National Aeronautics and Space Administration

FY23 Innovative Spontaneous Concepts Research and Technology Development (ISC)

3D Magnetic Field Visualization for Improved Understanding & Communication between Science and Engineering Teams

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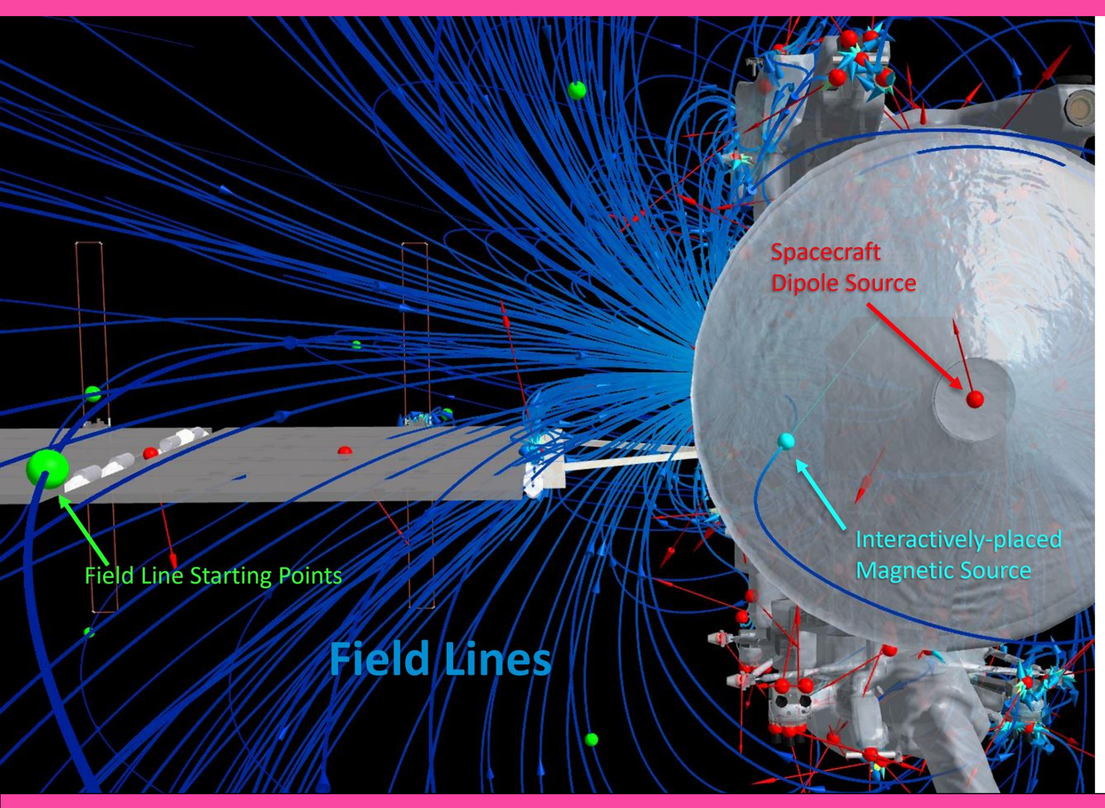

