# Distributed Operations as Applied in a Large Multi-Instrument Space Mission: Lessons Learned from the Cassini-Huygens Program

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Launched in October 1997, the Cassini-Huygens Mission sent the largest interplanetary spacecraft ever built in the service of science. Carrying a suite of 12 scientific instruments and an atmospheric entry probe, this complex spacecraft to explore the Saturn system may not have gotten off the ground without undergoing significant design changes and cost reductions. As a means to reduce operations cost, a novel concept, called "Distributed Operations", was chosen. This concept utilized advances in information technology and distributed computation to decentralize the mission control room and science operations.

Although other interplanetary missions have decentralized science operations, none of them can match Cassini-Huygens in the scale and complexity of the distributed system. With 12 science teams and one Huygens Probe team distributed worldwide, the coordination effort to design and integrate command sequences posed a significant challenge in mission operations. Furthermore, the spacecraft design of mounting remote sensing instruments and in-situ instruments on a fixed spacecraft bus introduced operational constraints for even the simplest of maneuvers.

As Cassini-Huygens approaches its tour of Saturn, we reflect on the broad implications of the Distributed Operations (DO) concept, especially to large scale, multi-instrument spacecraft. We find the roles of the Scientist and the Engineer under the DO environment to be blurred. We find the act of decentralization necessitated the Scientist to redefine their roles in the mission operations system. In particular, the Cassini spacecraft's lack of a scan platform for remote sensing instruments, some of whom have complex pointing constraints, blurred instrument health and safety with spacecraft bus health and safety. In other words, to safely point his or her instrument, the Cassini Remote Sensing Scientist has a vested interest in spacecraft attitude simulation and constraint checking. This expands the Scientist role from a spacecraft user to include spacecraft safety assurance, a responsibility traditionally assigned to the Engineers.

We conclude by arguing the case for Distributed Operations must be made carefully. We propose some criteria to assess if a particular mission design is suited for a Distributed Operations environment. The criteria are: a) Number of science instrument payloads; b) The scope of shared resources among science instruments (i.e. non-inclusion of a scan platform means spacecraft attitude is a vital shared

resource); c) The inclusion of a mission director to resolve Science vs. Engineering conflicts; d) The coordination of distributed teams across time zones.