# Walk-able Scale Model of the Solar System

# Located On The JMU Campus

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Currently, there is no science exhibit in Virginia that emphasizes the scale of cosmic sizes and distances. The *Voyage* scale model of the Solar System on the National Mall in Washington, D.C. is the closest such project to the James Madison University campus. The Voyage model shows the Sun and the planets, and the distances between them, at one ten-billionth of their actual sizes and distances (Figure 1). While the *Voyage* exhibit was designed for replication and installation elsewhere, the cost is $250,000, not including pedestals and maintenance. **We can create a world-class exhibit illustrating the size and scale of the Solar System on the James Madison University campus for significantly less.**

We should also emphasize that similar size installations cost significantly more than we are proposing. For example, the Planetary Society is working on a similar scale Solar System model in the city of Pasadena, CA. They are still seeking funding to complete this model, with an estimated completion cost of $1.2 million. The University of Colorado's scale Solar System is housed in marble pedestals, which significantly increased their cost of implementation. A unique advantage of implementing this project at a university such as James Madison University is that we have the available in house resources and talents to create an installment of this quality and magnitude without significant cost.

Our proposed location of the Sun in our model would be behind the Festival Conference and Student Center (Figure 2), a building that is used not only for university events but also for events open to the public. Our scale, based on the configuration of the JMU campus, will be 5 billion to 1. Figure 3 illustrates that the inner, or terrestrial, planets would be immediately visible from this location. Table 1 provides the sizes of our planets in such a model, while Table 2 provides the location of our planets, the Kuiper Belt and the Oort Cloud for our scaled Solar System. Such an auspicious location would encourage discovery of the Solar System by visitors to the Festival, especially since the Sun and the inner, or terrestrial, planets would be within sighting distance of the rear windows of the Festival. Our proposed location of the Kuiper Belt, or location of Pluto, would coincide with Memorial Hall (Table 2). The Kuiper Belt would be a unique feature of our scale solar system. Where other walkable solar system models have Pluto, which was demoted to dwarf planet status in 2006 by the International Astronomical Union, we would exhibit Pluto within the context of the Kuiper Belt, an exciting region where new dwarf planets continue to be discovered. In addition, the NASA New Horizons mission is scheduled to arrive at the Kuiper Belt in 2015. Our exhibit would be a timely reflection of up to date science rather than a rehashing of Pluto's demotion from planetary status.



**Figure 1: Photo showing the pedestals housing the Sun (the gold sphere on the nearest pedestal) and the inner planets in the Voyage scale model solar system.**

Another phase of our proposed scale Solar System that we would be able to immediately implement is the media interface. We would establish and maintain a website on the JMU server that would contain the detailed scientific information about the planetary objects. This website would also contain short, closed-captioned video clips to supplement the written information. Such videos would be designed with accessibility in mind, so that, for example, hard-of-hearing/deaf and visually impaired individuals would be able to benefit. The website would also be otherwise fully accessible. We would include information about the artistic methods and materials behind the creation of the planets, as well as an explanation of the scale we are using. In the initial phases of creation, we would also provide updates on our status and progress. Further, we would be able to field questions from this public interface, and possibly include an area where anyone can ask a scientist about a Solar System topic or ask one of our artists about the artistic media or methods involved in creation of such an installment. Such a public and widespread forum for showcasing our work could also be used by JMU public relations or alumni groups to highlight how the university is forward-thinking in the realm of STEM education.

Informal science education is playing an increasingly important role in our society (Dusenbery et al., 2007). Venues for such informal education are generally deliberately sought out by people who want to engage in educational experiences (Monzack and Petersen, 2011). Our proposed model Solar System would be open to the community and available to anyone who visits the JMU campus. The John C. Wells Planetarium, located on the Bluestone side of campus, draws more than 15,000 people per year, more than half are children from area schools. This walk-able model of the Solar System is a natural tie-in to the Planetarium given its mission of science education and public outreach. Additionally, this connection would allow us to make its availability known to both the public and regional school districts.

