STK/SOLIS and STK/ODySSy
Flight Software:
Supporting the Entire Spacecraft Lifecycle

2011 Flight Software Workshop
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“Dramatically Reduce the Cost to Develop and Operate Space Assets while Significantly Increasing Capability and Responsiveness”

• The ASI and AGI Team Makes this Dream a Reality for DoD, NASA and Commercial Spacecraft Programs
  – Two Inter-Related Products Support the Entire Spacecraft Lifecycle
    • STK/SOLIS – 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
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/SOLIS**  
(Spacecraft Object Library in STK)

- Provides complete spacecraft simulation environment in STK
  - Full rotational dynamics
  - Attitude control and determination
  - Sensor/actuator models
  - Power/payload modeling
  - Autonomous flight software emulation

- Integrates spacecraft simulation with mission planning and trajectory simulation

- Utilizes a desktop version of ASI’s ODySSy™ On-Board Flight Software
- **Attitude control system**
  - Attitude disturbance modeling and effects
  - Perfect, simple or full PID controller
  - Actuator modeling
  - Actuator wizard

- **Attitude determination system**
  - Perfect or fixed gain filter attitude determination
  - Sensor modeling
  - Sensor wizard
STK/SOLIS Capabilities Overview

- **Spacecraft subsystem modeling**
  - Power system
    - solar arrays, batteries, spacecraft loads
  - Payload
    - power, data production, mode emulation
  - Communication system
    - Tx/Rx data rates, command/telemetry availability based on ground station visibility

![Battery State of Charge](chart.png)
STK/SOLIS Capabilities Overview

- Spacecraft simulation with flight software emulation
  - Mission sequence modeling
  - Real-time commanding
  - Telemetry interface
  - On-board orbit determination
  - Options for executing in real time or faster than real time
Applications

- **Spacecraft Design**
  - System/Mission Requirements
    - Requirements definition, feasibility studies, component selection
  - Conceptual Design
    - Can system concepts meet mission requirements?
  - Preliminary Design
    - Define subsystem and component level specifications
  - Critical Design
    - Final verification of subsystem models and components
  - IV&V and Risk Reduction
    - Independent validation and sensitivity/margin analysis

- **Spacecraft Operations**
  - Training and analysis tool for ground operators and mission analysts
Benefits

- **Improved fidelity in the spacecraft design process**
  - Assure that the spacecraft capabilities and constraints are considered early in the spacecraft design lifecycle and met
  - Reduce necessary iterations between multiple teams

- **Integration of spacecraft and mission design**
  - Analyze spacecraft performance in context of broader mission requirements
  - Proposal teams, mission designers & spacecraft engineers are all on the same page

- **Reduces Program Risk, Schedule, and Cost**
  - Provides a validated simulation & test environment
  - Accelerates design and I&T phases
Based on simulations, flight software and spacecraft operational concepts with heritage on numerous missions

Utilizes actual flight software to “Close-the-Loop” with the STK orbit/environment modeling and the spacecraft systems

Simulation and Flight software includes:
- Air Force Research Laboratory (AFRL) TacSAT-2 Spacecraft
- AFRL DSX Spacecraft
- United States Air Force Academy (USAFA) FalconSAT-5 Spacecraft
- ORBCOMM Generation 2 Satellite Constellation

Utilizes the On-Board Dynamic Simulation System (ODySSy): full dynamic spacecraft simulation built right into the flight software

Validated against ASI’s high-fidelity MATLAB/SIMULINK simulations used for primary design and analysis on the above missions, verified post-launch with actual flight data
ASI's STK/SOLIS engineers involved in the GN&C and flight, ground, and simulation software development efforts for the following high profile NASA missions:

- Mars Reconnaissance Orbiter (MRO)
- Mars Global Surveyor
- Stardust
- Genesis
- Mars Phoenix Lander
- Juno
- GRAIL
- MAVEN
- GOES-R

STK/SOLIS Simulation results most recently validated against the USAFA FalconSAT-5 Spacecraft which launched November 2010
STK/SOLIS and STK/ODySSy Lifecycle Benefits

- **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
Questions

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