



Ph.D. DISSERTATION DEFENSE

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Degree: Doctor of Philosophy
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Title: Systems Methodologies for Predicting, Mitigating, and Remediating Orbital Debris

Chairperson: Dr. Hao Chen, Department of Systems and Enterprises, School of Engineering and Science, Stevens Institute of Technology

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ABSTRACT

Orbital debris is a pressing problem which presents a danger to global space operations and a barrier to continued development of the space economy and space infrastructure. As research continues regarding orbital debris, there is a need for tools to understand the system-level implications of orbital debris solutions. This research considers the orbital debris problem as a dynamic process. Based on dynamic system theories, time-series variables of the numbers of orbital debris, orbital objects, and object launches are causally linked, which means they share a common system attractor manifold. We propose a data-driven method based on complexity science to reconstruct a shadow attractor of the dynamic system using limited observable variables. The reconstructed shadow attractor helps us to understand the fundamental system dynamics for orbital debris and enables us to simulate the future of the orbital debris system based on changes to policy. These findings represent a significant advancement in our ability to understand high level impacts of space system policy with limited data available.

As orbital debris continues to become a higher priority for the space industry, there is a need to explore how partnerships between the public and private space sector may aid in addressing this issue. This research develops a framework for planning orbital debris remediation missions, providing a quantitative basis for partnerships that are mutually beneficial between space operators and debris remediators. By integrating network-based space logistics and game theory, we illuminate the high-level costs of remediating orbital debris, and the surplus that stands to be shared as a result. These findings indicate significant progress towards the continued development of a safe, sustainable, and profitable space economy.