Spirent Federal Systems Simulator Users' Conference

NASA Johnson Space Center
Mini AERCam testing with the GSS6560

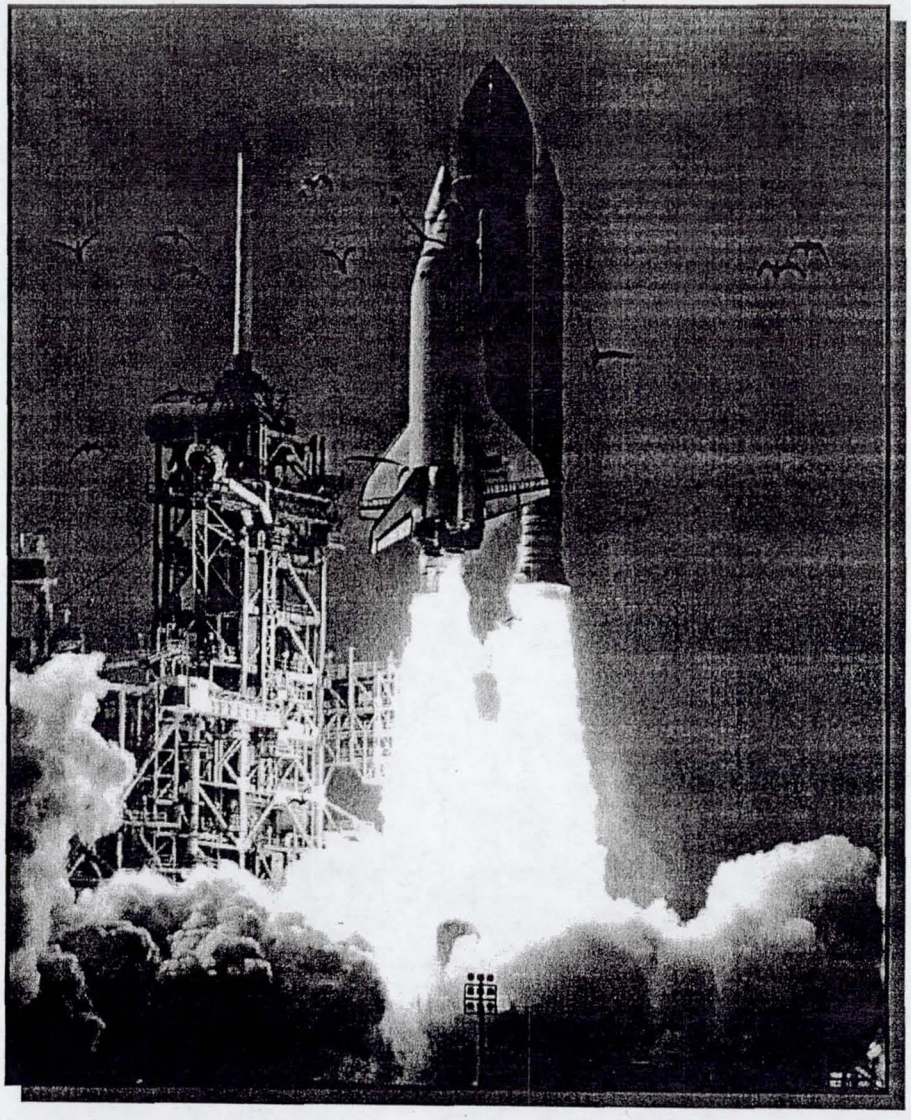
April 6 & 7, 2004

GPS Based Programs at NASA-JSC

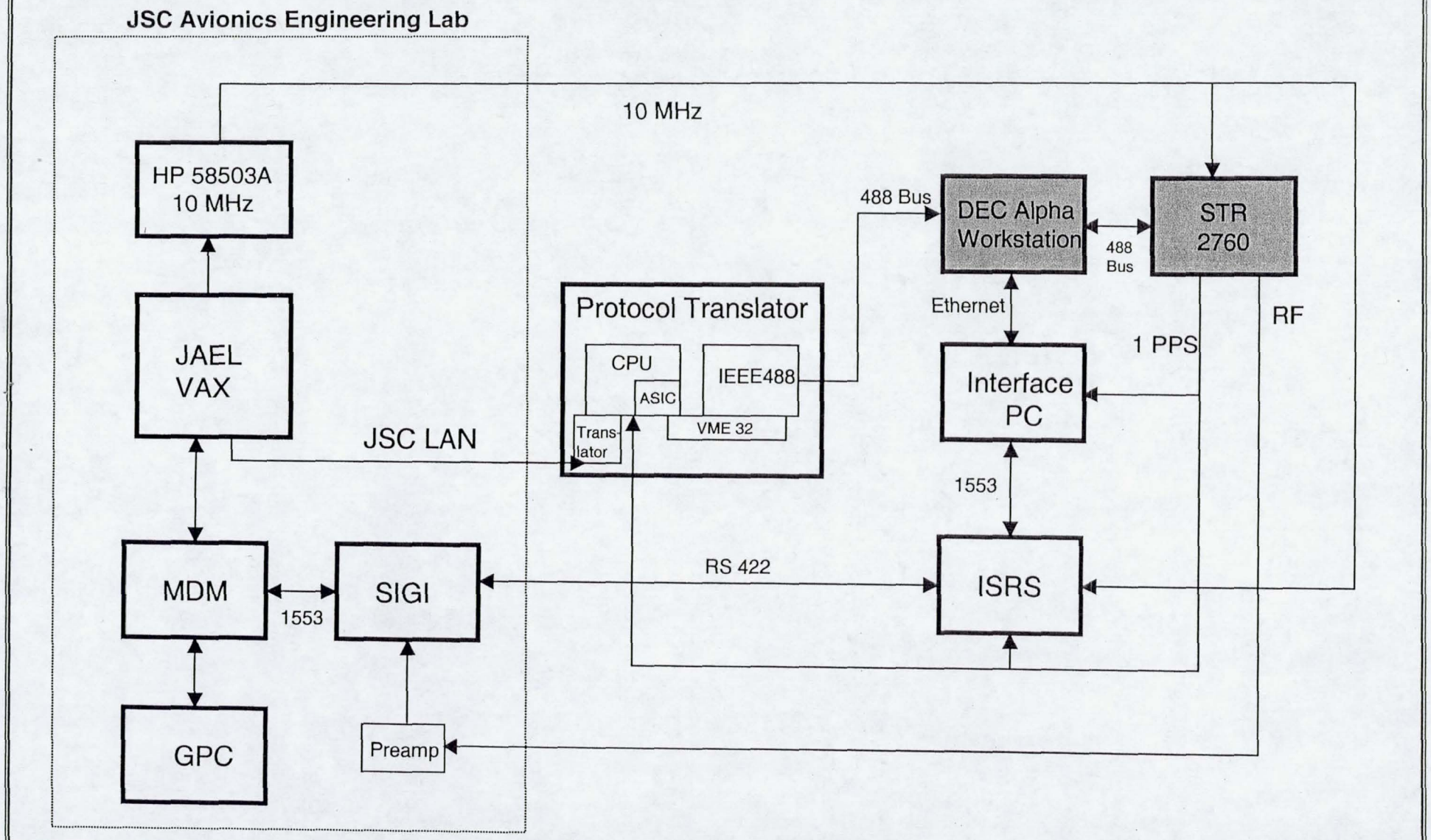
- Several Detailed Test Objectives (DTOs) flown on STS missions featuring GPS as the primary focus of the DTO:
  - GANE on STS-77
  - RGPS RME on STS-80
  - ARPK on STS-84 & STS-86
  - SIGI DTOs on STS-88, STS-101 (SOAR) and STS-108 (CRV)
- Shuttle program switching to GPS receivers for navigation sensor
- International Space Station baselined with GPS based navigation and attitude determination. Operational since 2002.
- Crew Return Vehicle featured GPS based navigation.
- Mini Autonomous Extravehicular Robotic Camera (AERCam) relies on precise real-time relative GPS for relative navigation.

Shuttle GPS Testing

- Shuttle's Rockwell Collins "MAGR-S" tested regularly in the Shuttle Avionics Integration Laboratory (SAIL) before any Shuttle flight
- Shuttle SIGI Testing
  - Shuttle SIGI contains a Rockwell Collins GEM-3 GPS receiver and Honeywell INS
  - Was considered a candidate for replacing current Shuttle IMUs
  - Successfully attained accurate STS ascent simulation runs using an open-loop architecture.
  - Achieved stable STS ascent runs with a closed-loop simulation.
  - Supported short duration STS orbit and entry runs.

