Storytelling with Uniview #01:
Scale in the Solar System

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Welcome to the first in an ongoing series about how to tell effective astronomy stories using Uniview -- either on the Orbits Table or in the Gates Planetarium. Of course, you don't need to use these suggestions exclusively with the Uniview software. You could be in front of the Science On a Sphere, or at a star party, or talking to people next to you in line at the post office. But the genesis of these ideas are based on what you can do with the visualization tools that we have in the *Space Odyssey* exhibit, so they are best paired with the visuals from Uniview.

Comments, suggestions, questions, and corrections are welcome, so feel free to email me!

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For this inaugural column, I would like to begin with a discussion of the distances in the Solar System. (Scale in the rest of the Universe will be a topic for another time.) Sizes and distances in outer space are concepts difficult for most people to comprehend. Since most of us do not have any direct experience, our mental models are typically built from a mish-mash of ideas picked up and half-remembered from books, the Internet, TV shows and movies, teachers and other acquaintances. Hence you will see remarkable misconceptions amongst the public, such as the Sun and Moon being close in distance from Earth, that the space shuttle has traveled to the stars, and so forth.

If you want to make an impression about how big space truly is, start off at the Earth. Since we cannot land on the planet in Uniview running on the Orbits Table, I like to attach the camera to the International Space Station, and move time forward at normal speed (1 second of simulation time equaling 1 second of real time). You can point out to the visitor that if she was orbiting with the ISS, that is how fast the Earth's surface—250 miles below—would be scrolling by underneath (or overhead, depending on your perspective) at 17,000 mph. Another impressionable fact is how close the edge of space and the ISS is to the Earth's surface. The distance from Denver to Grand Junction is only about 240 miles. Thus a 4 hour road trip, depending on I-70 road conditions, is equivalent to driving up to the Space Station, if your car could magically drive straight up.

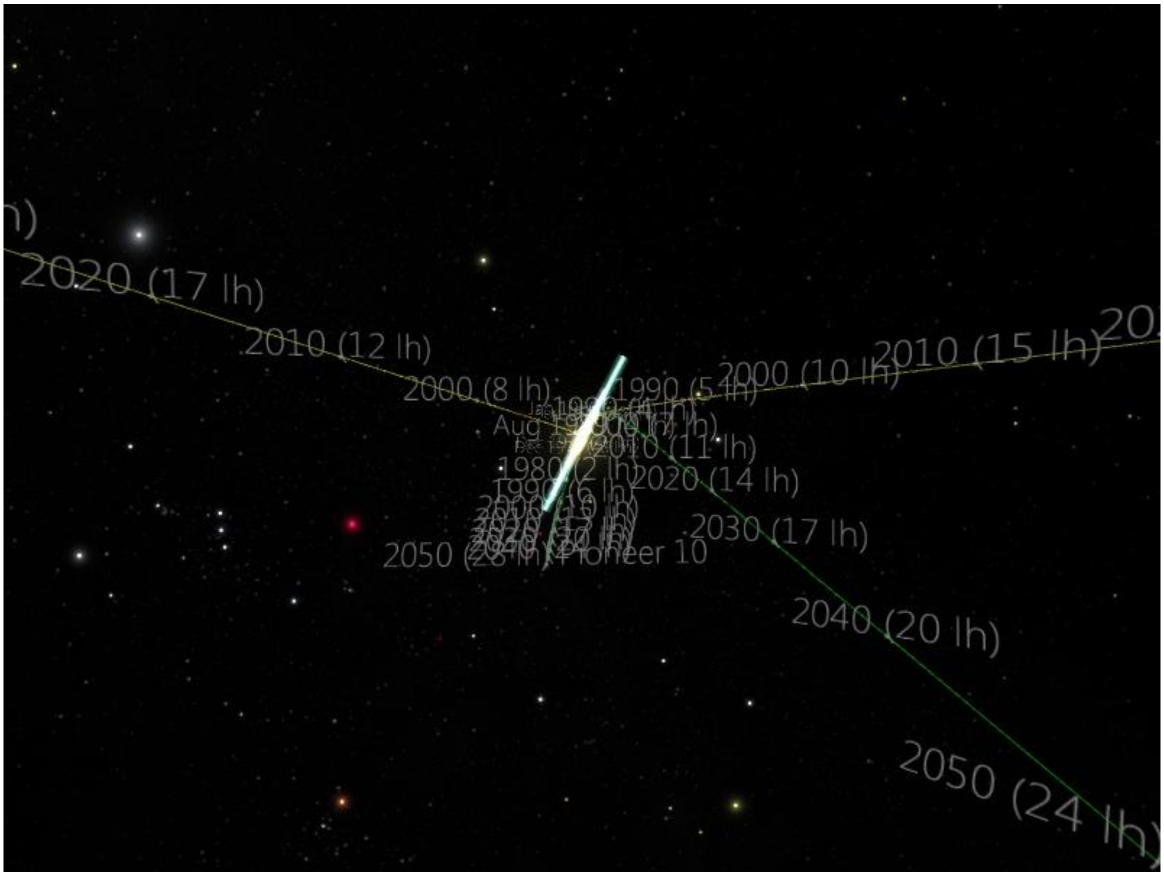
If I slowly pull away from the Earth (toggle on/off translational friction to manage how fast you zoom away), I also like to bring in the idea of light travel time. Distances in the Solar System are large enough that it becomes meaningless to talk to the public in kilometers or miles. I also tend to shy away from astronomical units, unless you have someone already knowledgeable about that term. Here are some memorable tidbits that I have used:

