Solving the orbital debris problem - one observation at a time

Trouble in orbit

Lost on your way to an important meeting? – turn on your navigation system. Trying to decide what to wear? – check the weather. What would you do if these simple solutions were no longer possible?

Behind every navigation system or weather prediction is a satellite system or constellation of such systems continually working to provide these day-to-day services. From banking transactions to global communication to GPS mapping – we rely on satellite technology.

One threat faced by the satellite systems that provide these services is the rapidly increasing amount of space debris in near earth orbit. There are currently millions of pieces of debris, otherwise known as “space junk,” orbiting earth, and their vast quantity and speed is a threat to anything crossing paths with them.

In low earth orbit, where most Space Junk resides, objects travel at 2-4 miles per second. At this speed, even an object as small as a paint fleck could render great damage to a satellite upon collision.

Saving our satellites

Working in collaboration with the University of Arizona (UofA), AEM Professor, Richard Linares, his Postdoctoral research associate, Piyush Mehta, and a team of University of Minnesota (UMN) students have set out to solve this issue. By combining Professor Linares’ expertise in space debris characterization with the University of Arizona’s expertise in small telescope technologies, the groups have a unique capability for solving the orbital debris problem; an optical telescope with the ability to track space debris and satellites.

“Solving the orbital debris problem requires developing a more detailed understanding of the orbital debris population,” says Linares. “The goal of our telescope network is to conduct research on improving the knowledge of the orbital debris population.”

The telescope, which was constructed from the ground up by a group of five students at the University of Arizona will be equipped with two software programs designed by University of Minnesota undergraduate students, Michael Schmit and Garrett Peloquin.

“Over the summer, I have been working to develop software to determine which objects are visible in the night sky, create ranking criteria to most effectively rank the objects for viewing, and to essentially output an optimized list of which objects should be viewed at any given time,” says Schmit, who got involved in the project spring semester when he had Professor Linares for the course, Orbital Mechanics.

Meanwhile Peloquin has been working on the data visualization and presentation for the project. “I take the information the telescope outputs and the goal is to turn it into an animation or gif that is easy to understand,” says Peloquin, who spends up to 40 hours a week learning the programming application, Python and implementing code.

While the students work on developing the software programs, Linares and Mehta are working on translating the knowledge acquired through observations into accurate orbit predictions in order to avoid future collisions.

“The state of any object, including position and velocity at any given time, can be estimated through propagation in time using dynamic models that may not be accurate,” says Mehta. “Therefore, the estimated state has associated uncertainties which can be reduced with observations.”

In low earth orbit (LEO), the most densely populated orbital regime, inaccurate modeling of atmospheric drag has the potential to lead to especially large uncertainties in object location. This is because drag, which is a mechanical force generated by contact between an object and a fluid, liquid or gas, can significantly modify a satellite’s orbit. By developing and improving models of the thermosphere and drag coefficient, Mehta is able to characterize the interaction...
research

On display for the world to see

On June 20, 2017 officials from the Air Force joined Linares and his collaborators at the University of Arizona to celebrate the completion of the telescope.

“This is an exciting moment for my research group, as we are now able to collect observational data of the space debris population, and use this data to improve our understanding,” says Linares.

A global effort

While the University of Minnesota group develops the software programs, five undergraduate seniors from the University of Arizona's College of Engineering have been busy constructing a telescope designed to track orbital debris and satellites. Led by Vishnu Reddy, an Assistant Professor of Planetary Sciences at the UofA, these students have spent the past seven months designing, building, and testing the telescope in collaboration with the University of Minnesota.

“The orbital debris problem needs to be solved on a collaborative global scale, as it is something that affects everyone,” Mehta says. “The collaboration between the University of Minnesota, and the University of Arizona makes us one step closer to solving this problem.”

Schwartzentruber funded to advance heat-shield survivability for hypersonic vehicles

Professor Tom Schwartzentruber is leading a new research project, funded by the U.S. Air Force Office of Scientific Research, entitled “Nonequilibrium Gas-Surface Interactions at High Temperature.” The research group includes Prof. Graham Candler here in the AEM department, Prof. Tim Minton from Montana State University, Prof. Erica Corral from the University of Arizona, and Prof. John Perepezko from the University of Wisconsin. The project involves numerical simulations performed in the AEM department and high-temperature materials fabrication and experiments performed at the collaborating universities. Ultimately, the research will combine new experimental capabilities, new simulation techniques, and new material fabrication methods to advance the state-of-the-art in high-temperature materials for hypersonic vehicles.

Professor Mahesh funded by the Navy to develop and improve complex software

Krishnan Mahesh, Professor in the Department of Aerospace Engineering and Mechanics, has recently been funded to develop advanced fluid simulation tools for the Navy. The goal of this research project is to develop highly accurate simulation software that can simulate the complex turbulent flow around propulsors and their resulting fluid loading. The simulations will be used in propulsor designs that meet operational requirements.

Minnesota Department of Transportation funds Gebre-Egziabher's research to improve transportation safety

Professor Gebre-Egziabher, research fellow in the Department of Mechanical Engineering, Brian Davis, and Aerospace Engineering master’s student, John Jackson have received funding from the Minnesota Department of Transportation to investigate, “The Evaluation of Low-Cost, Centimeter-Level Accuracy OEM GNSS Receivers.” This collaborative research project will investigate centimeter level accuracy in low-cost Global Navigation Satellite System receivers, which has the potential to enable many safety enhancements in U.S. transportation systems such as lane departure warning systems, driver assist systems, and enhanced stability control systems. The work will focus on providing an independent performance assessment in realistic settings encountered in transportation systems.