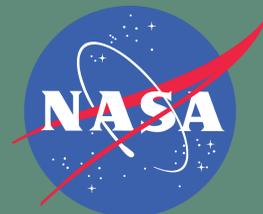


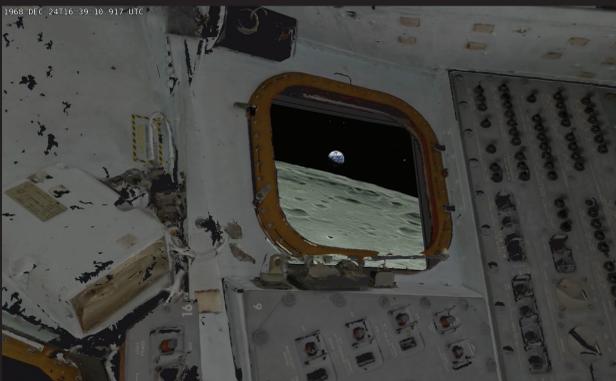


OpenSpace

AMERICAN MUSEUM
OF NATURAL HISTORYBrian Abbott¹, Denton S. Ebel^{1,2,3}, Rosamond Kinzler¹¹ American Museum of Natural History (AMNH), New York, NY;² Department of Earth & Environmental Sciences, Columbia University, New York, NY;³ Graduate Center of CUNY, New York, NY; ⁴ NC Museum of Natural Sciences, Raleigh, NC; ⁵ Appalachian State U., Boone, NC; ⁶ UNC Chapel Hill, NC

New Developments

- 17 interactive scenes of visualized NASA data now available.
- Non-technical story guides and user-friendly presentation buttons that align with content points have been introduced, and can be accessed on a mobile device.
- Models and trajectories for Apollo missions 8, 11, and 17 are available; with landing sites and rover traverses for missions 11 and 17.
- NASA **InSight** lander model and its trajectory during Martian atmospheric entry and landing was added. Model changes during the various phases of descent and landing.
- ESA's **Gaia** mission data was added using a new and experimental multiscale renderer. The dataset is automatically synchronized at startup and contains over 7 million stars and their radial velocities.
- More efficient rendering methods for small objects have allowed visualization of the trajectories and positions of all **space debris** objects as reported in [2].
- Saturnian moons **Hyperion** and **Mimas** are now included in all scenes.
- Trails of **Pioneer missions** 11 and 12 were added, and the Pioneer model was improved.
- **Trajectories** of the Swift-Tuttle comet, Tesla Roadster, and 'Oumuamua are optional content that can be added to any scene.
- In addition to the existing daily atmospheric layer in OpenSpace, **oceanographic** datasets are now available.



Earthrise from the interior of the Apollo 8 crew module, December 24, 1968. Using SPICE kernel reconstructions based on DSN telemetry (by Ernie Wright, GFSC, SVS). Interior 3D reconstruction by the Smithsonian Institution.

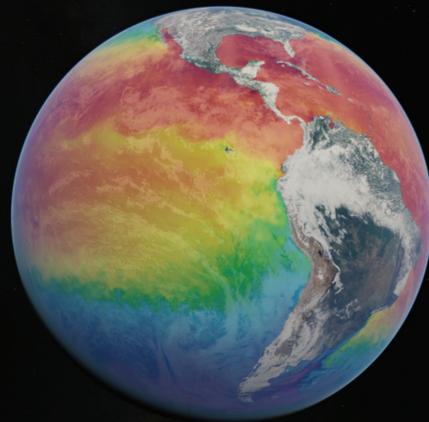
★ Capable of displaying ANY global dataset ★



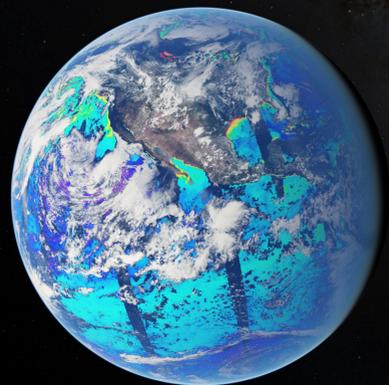
For a full list of datasets, contributors, downloads, and more.

