



# PSP GN&C, Glue, and 42

## Independent Dynamics for Independent Testing



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# BLUF – Why?

- NASA's Independent Verification and Validation Program

- Key: Independence

- Managerially, financially, technically

- Software within the system focus



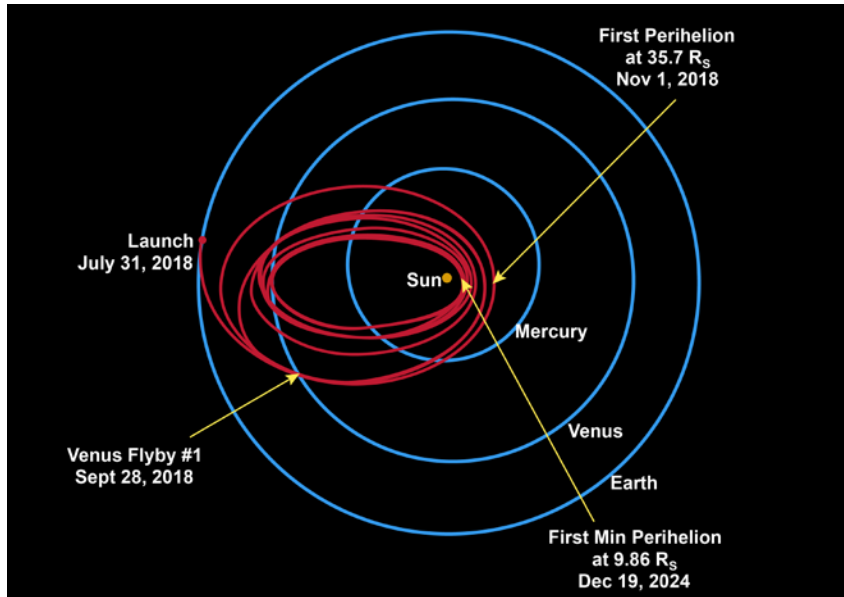
- NASA IV&V Engineer concern:

- Single truth/FSW GN&C Matlab/Simulink model developed by the SPP project

- **Can IV&V have an independent truth source?**

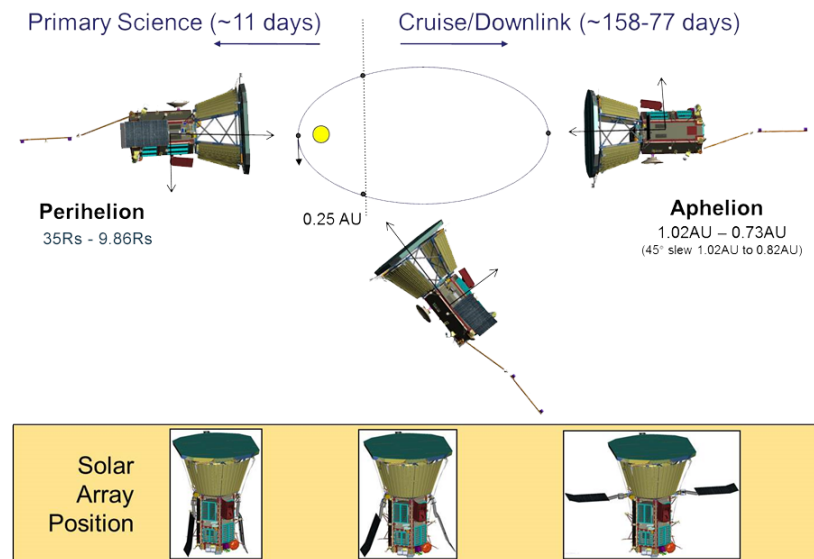


# Parker Solar Probe (PSP)



- Protected by a 4.5-inch-thick carbon-composite shield
- Withstand temperatures that reach nearly 2,500 degrees Fahrenheit
- Pointing is incredibly important!

