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

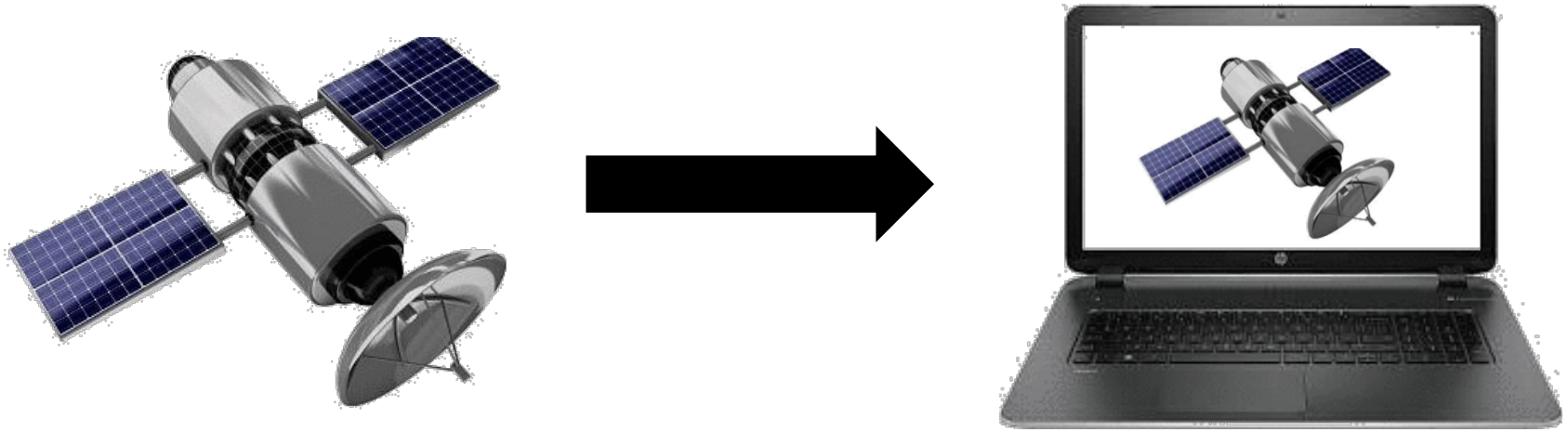
Other useful POCs:

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

Software-only Simulation



- 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"

NASA Simulation Warehouse

Human Exploration

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

Small Satellites

Mission	Platform
Simulation-to-Flight 1 (STF-1)	NASA Operational Simulator for Small Satellites (NOS^3)
Lunar Ice Cube	

Science Missions

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

Security

Purpose	Platform
Cyber security Spacecraft Training Environment	Cyber-Sim

*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

Issue Identification

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

SBC Tasks / Main / Configuration / Utility Code Files						
Acronym	Name	File	Line Coverage		Function Coverage	
SBS	Beam Steering Control	sbs.c	72.0 %	949 / 1318	84.3 %	70 / 83
SDI	Diagnostic	sdi.c	83.0 %	1343 / 1618	80.5 %	66 / 82
SIM	Instrument Manager	sim.c	66.3 %	555 / 837	79.3 %	23 / 29
SLA	Laser Control	sla.c	88.7 %	375 / 423	100.0 %	33 / 33
SMT	Main Computer Electronics Housekeeping and Telemetry	smt.c	76.2 %	214 / 281	66.7 %	14 / 21
SRT	Remote Terminal	srt.c	88.4 %	289 / 327	100.0 %	30 / 30
STH	Thermal Control	sth.c	85.6 %	664 / 776	97.4 %	38 / 39
SXP	Extrapolator	sxp.c	35.9 %	417 / 1161	60.6 %	20 / 33
SFM	File Manager	fm.c (common)	60.4%	462 / 765	76.9%	40 / 52
SHS	Health and Safety	hs.c (common)	84.7%	687 / 811	92.5%	49 / 53

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 (NOS^3)**
- **Cyber Simulation**
- Parker Solar Probe Guidance & Control Simulation
- JWST Integrated Simulation and Test
- Global Precipitation Measurement Operational Simulator
- Simulation-to-Flight 1
- ARRISTOTLE