Datasets

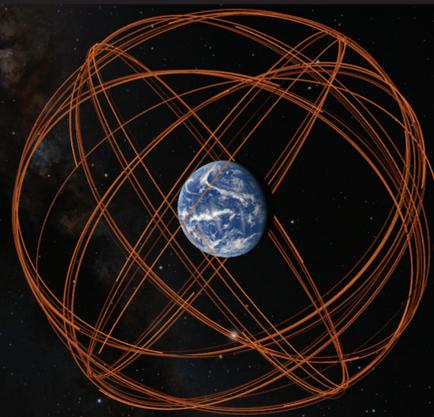
- Center on any object in the Solar System.
- View datasets draped on topography from landers, rovers and orbiters.
- Easily change perspective and orientation.
- Visualize orbits and trajectories of spacecraft, satellites, and space debris.



Near Real Time Earth Compositing: NASA Global Imagery Browse Service showing SNPP VIIRS True Color daily mosaic with international Group for High Resolution Sea Surface Temperature (SST).



ESRI VIIRS imagery combined with MODIS Terra temporal data depicting **Chlorophyll a** concentrations, used as an estimate of phytoplankton abundance. Daily cloud cover layer is also shown.



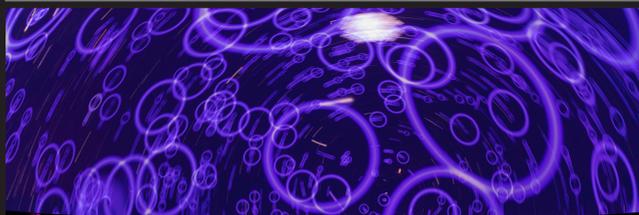
Visualization of GPS satellites in orbit around Earth; with accurate Milky Way position and starfield in the background.

Education and Outreach

- To date, OpenSpace has supported over 100 interns, from high school to post-baccalaureate.
- Interns learn vital STEM skills and knowledge, including computer programming, astrophysics, planetary science, and science communication.
- OpenSpace lends itself well to student involvement in the development of visual renderings, as well as the production of interactive "tours" for various audiences.



Since 2011, AMNH has hosted 17 seniors from Bergen County Academies High School. This year, students (above) have assisted with data entry into OpenSpace as part of their senior research program.



OpenSpace is a robust tool to communicate NASA science results and mission activities to the public. Work within OpenSpace has been shared via public programs at both AMNH (above and below, in the Hayden Planetarium) and partner ISIs.



OpenSpace

- OpenSpace [1] is an open source, interactive software designed to visualize the known universe and portray our ongoing efforts to investigate the cosmos.
- Bringing the latest techniques from data visualization research to the general public, OpenSpace supports interactive presentation of dynamic data from observations, simulations, atmospheres, and space mission planning and operations.
- In addition, OpenSpace enables simultaneous connections across the globe creating opportunity for shared presentations among audiences worldwide.

Platforms

- Software is scalable to nearly any platform, from computer screens to classroom projectors to planetarium domes.
- OpenSpace works on multiple operating systems with an extensible architecture powering high-resolution tiled displays and planetarium domes, making use of the latest graphic card technologies for rapid data throughput.

Team

- OpenSpace builds on a collaboration between Linköping University and the AMNH by including computer science experts at University of Utah's Scientific Computing and Imaging Institute and NYU's Tandon School of Engineering. Publications at [3].
- Multiple informal science institutions (ISIs) are actively engaged in the emerging OpenSpace ISI Network.
- The AMNH team works with scientists to incorporate their mission activities and data into the platform for public education and engagement.

New Technical Features

- **OpenSpace Launcher:** This new start-up option allows users to select their screen output and scene, negating the need to edit a text file to do so.
- **Session Recording:** This feature enables the recording of camera movements, state changes, time, speed, and user interface interactions which can then be played back or shared between computers. This is done from a recording menu that allows users to create, play, and stop the recording, as well as stream live to YouTube.
- **Slides Menu:** This allows users to show online and downloaded image files within OpenSpace. It has been used to show historic mission images within a visualization of that mission; can be used to display presentation slides while concurrently using OpenSpace.
- **Anchor and Aim:** This feature enhances the previous Focus Node. The camera can still focus on a single object and have all camera movements occur relative to that object, but it is now possible to anchor on one object while aiming at another, which stays fixed on the screen. This presents a view of the objects in relation to each other, affording cinematic results.
- **Search:** Scene and settings menu search bar functionality were significantly improved, easing usage.

References

- [1] <http://openspaceproject.com/> (OpenSpace Website Home)
[2] <https://celestak.com/>
[3] <https://www.openspaceproject.com/academia/>

Acknowledgements

OpenSpace is supported by the NASA Cooperative Agreement Number (CAN) NNH15ZDA004C, Amendment 1