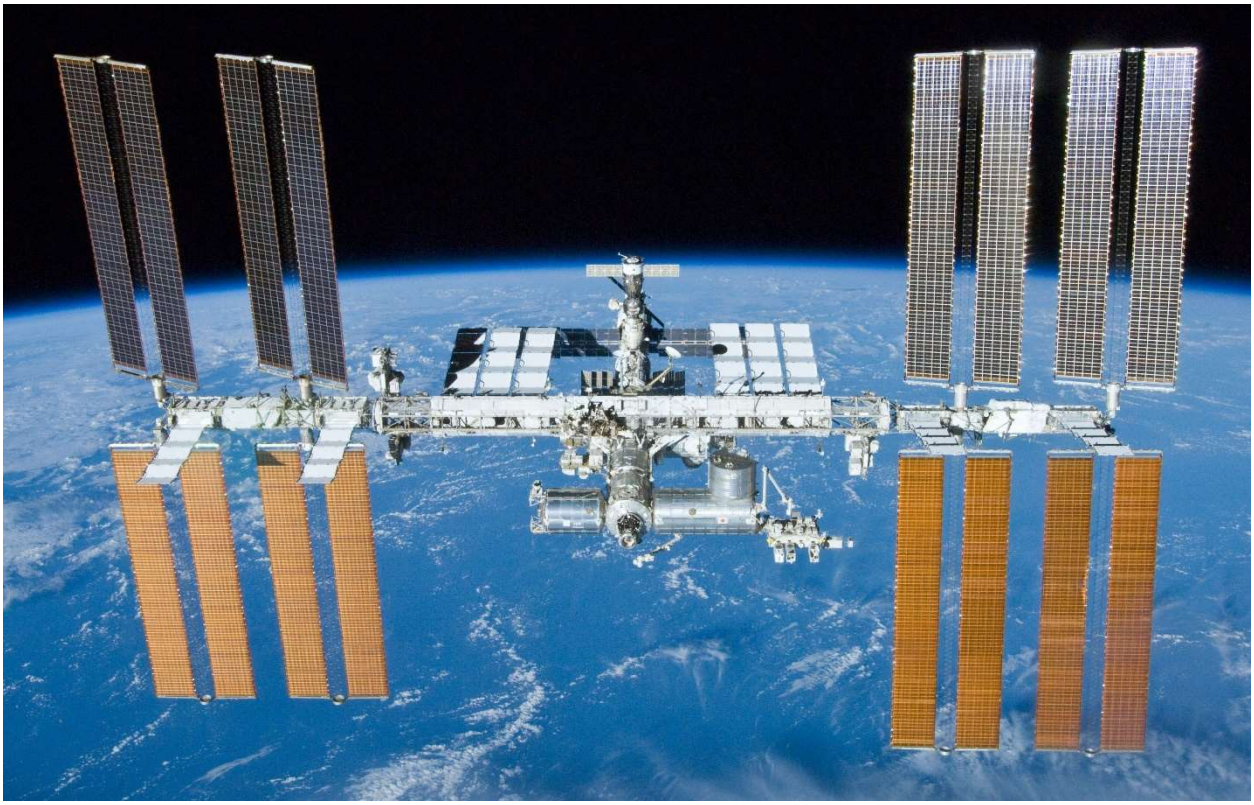
The Overview Effect

Bill Baylis, April 19, 2020

Two days ago, two astronauts and a cosmonaut from the International Space Station (ISS) returned to Earth after months in space. The world is now a different place than what they left, and they must enter two or three weeks in isolation in order to protect themselves and their immune-compromised bodies (a result of spending months in space) from the virus and other germs. But while they were on board the ISS, they experienced a new perspective of the Earth they had briefly left. The new perspective affects many astronauts deeply. It is called the "Overview Effect" and forms the topic of my talk today.



