Design-based Mission Operation

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Virtual Mission project led by Mission Simulation and Instrument Modeling Group at JPL has been playing an active role in the NASA-wide information technology infusion programs, such as, Information System Technology, Next Generation Infrastructure Technology, and Intelligent Synthesis Environment. The goal of the VM project is to enable automated design space exploration, progressive design optimization, and lifecycle-wide design validation to achieve faster, better, and cheaper missions. Design-based mission operation has been a major part of the research effort in order to establish system-wide as well as lifecycle-wide impact analysis as an integral part of the mission design process. The focus of this presentation will be on Virtual Mission Lifecycle (VML), modeling and simulation tools and system engineering processes involved in building a virtual mission system that can perform a realistic mission operation during the design phase of a mission. Adopting the real mission lifecycle convention, the VML is composed of design, development, integration and test, and operation phases, addressing representation of subsystem properties, automated software prototyping of the subsystems, dynamically configurable integration and coordination infrastructure, and operation scenario language and science data synthesis, respectively.

Subsystem Modeling: A mission system is decomposed into a set of logical subsystems. The current set includes science instrument, navigation, attitude control, processing, and telemetry. Each logical subsystem is modeled for its performance and operation. The performance model describes the functional capability of a subsystem while the operation model describes the control mechanism and corresponding resource usage for applying the functionality of the subsystem.

Software Prototyping: The performance and operation models of each subsystem are implemented as a client-server pair, the operation model as a client and the performance model as a server. The client module transforms the operation model into a command handler and a resource manger that verifies incoming request and interacts with the performance server. The server module transforms the performance model into a behavior synthesizer that generates the subsystem data products (engineering data as well as science data).

Integrated System Behavior Simulation: The subsystem prototypes are integrated employing a component-based distributed process mechanism. An operation executive interacts with the distributed subsystems employing subsystem-specific interface protocols for commanding, status reporting, and data product handling. The Operation executive executes a sequence of time coordinated subsystem commands and displays the subsystem states on a multi-screen operation console for monitoring of the simulation process as well as integrated system behavior.

Mission Operation: Execution of science observation scenarios on the virtual mission system is performed in three stages: high-level event-driven observation scenario composition, translation of the scenario into time coordinated subsystem command sequences, and description of mission operation environment with respect to the target phenomena, spacecraft trajectory, and observation geometry. The VM observation scenario language provides subsystem parallelism, inter-subsystem dependency, conditional events, and variable-based operation description.