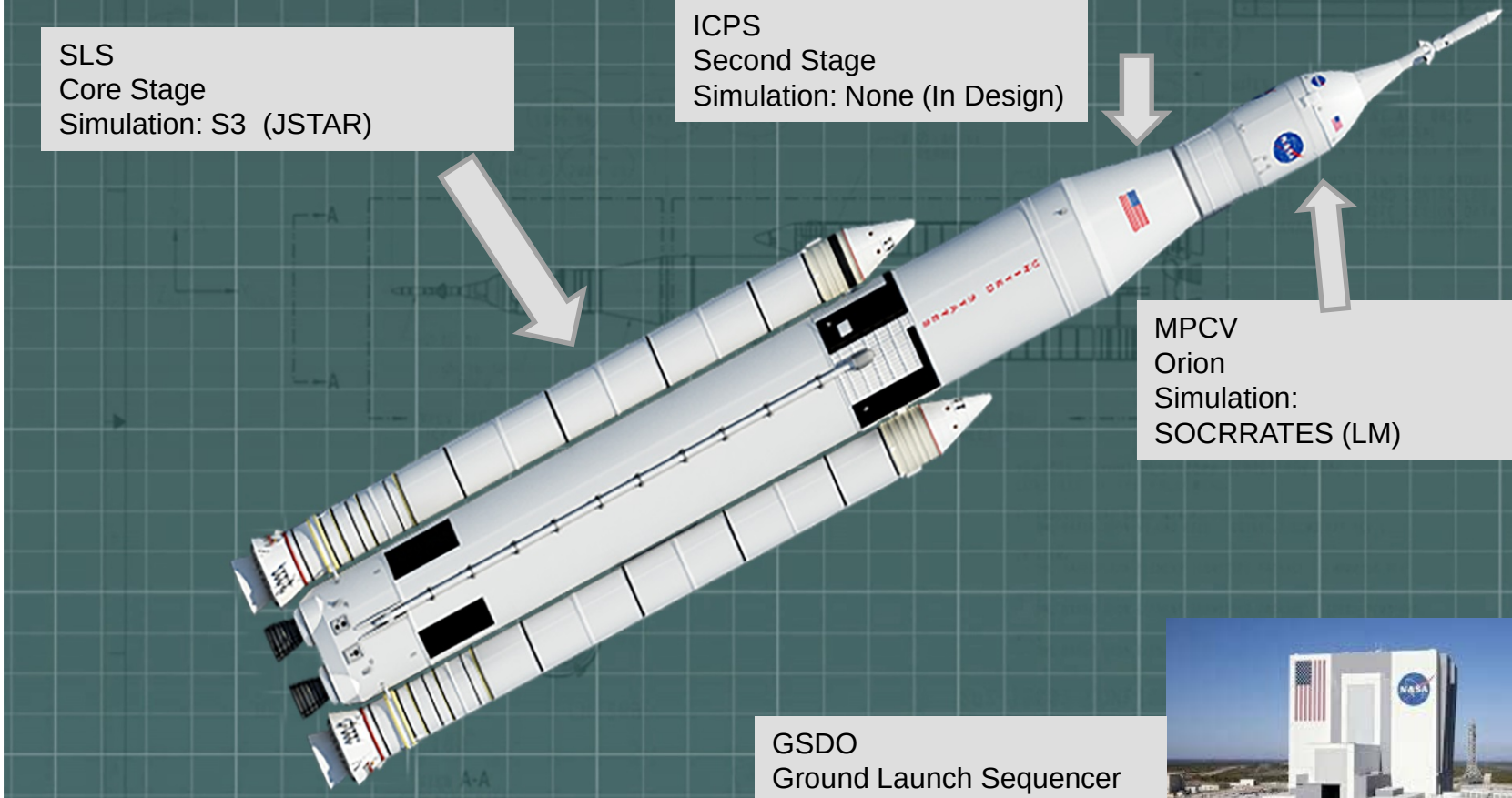

ARISTOTLE
ADVANCED RISK REDUCTION INTEGRATED SOFTWARE TEST &
OPERATIONS TRI-PROGRAM LIGHTWEIGHT ENVIRONMENT

HEO Terminology

SLS
Core Stage
Simulation: S3 (JSTAR)

ICPS
Second Stage
Simulation: None (In Design)