- Swoop closer to the Sun's surface than any spacecraft before it
- Face brutal heat and radiation conditions



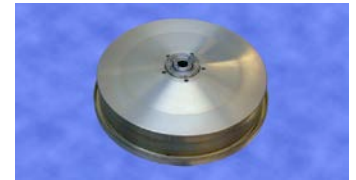


# Sensors/Actuators

- Star Trackers

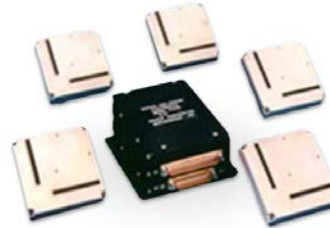


- Reaction Wheel Motors/Tachometers

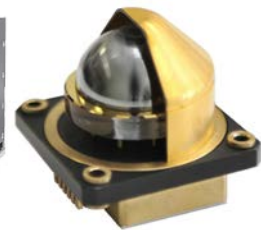


- Solar Limb Sensors

- Digital Sun Sensors



- IMU/Gyroscopes/Accelerometers



- Thrusters

- Solar Array Motors/Potentiometers



- High Gain Antenna Motor/Potentiometers







# 42 –

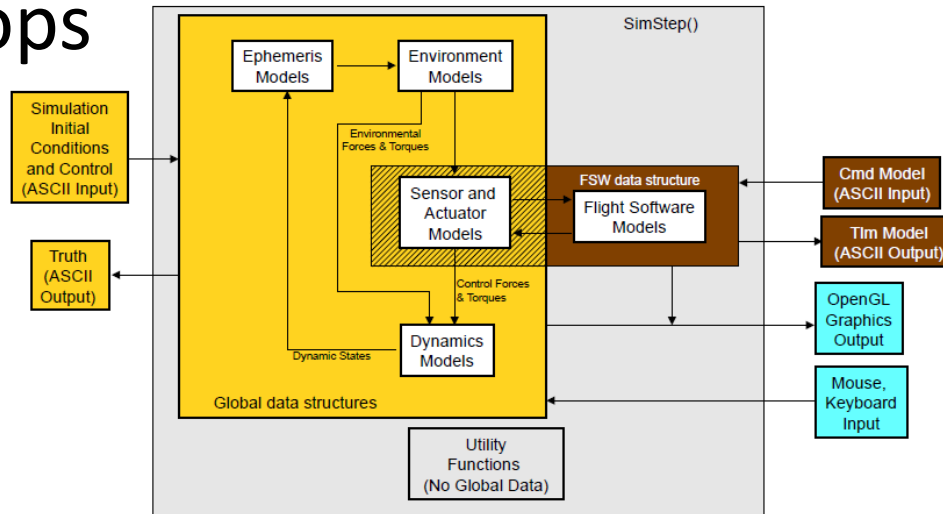


## An Independent Dynamics Source

- Developed by Eric Stoneking, GSFC
- A simulation of spacecraft attitude and orbital dynamics and control
- Intended for use from concept studies through

### 42's Architecture

ops



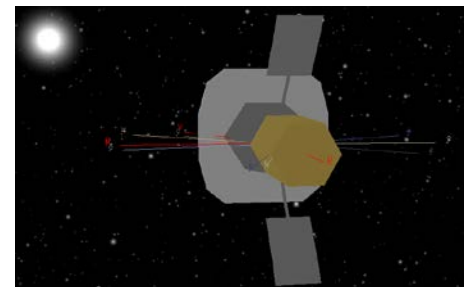
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# IV&V and JSTAR