The term originated in a book by Frank White: *The Overview Effect — Space Exploration and Human Evolution* (Houghton-Mifflin, 1987), (AIAA, 1998). It describes a profound cognitive shift in perspective experienced by many astronauts after seeing Earth from space. Astronaut Ronald Garan said "The experience is incredible, you have all this motion and colours and light that really gives you the sense that we live on a, a living, breathing organism and the experience is undeniable yet surreal, it remains very much part of who I am today," and Joseph Allen added "I've known every cosmonaut and every astronaut…without exception, every one of them cannot get over the beauty of seeing planet Earth. It just takes your breath away and [pause] you just cannot take your eyes off the Earth. It just is so beautiful." Astronaut Don L. Lind said "Intellectually, I knew what to expect. I have probably looked at as many pictures from space as anybody…so I knew exactly what I was going to see…But there is no way

you can be emotionally prepared for the emotional impact…It brought tears to my eyes." And Astronaut Edward Gibson made the key observation "You see how diminutive your life and concerns are compared to other things in the universe…The result is that you enjoy the life that is before you…it allows you to have an inner peace."

It takes the ISS, moving at 27,600 km/hr, just over 90 minutes to complete an orbit of 40,000 km around Earth, and passengers can see about 16 sunrises and sunsets every day. Videos made from the ISS show lightning storms and aurora as the ISS passes overhead. There are a number of video recordings of this impressive sight. Here's a 30-second time-lapse video from the European Space Agency (ESA):

https://www.esa.int/ESA_Multimedia/Videos/2017/09/A_time-lapse_view_of_Earth_from_the_Space_Station_from_Africa_to_Russia

The overview effect provides an important perspective that all humanity should experience. The world would be a better place if contentious politics and its many petty squabbles were replaced by this unifying image of Earth in vast space. But how can we accomplish this? Most of us will never have the opportunity to visit the ISS and even our politicians will never gain that valuable perspective (as much as we might like to shoot some of them into space!). In order to reach children of a larger portion of the population, the ESA began what they called SpaceBuzz project in December 2018. It uses virtual reality in a rocket-ship shaped bus to simulate views like those experienced by astronauts when visiting the ISS or traveling to the moon. For details see https://www.space.com/spacebuzz-virtual-reality-spaceflight-overview-effect.html .

We're looking at a different approach, using a human-scale exhibit in an attempt to elevate our thoughts from earthly squabbles to a more heavenly overview. Specifically we want to offer a scale-model solar system, where visitors can wander--often at the speed of light (at the scale of the model) or even faster—from planet to planet, see how large our solar system is compared to its planets and moons, and recognize how much larger still is the visible universe that we now know holds hundreds of billions of exoplanets, some of which may well hold "alien" life.