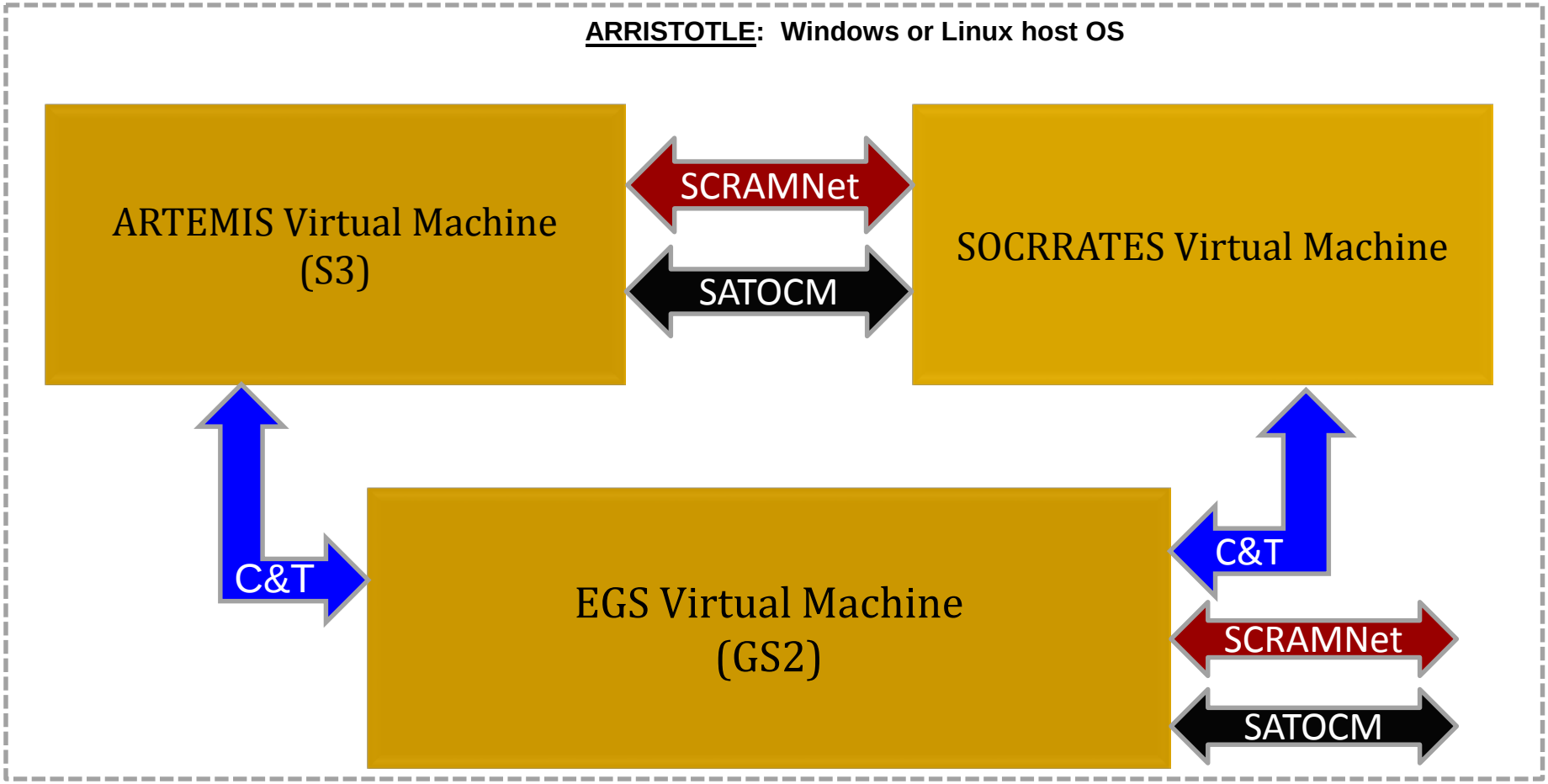
MPCV
Orion
Simulation:
SOCRRATES (LM)



GSDO
Ground Launch Sequencer
Simulation: GS2

ARRISTOTLE

ARRISTOTLE is a customized integration of ARTEMIS, SOCRRATES and EGS in an all-software environment



ARRISTOTLE Components

Simulation Components	Description
SLS Software-only Simulation (S3)	All software emulation of SLS core stage vehicle. Integration of ARTEMIS with emulation of triplex flight computer models
SOCRRATES	All software emulation of Orion vehicle.
GSDO Software-only Simulation (GS2)	Software-only simulation of the ESG with initial focus on the Ground Launch Sequencer (GLS) component
ICPS	Low-fidelity interface simulation of ICPS