**Figure 2: The circular building, part of the Festival Conference & Student Center, would be the location of our "Sun" and hence the starting point of our Solar System. Astronomy Park, the location of star parties hosted by the Dept. of Physics & Astronomy and the John C. Wells Planetarium, is in the foreground.**


**a.**

**b.**

**Figure 3: a: Proposed locations of planets when looking from back entrance to Festival. b: Festival when looking back from proposed location of Saturn.**

**Table 1: Sun/Planet Sizes**

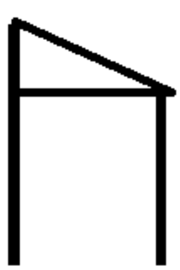
| OBJECT | ACTUAL RADIUS (km) | MODEL RADIUS | MODEL OBJECT |
|---|---|---|---|
| Sun | 695,000 | 13.9 cm | Basketball |
| Mercury | 2440 | 0.05 cm | Pencil point |
| Venus | 6051 | 0.12 cm | Shirt button |
| Earth | 6378 | 0.13 cm | Shirt button |
| Mars | 3397 | 0.07 cm | Pencil point |
| Jupiter | 71,492 | 1.43 cm | Golf ball |
| Saturn | 60,268 | 1.2 cm | quarter |
| Uranus | 25,559 | 0.5 cm | Marble |
| Neptune | 24,764 | 0.5 cm | Marble |
| Pluto | 1160 | 0.02 cm | Ball point |
| Kuiper Belt Object (Sedna/Eris) | 1430 | 0.03 cm | Ball point |

**Table 2: Sun/Planet Distances and Model Location**

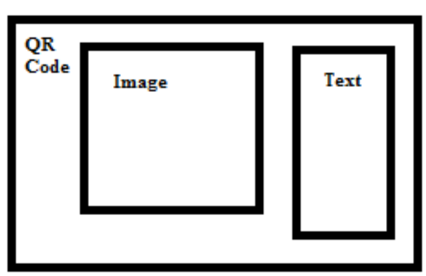
| OBJECT | ACTUAL DISTANCE (x $10^6$ km) | MODEL DISTANCE | MODEL LOCATION | LIGHT TRAVEL TIME | TIME FOR TRAVEL AT 100 KM/HR FROM SUN |
|---|---|---|---|---|---|
| Sun | --- | --- | Festival Hall | -- | -- |
| Mercury | 57.9 | 11.6 m | Sidewalk in front of Festival Hall | 3.2 mins | 66.3 yrs |
| Venus | 108.2 | 21.6 m | bench | 6.0 mins | 123.9 yrs |
| Earth | 149.6 | 30.0 m | Half-way to BioScience Building Greenhouse | 8.3 mins | 171.2 yrs |
| Mars | 227.9 | 45.6 m | BioScience Building Greenhouse | 12.7 mins | 260.9 yrs |
| Jupiter | 778.3 | 156 m | Behind Physics/Chem Buiding | 43.2 mins | 890.9 yrs |
| Saturn | 1427 | 285 m | Behind ISAT/CS | 79.3 mins | 1633.5 yrs |
| Uranus | 2870 | 574 m | Bridge at ISAT | 159.6 mins (2.7 hrs) | 3285.3 yrs |
| Neptune | 4497 | 899 m | Mr. Chips | 250.0 mins (4.2 hrs) | 5147.7 yrs |
| Pluto | 5906 | 1181 m | Commons/D-Hall | 328.3 mins (5.5 hrs) | 6760.5 yrs |
| Kuiper Belt Object (Sedna/Eris) | 10,120 | 2120 m | Memorial Hall | 562.6 mins (9.4 hrs) | 11584.3 yrs |

NOTE: Using a 5 billion to 1 scale, Proxima Centauri (nearest star) would be ~7600 km away! i.e., the distance between VA and HI, or equivalently, the distance between VA and Moscow, or the distance between VA and Santiago, Chile!

Such an exhibit would allow JMU students, and students from local K-12 schools to visually deduce the size and scale of our Solar System. Moreover, we can leverage existing resources to generate such a permanent display, and in the process, foster interdisciplinary collaboration between several JMU departments. The content to be displayed is already provided by a NASA has a program entitled From Earth to the Solar System (FETTSS) which provides images and accompanying text free of charge. See Figure 4c for an image of Jupiter provided by FETTSS and the text that accompanies the image. The image plus the text is an example of what the planet display boards would look like (Figures 4 a and b). They would also include a QR code that smartphone users could scan taking them to a website with more information, images spanning the electromagnetic spectrum, as well as information for teachers (lesson plans, teaching guides, etc.) Making use of online resources in this way would ensure cost-effectiveness, scientific accuracy of the scale solar system model, and will also allow us to update the information as we learn more. Shelly Hokanson of the SMAD Department at JMU has indicated an interest in having students in her SMAD 404 course design both the website and a mobile application for this project.