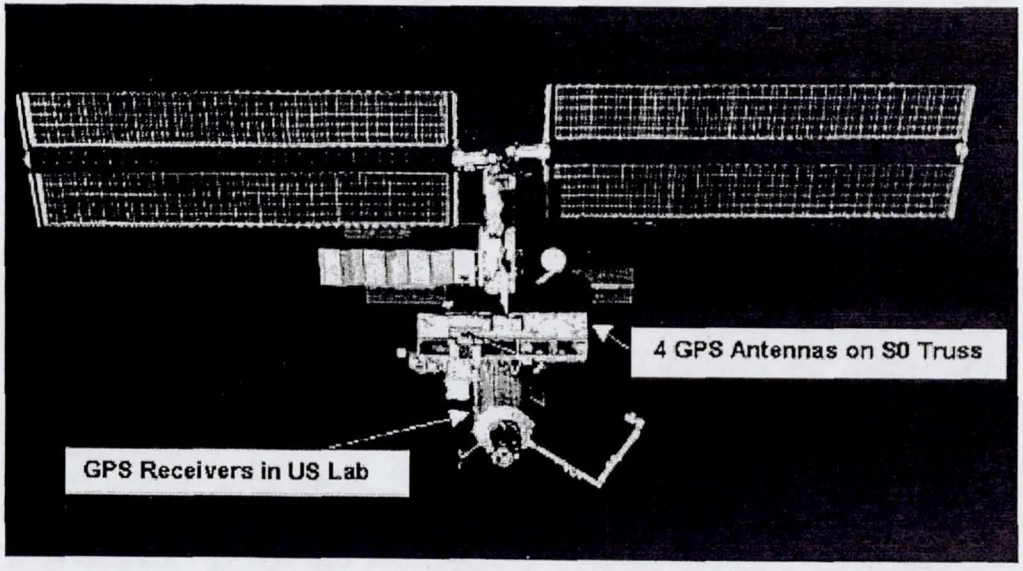


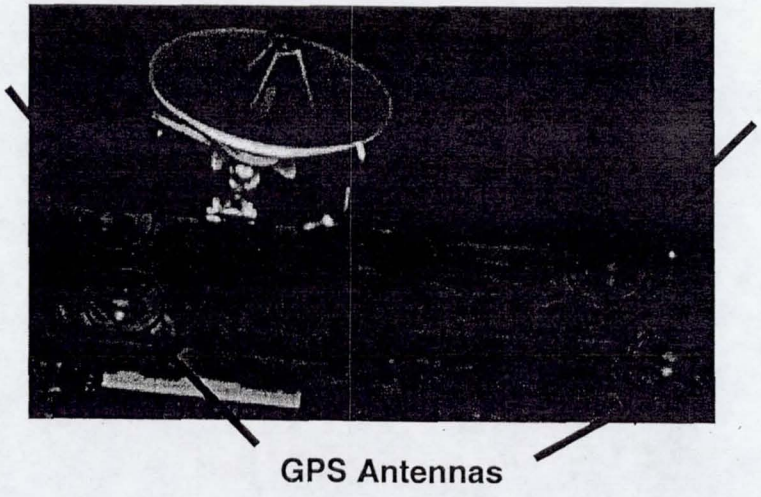
Shuttle SIGI Closed Loop Simulation Setup



