STEVENS INSTITUTE OF TECHNOLOGY 1870

Ph.D. DISSERTATION DEFENSE

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Title:	A Conceptual Mission Engineering Framework for Evaluating the Performance of Precipitation Observing Missions

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ABSTRACT

The miniaturization of satellites has enabled the rise of distributed spacecraft missions (DSMs) comprised of many small spacecrafts located in diverse orbital planes. While DSM designs collect space-based data at high spatio and temporal resolutions, they pose design challenges. There could be millions of potential designs for DSMs that meet scientific objectives. The complexity increases when space mission designs observe atmospheric dynamic processes such as convective precipitation, which forms, dissolves, and moves within a few minutes, and the satellite sensor poses power limitations; a sensor cannot always be on.

Mission engineering frameworks play a crucial role in evaluating and exploring multiple space mission designs during pre-Phase A studies when designers have a holistic view of the system. To evaluate complex systems such as precipitation-observing space missions with duty cycle-limited instruments, designers need mission engineering frameworks that integrate environmental data and explore multiple sensor policies to turn on the sensor to collect precipitation storm observations.

This dissertation develops such a mission engineering framework that integrates the NASA GEOS-5 Nature Run data set into a simulation environment and evaluates the performance of space missions. First, this study develops new coverage methods that improve simulation runtime to process large data sets. Second, the methodology develops a mission engineering framework that utilizes one of the developed coverage methods, integrates the NASA GEOS-5 Nature Run data set, and evaluates the performance of mission architectures based on data latency. Ultimately, this study develops two sensor policies that guide a satellite when it should turn on a sensor to improve precipitation storm observations. The land policy turns on a sensor when the satellite flies over land. The collaborative policy turns on a sensor based on information shared by a leading satellite and communicated from an external relay system. The results show that a collaborative policy represents convective storm observations better than a land policy.