**a. Side View**




**b. Top View of Display**

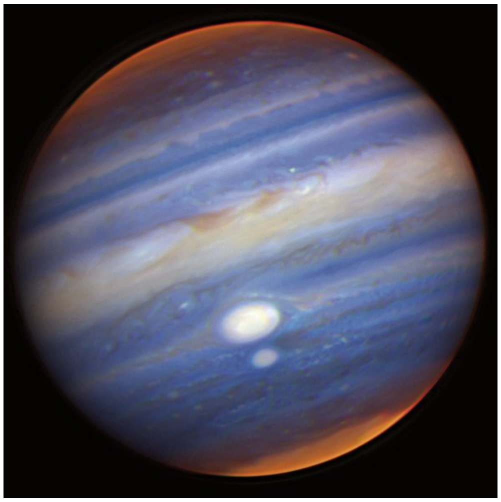


**Figure 4:a: Side view of proposed display board. b: Schematic of top view layout of display board. c: Image of Jupiter provided by NASA's FETTSS program. High resolution images are available for all Solar System objects as well as text to accompany each image.**

| **Example: Scientific Text to Accompany Image of Jupiter** |
|---|
| A MINI-SOLAR SYSTEM: Jupiter, the most massive planet in our Solar System—with over 50 known moons and an enormous magnetic field—forms a kind of miniature solar system. Jupiter resembles a star in composition, but it never grew big enough to ignite. Several of its moons are of interest to astrobiologists searching for life elsewhere in the Solar System. This image of Jupiter has been color-coded to show cloud height from high altitude (white) through mid-range (blue) to low altitude (red). NASA's Juno mission, launching in August, 2011 and arriving at Jupiter in July, 2016, will map the gravity field, magnetic field, and atmospheric structure of Jupiter, and provide key insights to enhance current theories about the early formation of our Solar System. Image Credit: Travis Rector (U. Alaska, Anchorage), Chad Trujillo and the Gemini Altair Team, NOAO/AURA/NSF |

A scale Solar System model could also be incorporated into more formal curricula in local schools. Part of our proposed project would include lesson plans and content aligned with national, state, and local science education standards for all grade levels. The standards-based learning that is prevalent in our schools could be supplemented with an engaging exhibit designed to stimulate the natural curiosity of children and actively involve them in learning more about the planets, the scale of our Solar system, and about science in general. Our walk-able Solar System, as is true for many informal science education resources, can offer resources not necessarily available in formal school settings and these resources can nurture curiosity, improve motivation, and foster positive attitudes toward science. In addition, as the United States continues its transition from an industrial society to an information society, learning across the life span is increasingly important, and free-choice learning is an essential component. (Dierking and Falk, 2003).

In the United States, there is a concerted effort to improve academic achievement amongst our students. However, an international survey of achievement amongst 15 year olds found that the U.S. routinely performs below the international average (Petrilli and Scull, 2011). This study, completed by the Organization for Economic Co-operation and Development (OECD), also found that the U.S. has a proportionally large number of low achievers, particularly in math. In the U.S., 91% of high school math and science learning involved solving problems by routine procedures or the teacher simply stating the answer (NCES, 2007). Other countries which perform better in math and science learning, including Australia, the Netherlands, Japan, and the Czech Republic, devote much more time to making connections and reasoning (NCES, 2007). Implementation of a hands-on science venue will give students and informal learners alike the opportunity to discover for themselves various aspects of the Solar System and foster an environment of scientific discovery. In a recent survey of adults, nearly half of all those surveyed claimed to have learned science during their leisure time, through some kind of free-choice learning experience (Dierking and Falk, 2003). Since scientists themselves engage in the art of open minded discovery and learning rather than rote memorization, it is essential that we provide learners of all ages a chance to experience the spirit of inquiry for themselves if we are to become a scientifically literate society.

There is a growing body of evidence that science is learned more and more out of a school setting (Falk and Dierking, 2010). Informal science learning stimulated by such an exhibit would nicely complement similar objective learning objectives of existing JMU resources like the John C. Wells Planetarium at Miller Hall and the Science on a Sphere exhibit at Memorial Hall. Not only would a JMU scale Solar System provide the framework for local schools to enhance their science curricula in ways that are not possible in a classroom, it would provide an environment that would foster lifelong learning. In addition, it would generate interdisciplinary collaboration amongst departments on campus that do not generally collaborate on projects, e.g. education, science, and art. As we proceed into the 21st Century, we want to create environments that stimulate intellectual discussion and our proposed project would accomplish this across all educational levels.