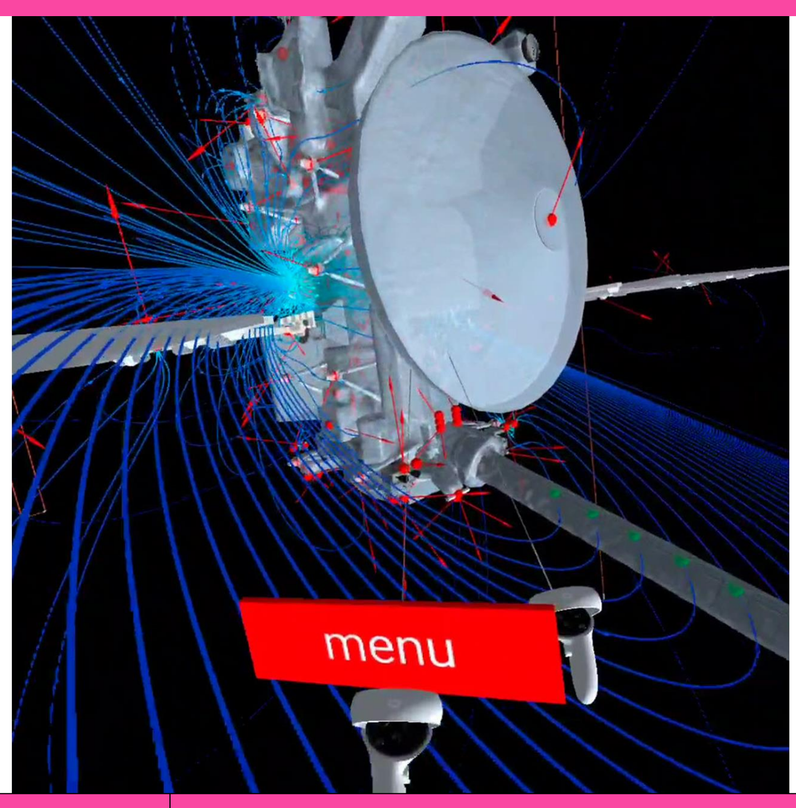

Objectives

- Demonstrate a technique that enables **rapid evaluation of magnetic cleanliness issues** and provides insight into potential solutions.
- Develop a novel approach to **visualize spacecraft magnetic fields in 3D**, in an immersive way and on the web, allowing for maximum accessibility and collaborative communication capabilities. This will enable a comprehensive view of spacecraft magnetic fields that will be matured as a mission progresses.

Background

- **Spacecraft magnetic fields are very complex** in nature (e.g., **Europa Clipper has over 300 individual magnetic sources**, which need to be tracked to ensure magnetic cleanliness). Fluctuations in spacecraft fields must be understood and minimized, as **they can mask or even mimic signals of interest**.
- Currently, the 3D nature of the magnetic field is simulated in Matlab, then visualized on 2D monitors. However, **2D views hide much of the information in the complex spacecraft magnetic field**.

Approach & Results

Approach:

- Informal interviews with EMC engineers and electromagnetic SMEs
- Build initial prototype, using WebXR with three.js and React, and continually gather feedback from SMEs
- Support for both Europa Clipper and Psyche Spacecraft Models
- Web & VR UI, field tracing line options, adding new dipole sources
- Field tracing conversion to JS: ~10x speedup (100s down to 10s)
- Meta Quest 2 frame rate: ~45 FPS

User Study Results:

- 8 participants (4 w/ 10+ yrs. of mag. field experience, 3 w/ 2-5 yrs.)
- Users felt that the web UI has better precision and accessibility, while the VR UI gives a better "real-life view of the model"; another stated, "VR helps dramatically for seeing exactly where to implement things."
- 5 preferred "both web & VR," 2 preferred "only web," and 1 preferred "only VR."

Significance/Benefits to JPL & NASA

- **First-ever VR spacecraft magnetic field visualization tool**
- User study results indicate strong potential usefulness for real-world electromagnetic tasks and public outreach
- Very well received by the Electromagnetic Compatibility (EMC) team and science teams at NASA JPL. *"This will be very useful to visualize the magnetic field interactions from [an] engineering perspective. We can then identify real world locations on how to mount or implement magnets. For public outreach, this gives people a chance to see magnetic fields and what it is doing, that can't be seen by the naked eye."*
- Future Work:
  - Showing field information at specific locations
  - Visualizing constraints on points, areas, and volumes
  - Comparing simulation runs
  - Exporting data

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Publications:

Benjamin Nuernberger, Corey J. Cochrane, Justin Williams, Lyle Klyne, Andreas Gottscholl, Hannes Kraus, Angelo Ryan Soriano, Pablo S. Narvaez, Chi-Chien Nelson Huang, Katherine Dang, Edward C. Gonzales, Neil Murphy, Carol A. Raymond, "Visualizing Spacecraft Magnetic Fields on the Web and in VR," *Proceedings of ACM symposium on User interface software and technology (UIST) 2023, (to appear, conference to be held October 29 – November 1)* https://doi.org/10.1145/3586182.3616618.

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