Development of a Virtual Reality xGEO Orbit Visualization Tool for Cislunar Mission Design

University of Colorado Boulder Bioastronautics

J. Cuberovic[1], J. Wood[1], S. Rodine[1], M. Frew[1], H. Schaub[1], A. P. Hayman[1]
[1]University of Colorado Boulder, Ann and H.J. Smead Aerospace Engineering Sciences

AVS Laboratory USRA

Motivation

Growing Interest in Cislunar Space

- Increase in the number of planned missions to establish and support a permanent human presence on the Moon [1]
- Need for operators well versed in cislunar orbital mechanics to design trajectories needed to provide logistical support

Complexity of Cislunar Orbital Mechanics

- Cislunar orbital mechanics are more chaotic and complex than more traditionally taught geocentric orbital dynamics [2]
  - 4-Body problem
- Non-intuitive and challenging for operators to understand

Emerging Teaching Technology Needs

- Cislunar orbital mechanics are rarely taught prior to the graduate level
- Education currently relies on non-immersive, 2D visualization programs with steep learning curves
- Need for simple, immersive, high-fidelity visualization tools [3]

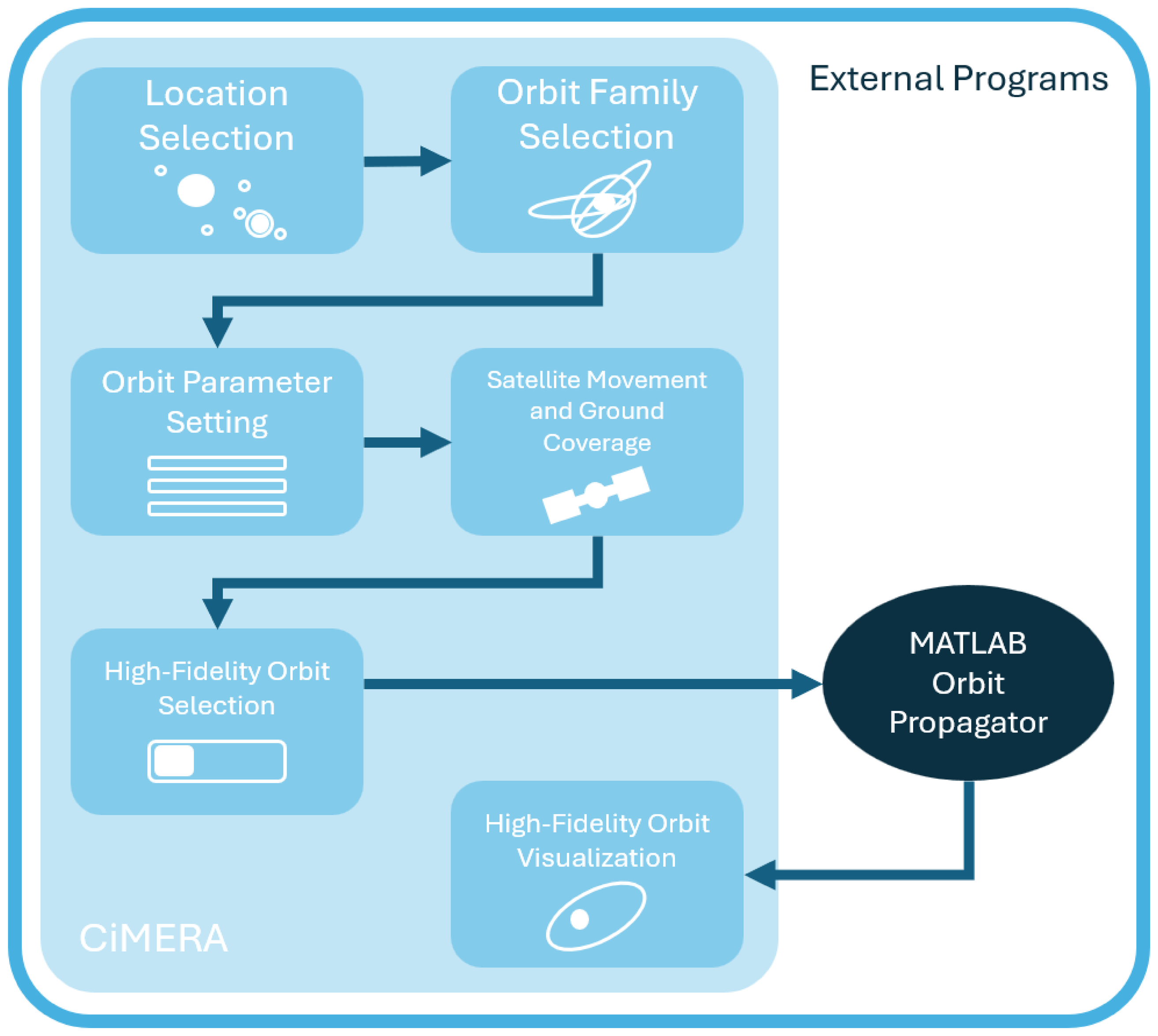
Aims

This work aims to **(1)** ***create a robust learning aid*** for the teaching of cislunar orbital mechanics and **(2)** understand how ***immersive 3D visualizations*** can impact an operator's ability to ***understand spatially complex environments.***

Environment Development

Operators select different orbits of interest they would like to view in high-fidelity from a pre-computed library of 775 periodic orbits

- Unity-based program, being adapted for use on a Meta Quest 3 headset
- Integrated with an external MATLAB tool
  - Uses initial conditions to calculate a high-fidelity orbit trajectory
- High-fidelity orbit visualization was developed using Vizard

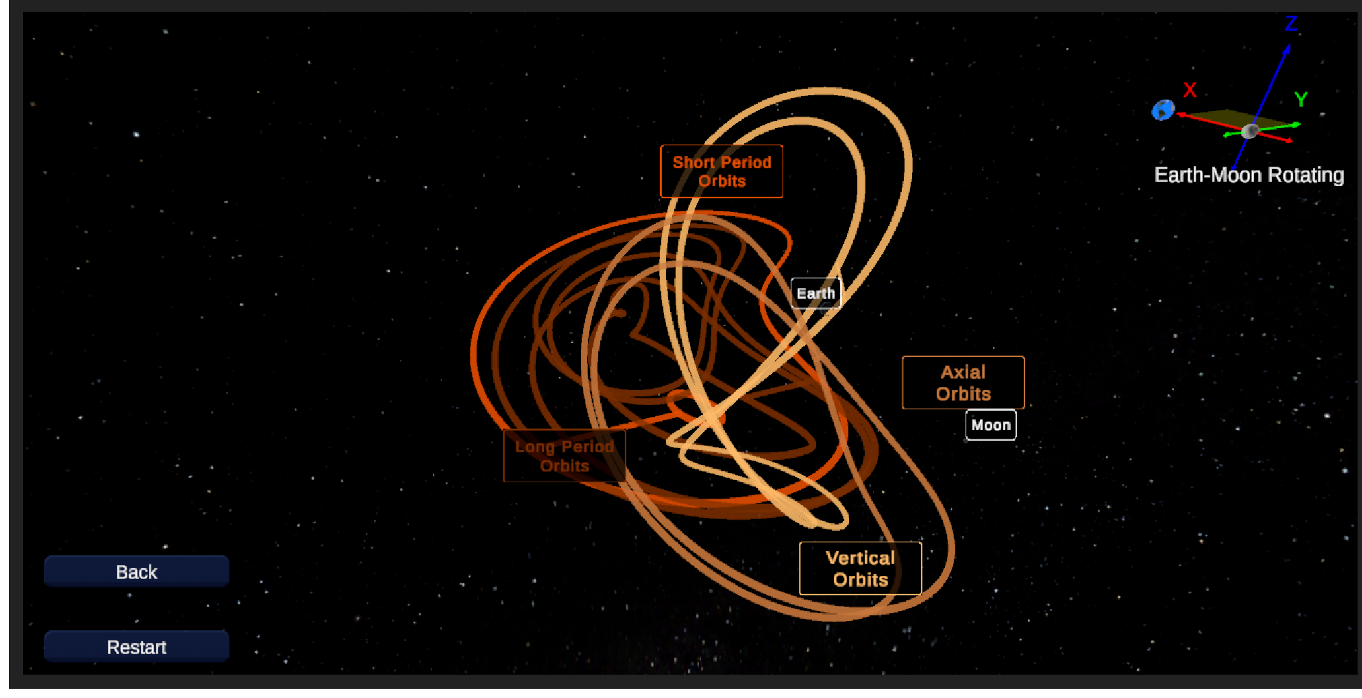


Operators have the ability to:

- View orbits from any angle
- View in several different reference frames
- Toggle ground coverage visualization on or off as needed
- Teleport between locations for a better view
- Use playback controls to speed up or slow down satellite movement
- Go back to any previous point in the selection process

CiMERA Program Display

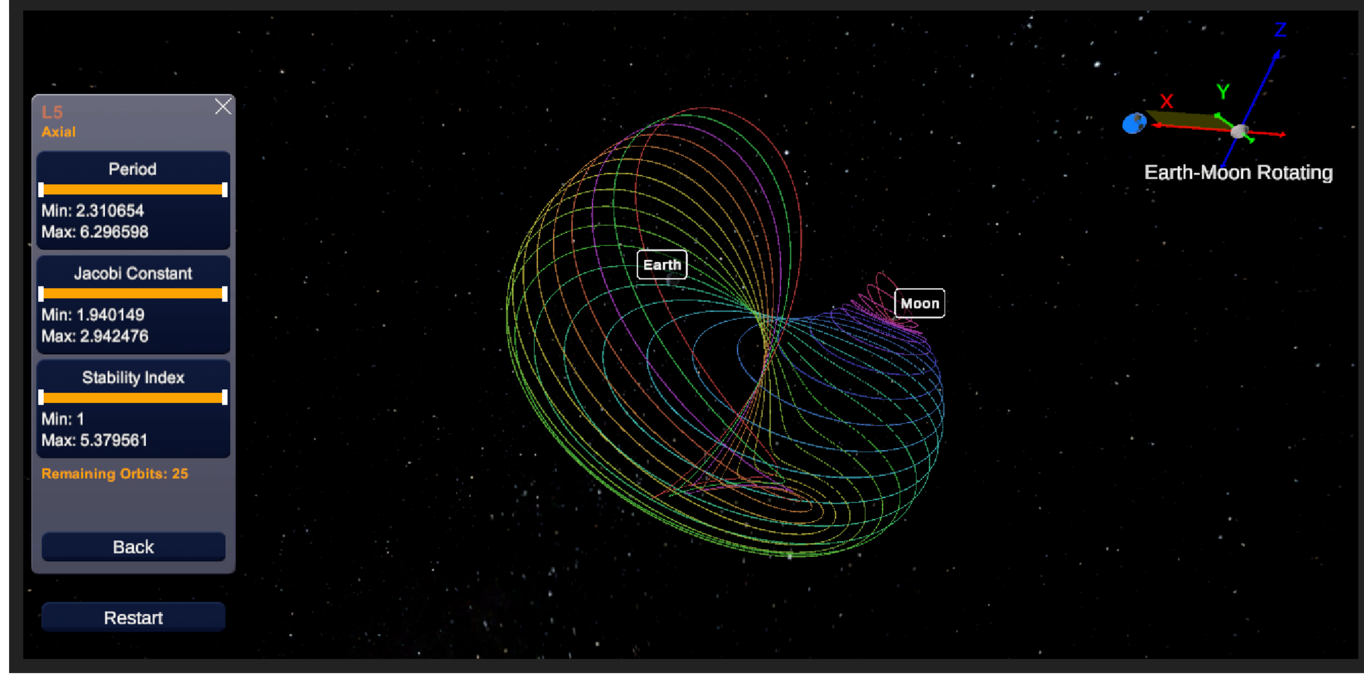
Orbit Family Selection



Narrows the range from 775 potential orbits by selecting an appropriate location and orbit family

- 6 available locations
- 11 distinct orbit family types
- Total of 31 orbit families overall