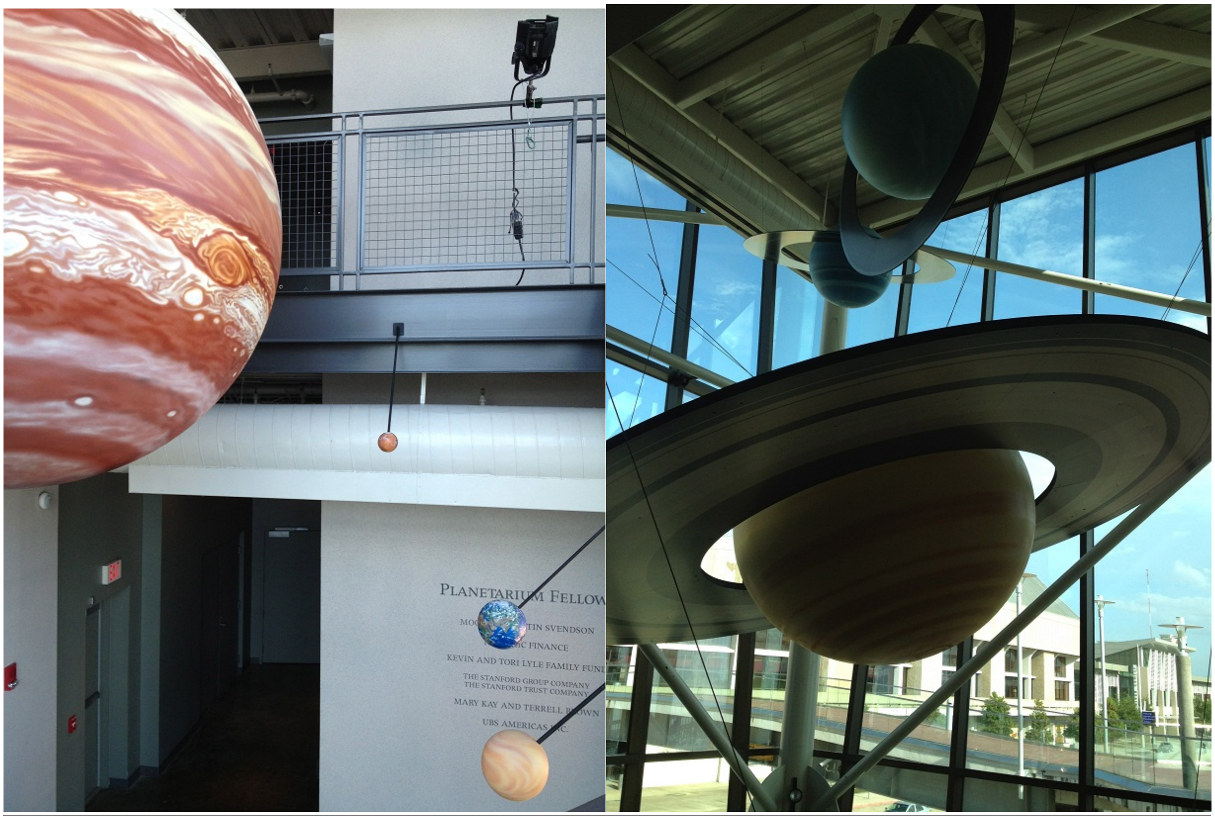



**Figure 5. Examples of a scale model solar system housed at the Louisiana Art & Science Museum.**

**Figure 6: Expanded view of the Solar Sytem model installed at the University of Alberta**

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THE PLANETS IN THE WEST CCIS ATRIUM

Scale Model of the Solar System

A scale model of the Solar system hangs in the CCIS West Atrium. The model depicts the location of the planets on September 23, 2008, the 100-year anniversary of the University of Alberta.

The plane of the solar system is vertical. Try to imagine the planets moving in orbits over and under the Sun.

The technical design of the installation was by Craig Heinke and Marc van der Sluys. The artist Michael Prettyman interpreted the design and built the model out of fibreglass and plexiglass. The installation was made possible through a generous donation by the Edmonton Centre of the Royal Astronomical Society of Canada.

For photos of the installation, visit our facebook photo album.

There are 3 different length scales used in this installation. This page will explain the different scales used.

Scale 1: Distance Between the Planets

- The real distance between the Sun and the Earth is $1.5 \times 10^8$ km = 150,000,000 km = 150 million km. Astronomers call this distance the Astronomical Unit (AU).
- In this model the AU was shrunk down to 50 cm, or a scale of 1:300 billion.
- The locations of the planets and the Sun (centre to centre) are all done to this same scale.
- The closest star to the Sun is Proxima Centauri. If we used the same scale, this star would be 130 km away, which is pretty close to the distance between Edmonton and Red Deer. (Red Deer is actually 150 km away.)