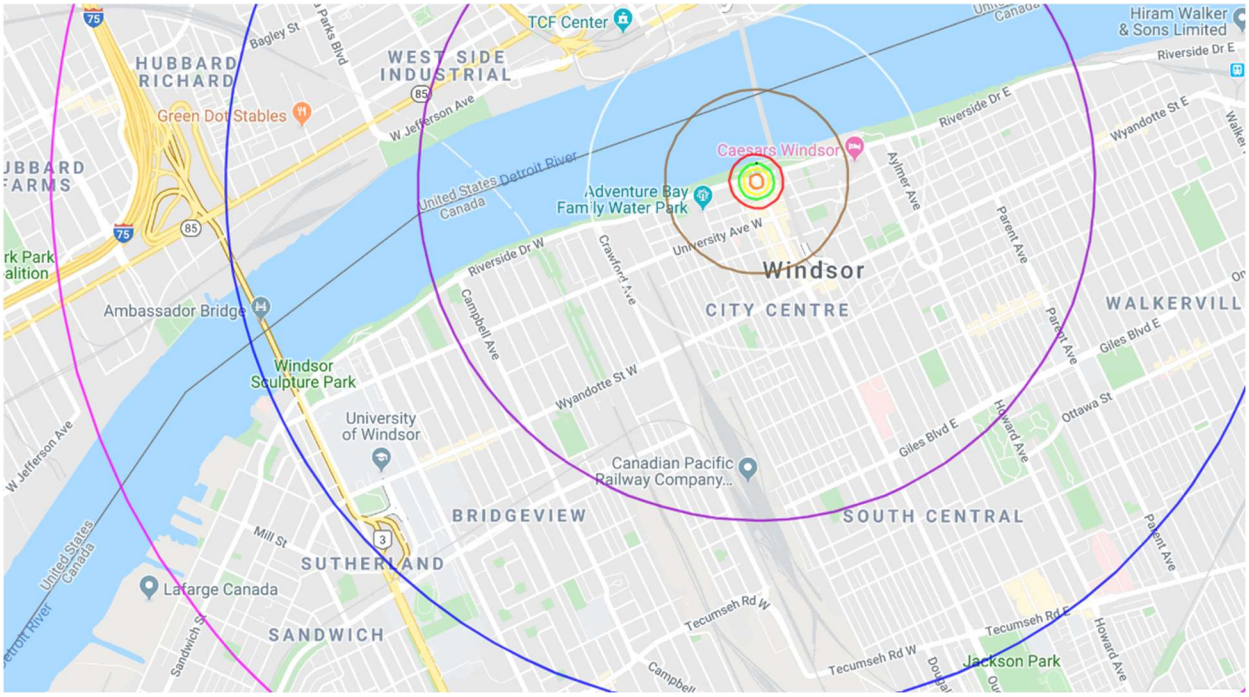
In the remainder of my reflection, I want now briefly to describe some of the problems inherent in constructing such a scale model, how those problems have been addressed in some successful scale models around the world, and what a scale model on the riverfront in Windsor might look like. Basically we want an attractive static scale model of the solar system along the riverfront in Windsor, Ontario. The model planets would be displayed on a path along the Detroit river, stretching from a model of the Sun near Ouellette Avenue to Neptune close to the Ambassador Bridge (and a kilometer beyond if we include the Kuiper belt). The relative sizes of the planets and their mean distances from the Sun would all be displayed on the same scale of roughly 1:1.5 billion relative to our actual solar system.

Earth in this model would be a marble-sized sphere about 8.5 mm in diameter at a distance of 100 m from the Sun, modeling the true Earth 1.5 billion times larger and thus about 8.5 x 1.5 million m = 12.8 thousand km in diameter and at a distance of 150 billion m and thus 150 million km from the Sun. See table below for more model sizes. By experiencing an accurate scale model of the Sun, the Earth, and other planets in our solar system, visitors can gain a perspective of the place of Earth in our cosmic neighbourhood and its size relative to that of the Sun and other planets. They will also be able to read about the planets, their associated moons, and their orbits about the Sun on plaques at the planet positions, as well as visualize, and listen to information about them on their smart phones, tablets, or

portable computers as they walk or ride along the river front. The solar system model will help visitors appreciate the vastness of the solar system relative to the size of Earth and experience some of the profound “overview effect” reported by several astronauts when viewing the Earth from satellite orbit or from the moon or the International Space Station.

Such models have been created and displayed in a number of locations around the world, but they are not common because of the difficulty of accurately combining the small sizes of the planets, especially Earth and the other terrestrial planets, relative to their distances apart and from the Sun. If the model Earth is to be larger than a mm in diameter, roughly the size of a BB pellet, the planetary model of the solar system must stretch over distances of a kilometer or more. Our waterfront along the Detroit river presents the opportunity of displaying a scale model with a reasonable compromise of sizes and distances.

In the sketch below, the orbits of the planets are modeled as circles around the Sun, and the model orbit of the most distant planet, Neptune, shown in blue, extends near the Ambassador Bridge, just over 3 km away. The Kuiper belt is about 4 km from the Sun in our model and is shown on the map as a magenta circle.