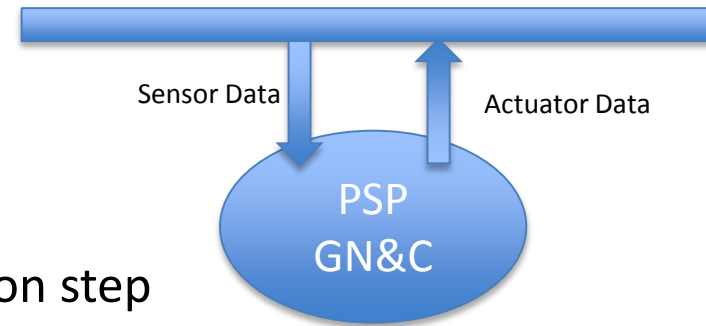
- IV&V
  - Perform analysis of software artifacts for a project
  - Requirements, Design, Code, Test, etc.
- JSTAR developers
  - Experts in simulations
  - Build tools used by IV&V analysts to do their job
- Sam Brown, IV&V Analyst, started the PSP Testbed
- JSTAR developers:
  - Re-architected environment
  - Modularized environment
  - Added sensor and actuator models





# Glue

- PSP GN&C – cFS app using S/W bus messages
  - Sensor data in
  - Actuator data out
- 42 architecture:
  - Allows call out to flight S/W each integration step
- JSTAR wrote the Glue Code
  - 42 dynamics data – position, velocity, acceleration, attitude, sun vector, wheel speeds, joint positions
    - Convert to body/sensor frame and then to sensor signals
    - Pass in to PSP GN&C as the software bus message data structures
  - PSP GN&C actuator control messages
    - Received by glue code and converted to 42 actuator commands
    - Thruster firing, reaction wheel torques, motor movements







# Video



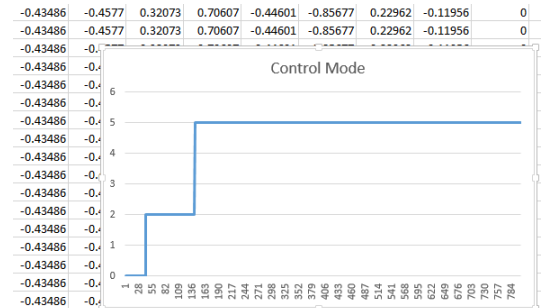
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# Advantages/Disadvantages

- Advantages
  - Using PSP auto generated & hand generated code
  - 42 makes it easy to call out... just set/get data at appropriate rates for PSP GN&C
  - Extensive CSV reporting of GN&C inputs, outputs, intermediate results, 42 truth data
  - Independent truth model
- Disadvantages
  - Took some time / GN&C expertise to develop







# IV&V Uses

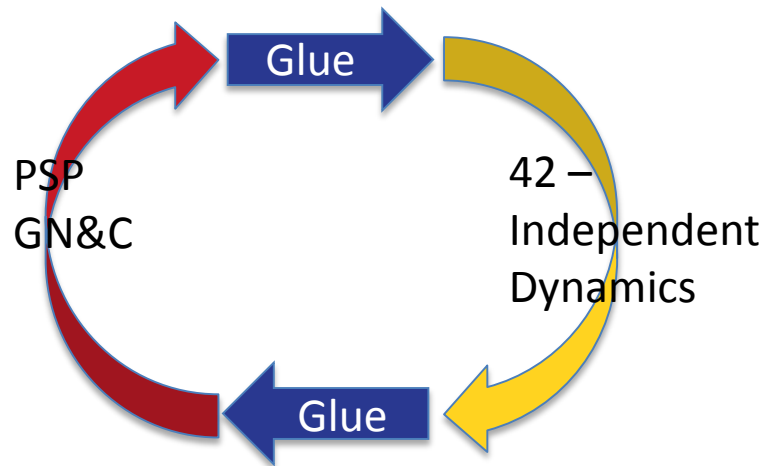
- Testing
  - Ability to independently test how the software will behave under adverse conditions
- Learning how the sensors/actuators really work and interact
  - A huge benefit not necessarily thought of at the beginning
- Just starting to really leverage the testbed





# Bottom Line

- Bottom line – why this is important
  - Provides independent testing capability based on IV&V identified need





# Future

- Future on SPP
  - Hope to get more IV&V analyst use as a testing and learning tool
- Future on other missions
  - Pathfinder, shows it is possible
  - We went closed loop!