Standalone ISS SIGI Testing

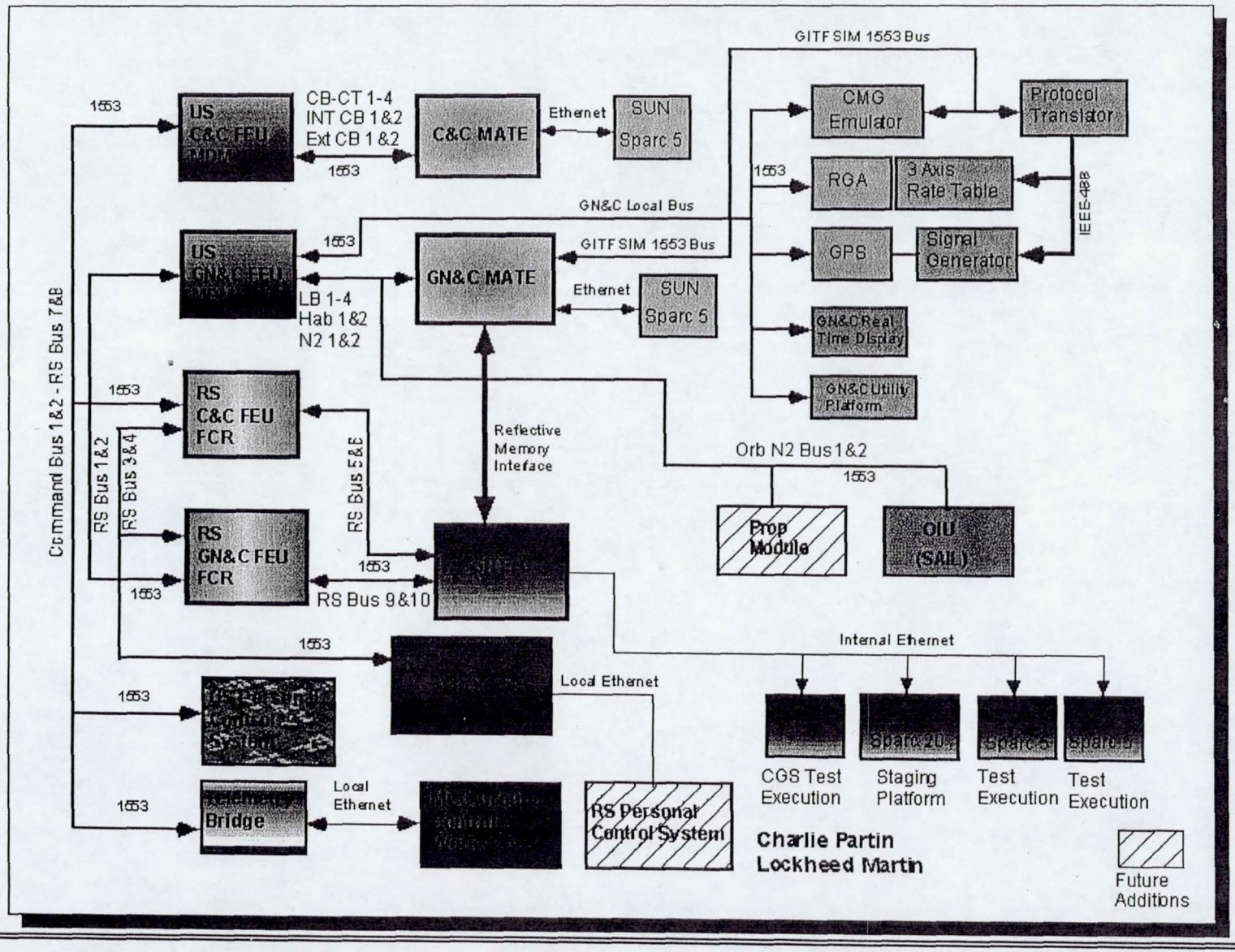
- Honeywell's ISS SIGI includes a Trimble Force 19 GPS (attitude-capable) and a core Honeywell INS, plus system software for blended GPS/INS, but ISS only uses the GPS and attitude processing
- JSC team created set of Spirent/GSS scenarios for ISS orbit
- Some scenarios include ISS rotational dynamics, others are in Local-Vertical-Local-Horizontal (LVLH) Hold or Inertial Hold
- Scenarios run with a detailed model of the ISS GPS 4-antenna array for attitude determination (including multipath)
- Extensive testing of the ISS SIGI with orbital scenarios over the past five years
- Two on-orbit flight experiments in May and September 2000 validated GPS simulator performance
- ISS SIGI went operational in May 2002 (see http://www.spacedaily.com/news/gps-02m.html)