See following table for a key to the sketch with model sizes and distances. The Oort cloud in the model is almost 1000 km from the Sun and is not shown in the model. The sketch and its calculations were made with the help of programs provided by the Exploratorium in San Francisco and the observatory of the University of Manitoba. The scale and positions of the Sun and planets can be adjusted as needed for permits and convenience as long as the relative sizes and distances are maintained.

The Solar System model is meant to be an attractive feature of the Windsor waterfront that encourages visitors to walk, jog, or bicycle along the more than 3 kilometers of the park while learning about the formation and properties of our nearest planetary neighbours. As you have seen, a number of astronauts who have viewed the Earth from the Moon or from the International Space Station have

commented on the profound experience of viewing the Earth as a brilliant blue marble in the vast black backdrop of space. It's a perspective that subjugates petty Earthly problems and squabbles to higher existential goals of preserving life and its habitat on the Earth for millennia of future generations. Few of us will ever be able to share this potentially life-changing perspective of viewing Earth from space, but it could serve us well if more of us appreciated the place of Earth in our Solar System as our neighbourhood of the cosmos. The model solar system should also be an attraction for visitors to Windsor, encouraging them to enjoy our beautiful waterfront while learning about the Earth, its environment, and other parts of our solar system.

Planet	Diameter (mm)	Average Orbital Radius (km)	Orbit Colour
Sun	928		
Mercury	3.252	0.038606	orange
Venus	8.068	0.072137	yellow
Earth	8.504	0.099733	green
Moon	2.316	0.000256	black
Mars	4.528	0.151964	red
Jupiter	95.322	0.518873	brown
Saturn	80.357	0.952944	white
Uranus	34.077	1.916679	violet
Neptune	33.017	3.002977	blue
Kuiper Belt	1.533	3.989343	magenta
Oort Cloud	1.13	997.335762	grey

Key to the sizes of the planets and their orbits, here approximated as circular, for the proposed scale model of the solar system in Windsor, Ontario, Canada. On this scale of**1:1.5 Billion**, it is reasonable to include the Earth's moon in the model (diameter 2.2 mm at a distance 25 cm from Earth).

The scale of **1:10 billion** is a popular choice in the U.S.A., used at sites known as a Voyage Communities (see http://voyagesolarsystem.org/). In the **Voyage model**, Earth has a diameter of only 1.2 mm and is 15 m from the Sun, whereas Neptune is 4.5 mm in diameter and lies 500 m from the Sun. Such models

have been set up in Boulder, Colorado; Washington, D.C.; Houston, TX; and other locations. Because the model planets at this scale, they must be mounted on pyramids or cones so that they can be easily seen. Voyage models has the advantage of being contained within a half kilometer of the model sum, but planet sizes are unfortunately also quite small.

The planetary path model at the 1:1 billion scale (e.g. Hagan, Germany and Eugene, Oregon) is ten times larger than the Voyage Model. The one in **Hagen, Germany**, dates back to a publication in November 1959 and claims to be the world's oldest solar system model at this scale. The planets are represented in the model by one or more bronze plates, and their orbits encircle the tower. Earth is modelled as a 1.27 cm-diameter ball, 150 m from the 1.39 m-diameter model Sun in the Rathaus.

In the planetary path model, the speed of light is reduced from the actual $3x10^8$ m/s = 30 cm/ns to 30 cm/s (from about a foot/ns to a foot/s), which is roughly the speed of a leisurely step-by-step stroll. The model has to extend at least 4.5 km to represent the distance of Neptune from the Sun, and further if trans-Neptunian objects are to be faithfully modeled, and the round-trip distance to Neptune in the model may be longer than many casual visitors (at least in America) might want to undertake.

