



JSTAR

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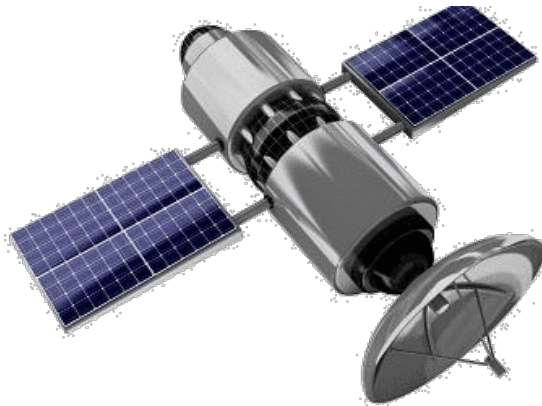


Other useful POCs:

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- 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

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

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.

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

- 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)

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

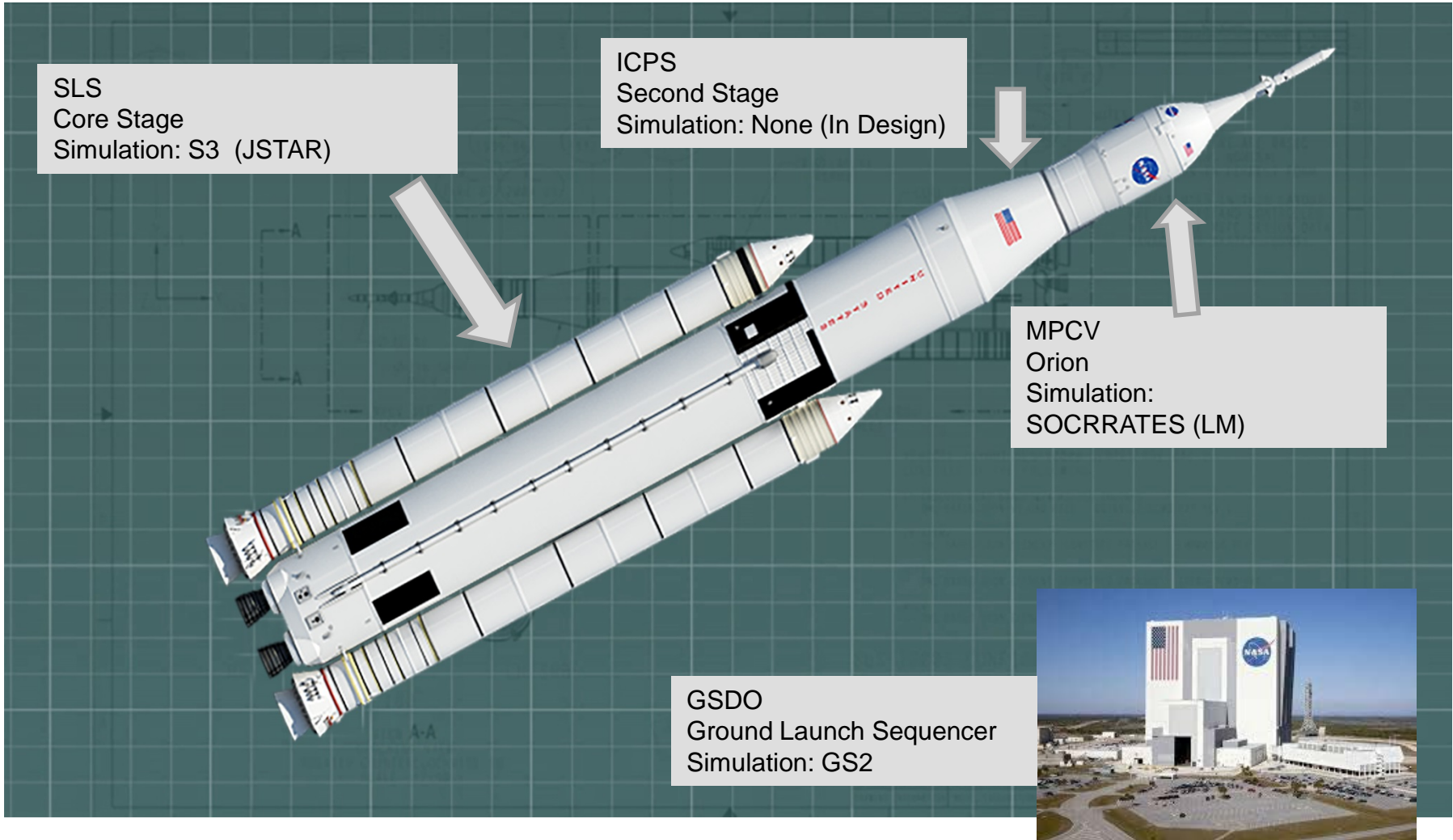
- **NASA Operational Simulator for Small Satellites (NOS³)**
- **Cyber Simulation**
- Parker Solar Probe Guidance & Control Simulation
- JWST Integrated Simulation and Test
- Global Precipitation Measurement Operational Simulator
- Simulation-to-Flight 1
- ARRISTOTLE