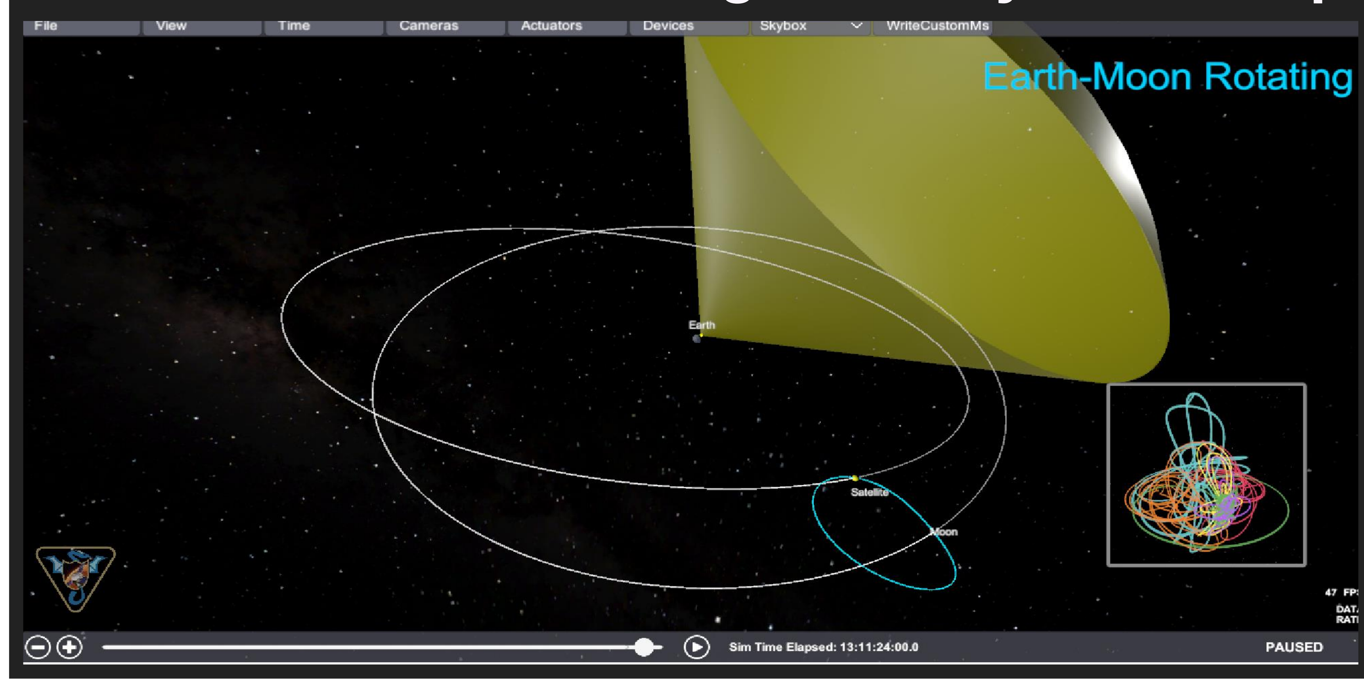
Setting Orbit Parameters



Visualization of up to 25 different orbits at a time

- Can down-select orbits by setting orbit parameter ranges
- Includes satellite motion and satellite ground coverage visualization functionality

High Fidelity Orbit Display



High fidelity orbit tool integration

- Can visualize the trajectory in the Inertial or Earth-Moon Barycentric Rotating reference frame
- Includes playback controls and ground coverage visualization

Conclusions

- Created an ***immersive 3D display*** using best ***human factors design principles*** designed to be used when teaching ***cislunar orbital mechanics***
- This research will inform future potential in **using VR and spatial ability training** to quickly and efficiently **improve operators' ability to understand spatially complex environments**
- This is ongoing work - the CiMERA program will be used in an upcoming human subject study

References

[1] Mueller, R.P. (2023) *Earth and Space* 2022, 858-70
[2] McCarthy, B.P. and Howell, K.C. (2020) *71st International Astronautical Congress, Virtual*
[3] Tall, D. (2000) *Mathematics Education Research Journal*, 2000, Vol. 12, No. 3. 210-230

Videos

Full User Navigation Path

Additional Capabilities

Contact

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