There are several other planetary-path solar system models at the scale of the one in Hagen, but the one in **Prague** (see http://www.hvezdolet.cz/planetarnistezka.htm), on a bicycle path along 13 km of the Vltava River valley there, from the model Sun in Prague to the dwarf planet Sedna, may be the most complete. It claims to model all dwarf planets as well as the larger moons of the solar system. It held its grand opening on May 13, 2018.

The world's largest permanent scale model is in Sweden in a scale of 1:20M. The Ericsson Globe in Stockholm, Sweden, actually represents the Sun together with its corona. It has a diameter of 110 m. (The photosphere of the Sun without the corona has a model diameter of 71 m.). Earth on this scale is 65 cm in diameter and lies a distance of 7.6 km from the globe. The Pluto-Charon pair is 300 km away. Other dwarf planets (and dwarf-planet candidates) Ixion, Eris, and Sedna, are also included. The termination shock, where the solar wind has slowed to the speed of sound, is located in the model 950 km from the globe and above the Arctic Circle. Some of the model objects are housed in museums, schools, and science centres, and some include art work. This is not a model that you would want to generally visit only on foot!

There are several more models across the world that can offer inspiration and ideas for the best choice of a model for Windsor, Ontario. Returning to the scaled model proposed, its scale of 1:1.5 Billion accommodates both planets with diameters in the cm range and distances of a still walkable few km from the Sun. The speed of light is 20 cm/s (8 inches/s) on our proposed scale, compared to 3 cm/s in the Voyage model and 30 cm/s in the planetary-path model). It uses the same scale as the model built in La Malbaie, Quebec, where model Jupiter is 10 cm in diameter.

At the moment, the installation of such a model solar system in Windsor is still a dream and there is much work to do, including on its design. I invite ideas of how best to make such a model an attractive, interesting addition to the Windsor Riverfront (such as adding artistic components) fostering the overview effect for visitors.

Thanks for your attention and let's welcome Earth Day now armed with an enhanced overview.

Some references

Frank White, *The Overview Effect — Space Exploration and Human Evolution* (Houghton-Mifflin, 1987), (AIAA, 1998).

Build a Solar System has a built-in calculator for sizes and positions of the planets. www.exploratorium.edu/ronh/solar_system/

Voyage Community: www.voyagesolarsystem.org/

The Colorado Scale-Model Solar System at the 1:10 billion scale used by Voyage exhibits, a popular scale that fits Sun to Pluto within 500 m. Plate supports are pyramids, with a transparent peak holding each planet: https://www.jeffreybennett.com/model-solar-systems/colorado-scale-model-solar-system/

Plot model planetary orbits on your site: https://umanitoba.ca/observatory/outreach/solarsystem/

https://en.wikipedia.org/wiki/Solar_System_model wikipedia compares 70 scale models of the solar system around the world. Generally scale models of 1:10 billion or more are no more than roughly a half km in radius and easily walkable whereas those of 1:1 billion or less are large enough (~5 km radius) to require a bike or other transportation.

https://www.astroblemecharlevoix.org/balade?lang=en The 1:1.5 billion scale solar system model in La Malbaie, Quebec (~40 km N of Quebec City near mouth of the St. Lawrence river, population 8,300; formerly Murray Bay)

https://en.wikipedia.org/wiki/Overview_effect

The Overview Institute: https://overviewinstitute.org/

Suggested hymns:

21 For The Beauty of the Earth
Words: Folliott Sandford Pierpont, 1835-1917, adapt.
Music: Conrad Kocher, 1786-1872, abridged
(Tune DIX)

123 Spirit of Life
W & M: Carolyn McDade, 1935 © 1981 Carolyn McDade
~)-| harmony by Grace Lewis-McLaren, 1939- , © 1992 Unitarian Universalist Association
(Tune SPIRIT OF LIFE)

345 With Joy We Claim the Growing Light
~)-| Words: Samuel Longfellow, 1819-1892
Music: Musicalisches Handbuch, Hamburg, 1690, adapt.
(Tune WINCHESTER NEW)