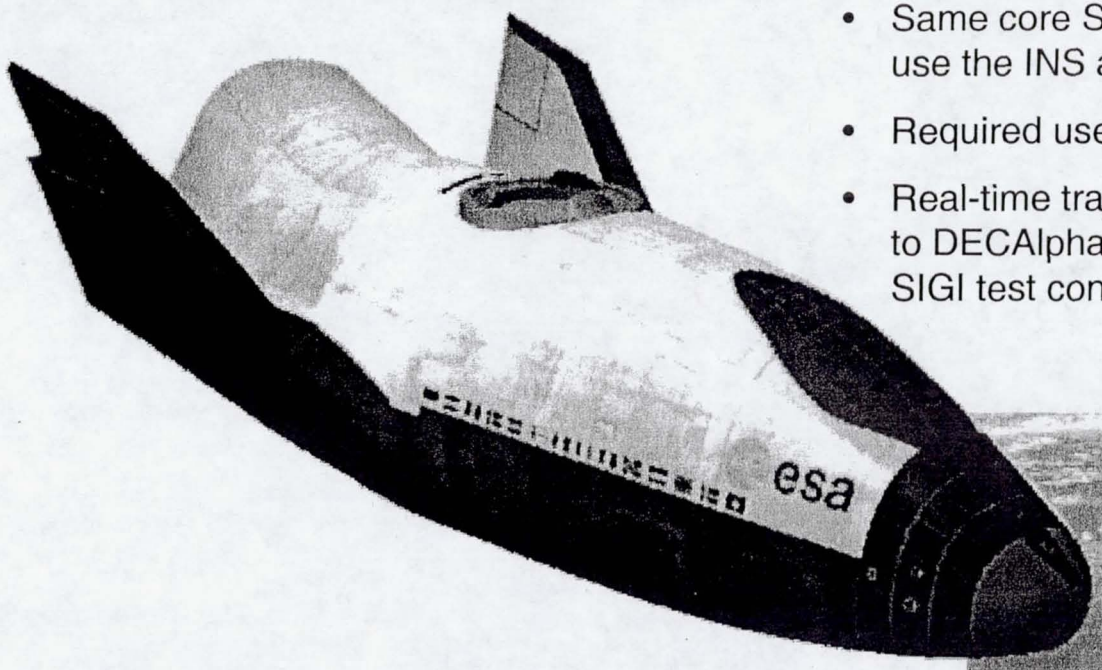

GPS Antennas

ISS GN&C Integration Test Facility

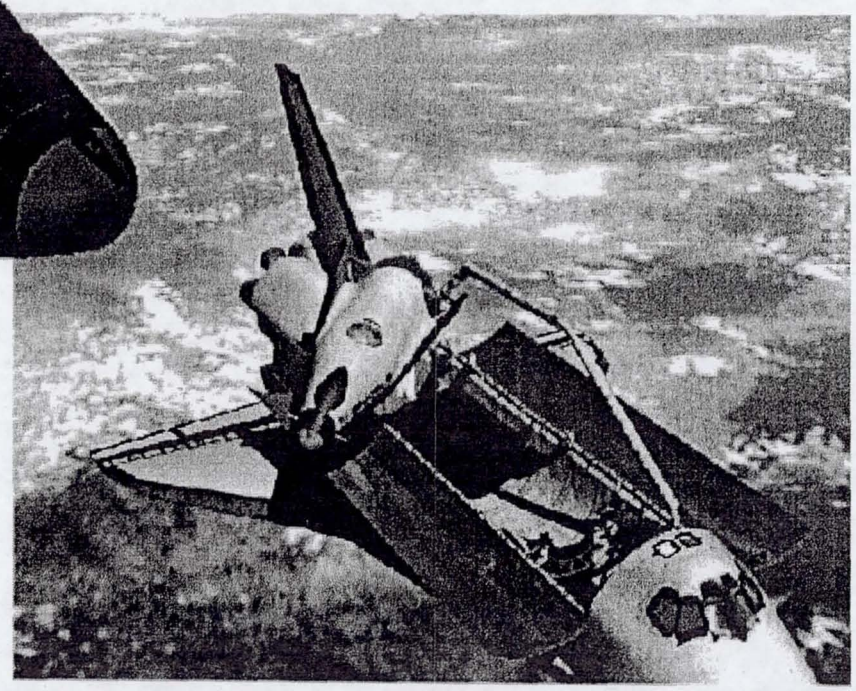
- Closed-loop GN&C testing for the ISS
- US GN&C, Command and Control computers in the loop
- Russian computers were in the loop for some tests
- Also uses 3-axis rate table with ISS Rate Gyros in the loop



