Embedding the Power of STK On-Board Space Assets via the On-Board Dynamic Simulation System (ODySSy/STK™)

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Customer Needs/Expectations

• JPL Thoughts on the Need to Leverage Smarter, More Autonomous Flight Software

  “With the advent of faster processors and advanced hardware architectures, the modern spacecraft is highly reliant upon flight software for mission success. Software is integral to many subsystems ranging from power to propulsion to instrument operations. Additionally, spacecraft developers are moving beyond providing only infrastructure to creating applications that can revolutionize how these vehicles are operated and how data is processed on-board.”

[2009 Workshop on Spacecraft Flight Software]

• Topics that JPL Expects to be Addressed
  • Flight software engineering and testing
  • Autonomy (e.g. navigation, fault management, and command sequence control)
  • On-board communication
  • On-board data processing
  • Software modeling, simulation and testbeds
  • Spacecraft software architectures
  • Planning, tasking and execution
  • Relation to systems engineering
  • Software Verification and Validation
  • Software modeling, simulation and testbeds
  • Guidance and control
The Vision

“Dramatically Reduce the Cost to Develop and Operate Space Assets while Significantly Increasing Capability and Responsiveness”

- The ASI and AGI Team Finally Makes this Dream a Reality for DoD, NASA and Commercial Spacecraft Programs
  - Two Inter-Related Products Support the Entire Spacecraft Lifecycle
    - SOLIS Module – Spacecraft Object Library In STK
    - STK/ODySSy – On-board Dynamic Simulation System with STK
  - Rapid Spacecraft Development, Assembly, Test and Integration
  - Highly Autonomous Spacecraft Operations
  - Unified and Validated Toolset from Mission Design through Operations
  - Exploits the Emergence of Faster Processors and Advanced Avionics
Objective

- Reduce the Cost and Increase the Efficiency of Spacecraft Programs
  - Provide highly responsive spacecraft architectures while continuing to ensure mission robustness and flexibility.

Description

- Modular C&DH software can be targeted and adapted to a wide variety of spacecraft designs, payloads, and requirements.
- Includes the On-Board Dynamic Simulation System with STK (STK/ODySSy™) to provide built-in-test (for AI&T and on-orbit checkout) and Autonomous Mission Planning and Execution.
STK/ODySSy™ Implementation Example

- On-board Dynamic Simulation System with STK (STK/ODySSy™) models the Attitude Control, Propulsion and Power Subsystems.
1. User Requests high level mission goals via command uplink (or spacecraft crosslink for constellation operations).
2. Autonomous scheduling and prioritization of mission goals and activities in concert with the event planner.
3. Event planner queries STK/ODySSy functions.
4. STK/ODySSy provides selection of event solutions given spacecraft and environment (i.e., orbit) constraints.
5. Event planner provides most optimal event timeline to scheduler.
6. As the event nears, the scheduler initiates the sequence builder.
7. The sequence builder queries STK/ODySSy functions given the current state of the spacecraft and environment.
8. STK/ODySSy provides parameters and a set of time and event triggers consistent with current spacecraft capabilities.
9. The event sequence is built and loaded into the Seq/Cmd engine.
10. The spacecraft executes event.
• Expand STK’s capabilities beyond the traditional mission planning and trajectory simulations into a Complete Spacecraft Simulation Environment
  – Complete rotational dynamics to transform STK into a high-fidelity, 6 degree-of-freedom simulation engine
  – Closed-Loop Attitude Control and Power Subsystem Modeling

• Utilizes a Desktop Version of the Spacecraft’s STK/ODySSy™ On-Board Flight Software
  – Provides a unified tool chain from initial mission design through on-board systems and operations
  – Click of a button generates Flight Software specific to avionics target environment
STK/SOLIS Module

- Example Screenshot Showing Setup of Attitude Controller
• **Proposal Phase and Early Mission Design Activities**
  - Proposal Teams and Mission Designers use the STK/SOLIS Module (Spacecraft Object Library in STK) to Enhance STK and Assure that Spacecraft Capabilities and Constraints are Considered Early in the Spacecraft Lifecycle
  - SOLIS is emPowered by STK/ODySSy (the On-Board Flight Version of STK)
  - Reduces Program Risk, Schedule and Cost by Assuring that Proposal Teams, Mission Designers and Spacecraft Engineers are on the Same Page

