JSTAR
Jon McBride Software Testing & Research Lab

Max Spolaor, Ph.D.
Sr. Systems Engineer and Chief Scientist
NASA IV&V Program and TMC Technologies of WV Corp.
max.spolaor@nasa.gov, max.spolaor@tmctechnologies.com
Other useful POCs:

Justin Morris  
NASA IV&V Program  
Computer Engineer and ITC-JSTAR Lead  
justin.r.morris@nasa.gov

Marcus Fisher  
NASA IV&V Program  
Chief Engineer/ GSFC Senior Fellow  
marcus.s.fisher@nasa.gov

William Stanton  
NASA IV&V Program  
Gateway IV&V Deputy Project Manager  
william.m.stanton@nasa.gov
Condense Entire Flight “System” to a Laptop
  • Sensors/Actuators are Simulated
  • Flight Computer Hardware is Emulated to create Virtual Platform
  • Flight Software binaries executed as delivered.
  • Ground Operations Integrated.

“Software-only Flatsat”
## Human Exploration

<table>
<thead>
<tr>
<th>Mission</th>
<th>Platform</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space Launch System (SLS)</td>
<td>SLS Software-only Simulator (S3)</td>
</tr>
<tr>
<td>Ground System and Data Operations (GSDO)</td>
<td>GSDO Software-only Simulator (G2)</td>
</tr>
<tr>
<td>Multi-Purpose Crew Vehicle (MPCV)</td>
<td>Software-Only Crew Exploration vehicle Risk Reduction Analysis Test Environment Simulation (SOCRRATES)</td>
</tr>
<tr>
<td>Integrated Tri-Program Simulation</td>
<td>Advanced Risk Reduction Integrated Software Test and Operations Tri-program Lightweight Environment (ARRISTOTLE)</td>
</tr>
<tr>
<td>International Space Station (ISS)</td>
<td>MADE Final Qualification Tests (FQTs)</td>
</tr>
</tbody>
</table>

## Science Missions

<table>
<thead>
<tr>
<th>Mission</th>
<th>Platform</th>
</tr>
</thead>
<tbody>
<tr>
<td>JWST</td>
<td>JWST Integrated Simulation &amp; Test (JIST)</td>
</tr>
<tr>
<td>DSCOVR</td>
<td>Mission Test Set (MTS)</td>
</tr>
<tr>
<td>GPM</td>
<td>GPM Operational Simulator (GO-SIM)</td>
</tr>
<tr>
<td>OSIRIS-Rex</td>
<td>SoftSim (Lockheed Martin)</td>
</tr>
<tr>
<td>MAVEN</td>
<td>ATLAS FSW Simulation Environment</td>
</tr>
<tr>
<td>ICESAT-II</td>
<td>ATLAS FSW Simulation Environment</td>
</tr>
<tr>
<td>WFIRST</td>
<td>Leon-4 Emulator, cFS, ASIST, 42, WFI/CGI simulator</td>
</tr>
<tr>
<td>Europa</td>
<td>RAD750 Emulator, CORE, GDS, WSTS</td>
</tr>
</tbody>
</table>

## Small Satellites

<table>
<thead>
<tr>
<th>Mission</th>
<th>Platform</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simulation-to-Flight 1 (STF-1)</td>
<td>NASA Operational Simulator for Small Satellites (NOS³)</td>
</tr>
<tr>
<td>Lunar Ice Cube</td>
<td></td>
</tr>
</tbody>
</table>

## Security

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Platform</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyber security Spacecraft Training Environment</td>
<td>Cyber-Sim</td>
</tr>
</tbody>
</table>

*Acquired Simulations*
Why do we do it?

- Enables IV&V Program project teams to IV&V complex system and software behaviors
- Fault Injection
- Flexible Time
- Source Level Debugging
- Unlimited Simulation Resources
- Operational Spacecraft Environments
- Training Platforms
A couple recent examples

• **6 Issues found in Project X Board Support Package**
  – Most could only be validated using an all software emulation
    • Interrupt and timing related
    • Bad states due to hardware failures

• **Severity 1 Project Y Issue that escaped ACS SIM and FSW Verification Test**
  – Mission ending if not discovered prior to launch
  – The gyro data validity indicator in test inputs vectors was set incorrectly to “invalid” per ICD; however, the FSW was processing the data as if it were “valid” and continued to process gyro rates.
  – The problem was traced to the ACS simulator from which the requirements, design, source code, and V&V were all derived.
  – Basically, the Verification Simulator was driven from the FSW design instead of according to the ICD.
# Measurable Assurance