CRV SIGI Testing



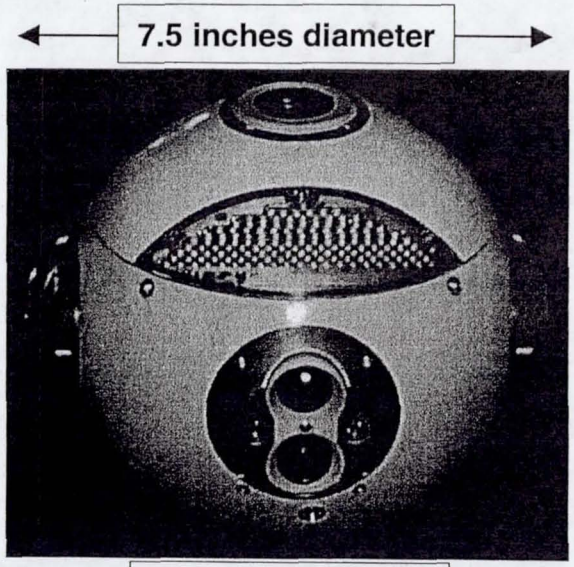
- Same core SIGI as the ISS SIGI but CRV planned to use the INS and Blended navigation solutions as well
- Required use of the ISRS for full GPS/INS inputs
- Real-time trajectories generated in simulation and sent to DECAlpha from remote source, similar to Shuttle SIGI test configuration



- Real-time trajectories also used to generate motion files for standalone testing
- Simulated "blackout" during entry (due to ionization in the atmosphere) by unplugging GPS antennas to simulate loss of GPS
- Two on-orbit flight experiments have validated GPS simulator performance

Mini AERCam Relative Navigation

- Miniature Autonomous Extravehicular Robotic Camera (Mini AERCam) is a small, free-flying camera for remote inspections of the ISS
- Uses precise relative navigation with differential carrier phase GPS to provide situational awareness to operators
- Prototype system is being tested at the Johnson Space Center
- GN&C testbed includes GPS simulator (GSS6560) in the loop



Mini AERCam

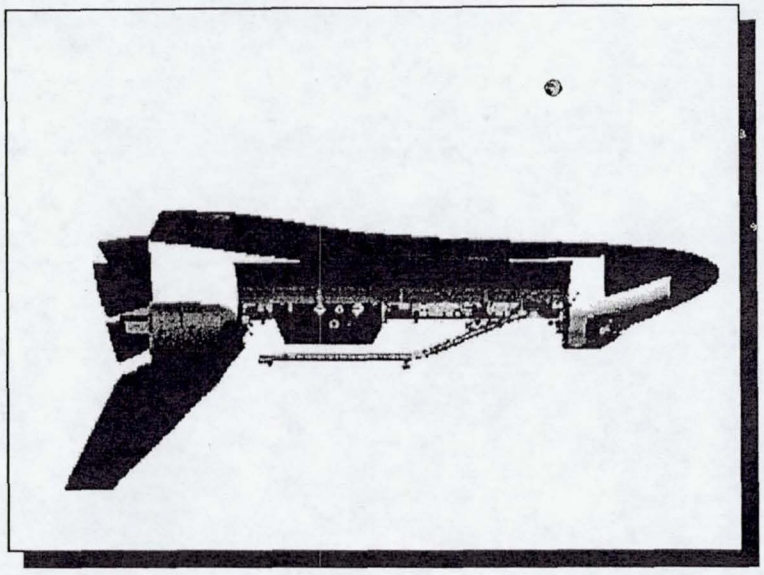
Mini AERCam

Facts

- Sponsor: NASA
- 11lb free-flyer (12-13 lbs with LADAR)
- Mission: Provide extravehicular inspection for human space operations
- Deploy and retrieve from Space Shuttle Payload Bay
- Crew teleoperation and supervised autonomous scanning

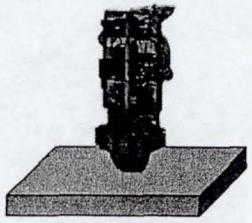
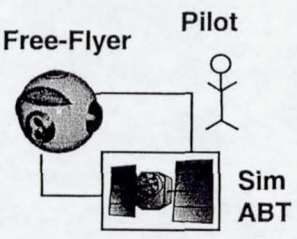
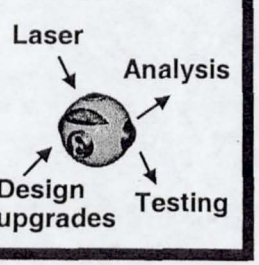
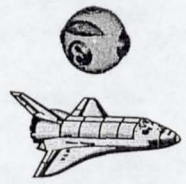
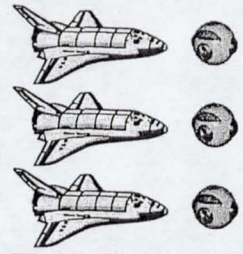
Key Points for Shuttle Inspection

- Mini AERCam has always been designed for visual external inspection of the Shuttle or ISS.
- Any other existing systems would require redesign to make them more like Mini AERCam.