• **Flight Avionics and Flight Software Development and Verification**
  - Full Mission Scenarios can be Executed, without any external test equipment, as soon as Code is Loaded to the Flight Avionics under Development
  - Reduces Program Risk, Schedule and Cost by Providing a Full Built-In Simulation and Test Capability at the Board and Box Level

• **Spacecraft Assembly, Integration and Test (AI&T)**
  - STK/ODySSy Software Simplifies Spacecraft Integration & Test While Facilitating a Test Like You Fly Environment
  - Use of STK/ODySSy during AI&T Bridges the Gap Between Mission Design/Analysis and Mission Operations with a Seamless and Consistent Set of Tools
  - Reduces Program Risk, Schedule and Cost by Expediting the AI&T Timeline, Reducing the Test Infrastructure Requirements and Providing a Pre-Validated Test Environment

• **Spacecraft Operations**
  - STK/ODySSy™ Simplifies Mission Operations Planning & Execution While Providing On-Board Optimization to Maximize a Spacecraft’s Potential
  - STK/ODySSy™ Provides On-Board Autonomous Mission Planning and Execution including Real-Time Maneuver Validation and Constraint Checking
  - SOLIS Ground-Based Tools Provide a Cohesive Set of Analysis Tools to Aid Mission Analysts and Operators
Multi-Discipline Development and Test

- Full FSW Development Environment with VxSim
- AGI Satellite Toolkit (STK) with SOLIS (Spacecraft Object Library in STK)
- L3 In-Control Command/Telemetry GDS (Server and Client)
- Target FSW Configured by SOLIS for Flight Avionics
- FSW Executes with Full Built-In Simulation and Test via the On-Board Dynamic Simulation System (STK/ODySSy)
- On-Board Autonomy via STK/ODySSy
- As Hardware Components are Integrated, STK/ODySSy Configures the Simulation Corresponding to the System Configuration
- Full STK Visualization of Mission Scenarios During Code Execution and Test
• Backup Slides
  – Advanced Solutions, Inc. Background Information
• Advanced Solutions, Inc (ASI)
  – Incorporated in Colorado 1995
  – Headquarters in Littleton, CO

• Key Areas of Expertise
  – Spacecraft Guidance, Navigation, and Control Systems
  – Aerospace Ground Data Systems and Simulators
  – Avionics and Flight Software
  – Space-Qualified ADCS Components
  – Aerospace Systems Engineering
  – Spacecraft Integration, Test, and Mission Operations
Orbcomm Generation 2 (OG2) Satellite Constellation

- ORBCOMM is a wireless telecommunications company providing narrow band two-way digital messaging, data communications, and geo-positioning services on a global basis.
- 18 Satellites Initially – Up To 48 Total
- Replace Current OG1 Constellation

• For OG2 ASI is Providing:
  - Bus Flight Software and Simulation
  - Attitude Determination and Control System
  - Integrated Avionics Design and Fabrication Support
  - EGSE and Test Equipment Design and Development
  - Ground Data System Design and Development
ASI Space Projects

JPL/LMA Mars Reconnaissance Orbiter (MRO)

– Attitude Control System
– Orbiter Analysis Software
– Flight Software
– EGSE Software and Test
– Ground Data System

LMA Mission/Project Support

– Odyssey and MGS (Mars Orbiters)
– Stardust (Comet Sample Return)
– Phoenix (Mars 2007 Lander)
– ORION (Crew Exploration Vehicle)

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AFRL/MSI TacSAT-2 Mission

- Attitude Determination and Control System (ADCS)
- On-Board Dynamic Simulation System (ODySSy™)

United States Air Force Academy FalconSAT-5

- Modular C&DH Software with Built-In Simulation/Test
  - On-Board Dynamic Simulation System (ODySSy™)
  - Attitude Determination and Control System (ADCS) Support
ASI Space Hardware

• Space-Qualified ADCS Components
  • Sun Sensor Assemblies
  • Rate Sensor Assemblies