ARISTOTLE

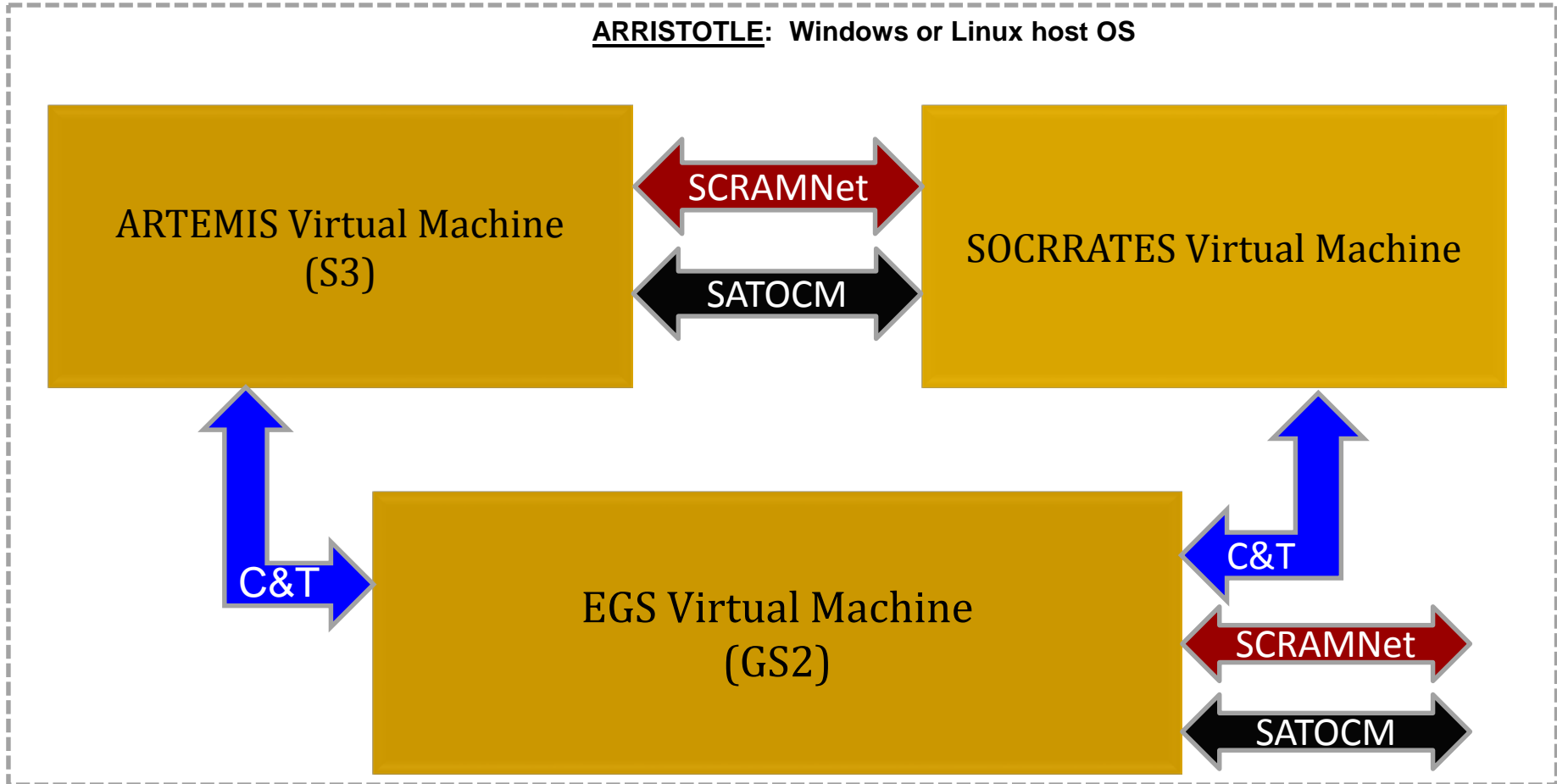
ADVANCED RISK REDUCTION INTEGRATED SOFTWARE TEST &
OPERATIONS TRI-PROGRAM LIGHTWEIGHT ENVIRONMENT

HEO Terminology



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

ARRISTOTLE: Windows or Linux host OS



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