1. Light reflecting off a person standing a meter away from you takes 3 billionths of a second to travel to your eyes.
2. If you time it right, the orbit of the Moon will appear as you mention that signals from the Moon take 1.3 seconds—about the length of a pause in a conversation—to get to Earth.
3. Swing around so that the Sun is visible. Light from the Sun takes about 8 ½ minutes to get to Earth. If the Sun were to go dark during a commercial break of a sitcom, we wouldn't see it

happen here on Earth until well into the next commercial break.

4. Depending on where Mars is in its orbit, radio signals can take anywhere from 4 to 21 minutes to travel to Earth.
5. For the remaining planets, the light travel times between each body and the Sun are: 43 minutes for Jupiter, 80 minutes to Saturn, 160 minutes to Uranus, 4 hours to Neptune.

Finally another great way to discuss scale in the Solar System is to use spacecraft. We have trajectories for the Voyager I and II spacecraft (Solar System→Satellites→Voyager 1 and 2; launched in August-September 1977), as well as Pioneer 10 and 11 (Solar System→Satellites→Pioneer 10 and 11; launched March-April 1972). If you toggle these and their labels on, you will see the orbital paths laid out from when the spacecraft were launched to the year 2050. Make sure to tell the visitor these spacecraft will continue on trajectories that results in them leaving the Solar System (and what defines the edge of the Solar System is yet another column). Their orbit lines truncate at 2050 because that's how far the trajectories were calculated for these particular visualization modules.



If you look closely at the labels, you will see that they are marked by the year, and a parenthetical light travel time in light hours ("lh"). In the year 2050, here are the distances to the four spacecraft:

Spacecraft	Light Travel Time
Voyager I	35 lh
Voyager II	30 lh
Pioneer 10	28 lh
Pioneer 11	24 lh

These are four of the fastest spacecraft we have ever launched.[1] By 2050, they will have been in flight for 73-78 years, which means in roughly a human lifetime, our fastest spacecraft will have traveled 1-1.5 light days or so. So even if they were aimed at Alpha Centauri (which they are not), it will take more than 1000 human lifetimes for them to reach the nearest star. And of course, the distances to stars within our solar neighborhood are just the beginning of our journey into the rest of the Universe.

Note: Comparing distances spacecraft will have traveled in a human lifetime was something I first heard from Carter Emmart, Director of Astrovisualization at the American Museum of Natural History, and one of the people partially responsible for the creation of Uniview.

[1] The fastest is New Horizons which is due for rendezvous with Pluto on Bastille Day, 2015.