If we used the same scale to display the Sun and the Planets, the Sun would have a diameter of only 5 mm, Jupiter would be 0.5 mm, and Earth would be 0.05 mm. This would be an accurate, but boring model!

Scale 2: Sizes of the Planets

- The sizes of the planets had to be increased so that we could see them.
- The scale used for the sizes of the planets is 1:180 million.
- The real diameter of Jupiter is $1.4 \times 10^5$ km = 140 thousand km.
- In the scale model, Jupiter has a diameter of 76 cm.
- The sizes of the planets and their rings are all made to the same scale.

Scale 3: Size of the Sun

- The Sun is approximately 10 times larger than Jupiter. If we made the Sun to the same scale as the planets, it would be 8 m in diameter, and the orbits of the 4 inner planets and Jupiter would lie inside of the Sun!
- The size of the Sun had to be shrunk so that we could show the orbits of the inner planets around it.
- The scale used for the Sun is 1:6 billion
- The true diameter of the Sun is $1.4 \times 10^6$ km = 1.4 million km
- In the scale model, the Sun's diameter is 22 cm.

Photos of the Installation (Nov. 28, 2011)

Click on a picture to see the album.

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**Figure 7. Example of what our top-level website would look like for our Solar System model. Display boards would also have QR codes embedded so smartphone users can access this information on location.**

Implementation of a scale model of the Solar System would be beneficial for undergraduate instruction on campus. Undergraduates are required to take general education courses as part of their degree programs. Cluster Three of these general education requirements encompasses math and science.

For the academic year 2011-2012, **8,355 students** were enrolled in Cluster Three general education courses that were either directly or indirectly related to topics that could be taught using a graphic visual such as a walkable Solar System. This represents **47.8% of the undergraduate population** on campus during the 2011-2012 academic year. James Madison University's estimated enrollment is projected to increase between 1.5% and 1.7% per year over the next three years, giving an even larger student body that would be able to take advantage of such a large scale installation on campus. Table 1 lists select Cluster Three general education courses that could directly benefit instructionally from the use of a permanent solar system installation on campus and their enrollments for the last academic year.

**Table 3: Impact of Solar System Model to the JMU Student Population**

| | FALL 2011 | SPRING 2012 |
|---|---|---|
| | # Enrolled Students | # Enrolled Students |
| **Group 2** | | |
| **GISAT 112** | 144 | 81 |
| **GSCI 101** | 907 | 1287 |
| **GSCI 121** | 191 | 45 |
| **PHYS 140** | 356 | n/a |
| **PHYS 140L** | 536 | n/a |
| **PHYS 215** | 23 | 20 |
| **PHYS 240** | 258 | n/a |
| **Group 3**<br>**ASTR 120** | 82 | n/a |
| **ASTR 121** | N/A | 175 |
| **GEOL 110** | 210 | 215 |
| **GEOL 200** | N/A | n/a |
| **GEOL 210** | 40 | n/a |
| **GEOL 211** | 261 | 239 |
| **GGEOL 102** | 139 | 200 |
| **GGEOL 115** | 209 | 100 |
| **GISAT 113** | 40 | 135 |
| **GSCI 104** | 451 | 616 |
| **Track II** | | |
| **GSCI 161** | 155 | 138 |
| **GSCI 162** | 154 | 133 |
| **GSCI 163** | 181 | 123 |
| **GSCI 164** | 180 | 121 |
| **GSCI 165** | 101 | 109 |

In addition to being of benefit to JMU undergraduates, this proposed installation, as mentioned, would be of benefit to regional school districts. In Virginia, the Standards of Learning address astronomy concepts related to the Solar System in the 4th grade. We intend to submit a proposal to a NASA RFP that would allow us to pay any expenses, such as busing, to bring any local 4th grade class to campus if they would like to visit. Thus we will have extended the impact of our proposed model.

## Budget

The installation at the University of Alberta cost was $15,000 for materials and $10,000 for installation. To complete this project they contracted with a New York artist. However, our expenses are expected to be considerably less due to the smaller size of our scaled planets. We anticipate a total cost of $10,000. This cost is far less than the $250,000 that would be required to install the Voyage pre-packaged Solar System on campus, plus as an added benefit we can take advantage of the natural layout of campus without being constrained by pre-set limits within Voyage.

## References

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