fix this once you're low in the well.

Rendezvous at low altitude is harder because you need to be very close and completely relatively stopped before you can treat this ship as a “point-and-shoot” vessel. Because the well is deeper and the orbital frame rotating much more rapidly than out by the colony, Hall effects will see you thrown out of position in no time if you're not careful. I recommend use of the Approach MFD to nail this phase of the approach.

The big ships will automatically refuel when docked at the Stanford Torus, or any object that masses 50 million kilos or more. These are presumed to be space colonies with available slag from manufacturing processes. The mass “appears” magically; it isn't subtracted from anywhere else.

The Oberth has even worse thrust/weight problems due to its higher fuel fraction. Fortunately, it starts out fully fueled while at the Stanford Torus, and it's supposed to go OUTWARD from there.

The Oberth can also refuel if landed on an object. The Oberth lands nose-down; ensure local gravity is light enough that you can take off again using just the linear thrusters! For Phobos and Deimos, this is no problem. I haven't tested Ceres, though.

Greater distance from the sun will also reduce the pellet-firing rate of the mass-driver, so the Oberth suffers a bit as it gets further from the sun. Unfortunately, there's no corresponding benefit to getting closer to the sun...the equipment is optimized for Earth orbit.

<u>Thrusting</u> – To engage the mass-driver propulsion system, simply move the throttle past 1/20 deflection (joystick, or CTL-+). The sound effects and moving-rock animation are subtle, and so not noticeable under time acceleration. Normally, moving the throttle will vary the thrust in Orbiter (at least for one clock cycle, before the program could fix it for you). However, we want each pellet to be the same size and maximum allowed velocity; to throttle down, only the firing RATE should vary. To accomplish this, the mass-driver drive is implemented as a user-programmable thruster that just checks the position of your throttle. Thus, the throttle doesn't actuate your thruster directly in the conventional manner; instead, it sets in motion a single rock-throwing event, which takes about half a second to conclude. If the throttle is less than max, or the sun angle is less than optimal, there will be a “recharge” delay until the next pellet is fired. One disadvantage of this system is that the main thruster's acceleration value will NOT be displayed in the upper left of the HUD, as is conventional.

<u>Safety Zone</u> – An operating mass-driver is obviously a bit dangerous to be directly in the ejection path.

If there's an object within 10 km of the operating mass-driver, and in line directly behind it, you'll get a warning message and the target will lose 5% fuel due to damage. Try not to hit anything, okay?

Notes:

I wanted to do something from the space-colonization visions of the 1970's, and the release of the Stanford Torus made that a bit more urgent. I also wanted to do a low-thrust mass-driver ship. Happily, I remembered the Tsiolkovsky and Goddard, and so got to do both at once.

Enjoy.

Bibliography:

Gerard K. O'Neill, Colonies in Space

Version history:

v1.01
- Re-compiled for Orbiter 2010
- Added HUD insolation value
- Uses GenericEVA code
- Scenarios edited for Aldrasio's 2010 refactor of Stanford Torus

v1.0
- First release