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Name</th>
<th>File</th>
<th>Line Coverage</th>
<th>Function Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBS</td>
<td>Beam Steering Control</td>
<td>sbs.c</td>
<td>72.0%</td>
<td>949 / 1318</td>
</tr>
<tr>
<td>SDI</td>
<td>Diagnostic</td>
<td>sdi.c</td>
<td>83.0%</td>
<td>1343 / 1618</td>
</tr>
<tr>
<td>SIM</td>
<td>Instrument Manager</td>
<td>sim.c</td>
<td>66.3%</td>
<td>555 / 837</td>
</tr>
<tr>
<td>SLA</td>
<td>Laser Control</td>
<td>sla.c</td>
<td>88.7%</td>
<td>375 / 423</td>
</tr>
<tr>
<td>SMT</td>
<td>Main Computer Electronics Housekeeping and Telemetry</td>
<td>smt.c</td>
<td>76.2%</td>
<td>214 / 281</td>
</tr>
<tr>
<td>SRT</td>
<td>Remote Terminal</td>
<td>srt.c</td>
<td>88.4%</td>
<td>289 / 327</td>
</tr>
<tr>
<td>STH</td>
<td>Thermal Control</td>
<td>sth.c</td>
<td>85.6%</td>
<td>664 / 776</td>
</tr>
<tr>
<td>SXP</td>
<td>Extrapolator</td>
<td>sxp.c</td>
<td>35.9%</td>
<td>417 / 1161</td>
</tr>
<tr>
<td>SFM</td>
<td>File Manager</td>
<td>fm.c (common)</td>
<td>60.4%</td>
<td>462 / 765</td>
</tr>
<tr>
<td>SHS</td>
<td>Health and Safety</td>
<td>hs.c (common)</td>
<td>84.7%</td>
<td>687 / 811</td>
</tr>
</tbody>
</table>
Typical Uses

• Dry run flight software testing
• Dry run operational scenarios / end-to-end
• Risk reduction testing
• Software Integration Testing
• Failure scenarios
• Increases testing resources which decreases reliance on FlatSat environments
• Increases test opportunities (interns, new hires)
Ground System Software

- GSFC ASIST
- GSFC ITOS
- Raytheon ECLIPSE CCTS
- Ball Aerospace COSMOS
- KSC EGS
- JPL AMPCS
- JPL AMMOS Instrument Toolkit (AIT)
Simulation Platforms

- NASA Operational Simulator for Small Satellites (NOS³)
- Cyber Simulation
- Parker Solar Probe Guidance & Control Simulation
- JWST Integrated Simulation and Test
- Global Precipitation Measurement Operational Simulator
- Simulation-to-Flight 1
- ARRISTOTLE
HEO Terminology

SLS
Core Stage
Simulation: S3 (JSTAR)

ICPS
Second Stage
Simulation: None (In Design)

MPCV
Orion
Simulation: SOCRRATES (LM)

GSDO
Ground Launch Sequencer
Simulation: GS2
ARRISTOTLE is a customized integration of ARTEMIS, SOCRRATES and EGS in an all-software environment

ARRISTOTLE: Windows or Linux host OS

ARTEMIS Virtual Machine (S3)

SOCRRATES Virtual Machine

EGS Virtual Machine (GS2)

C&T

SCRAMNet

SATOCM
# ARRISTOTLE Components

<table>
<thead>
<tr>
<th><strong>SIMULATION COMPONENTS</strong></th>
<th><strong>DESCRIPTION</strong></th>
</tr>
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<tr>
<td>SLS Software-only Simulation (S3)</td>
<td>All software emulation of SLS core stage vehicle. Integration of ARTEMIS with emulation of triplex flight computer models</td>
</tr>
<tr>
<td>SOCRATES</td>
<td>All software emulation of Orion vehicle.</td>
</tr>
<tr>
<td>GSDO Software-only Simulation (GS2)</td>
<td>Software-only simulation of the ESG with initial focus on the Ground Launch Sequencer (GLS) component</td>
</tr>
<tr>
<td>ICPS</td>
<td>Low-fidelity interface simulation of ICPS</td>
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