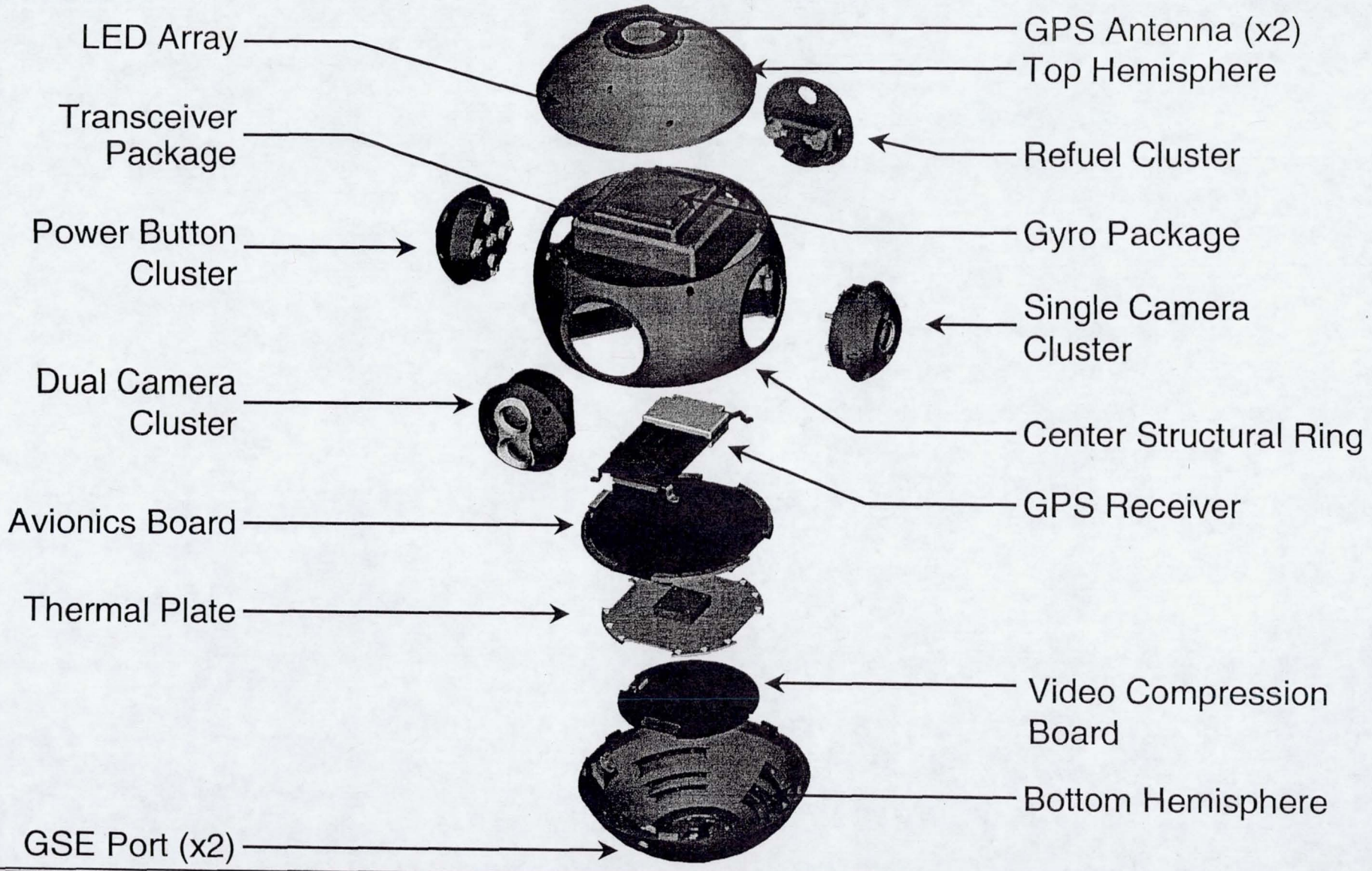


Mini AERCam Path to Flight

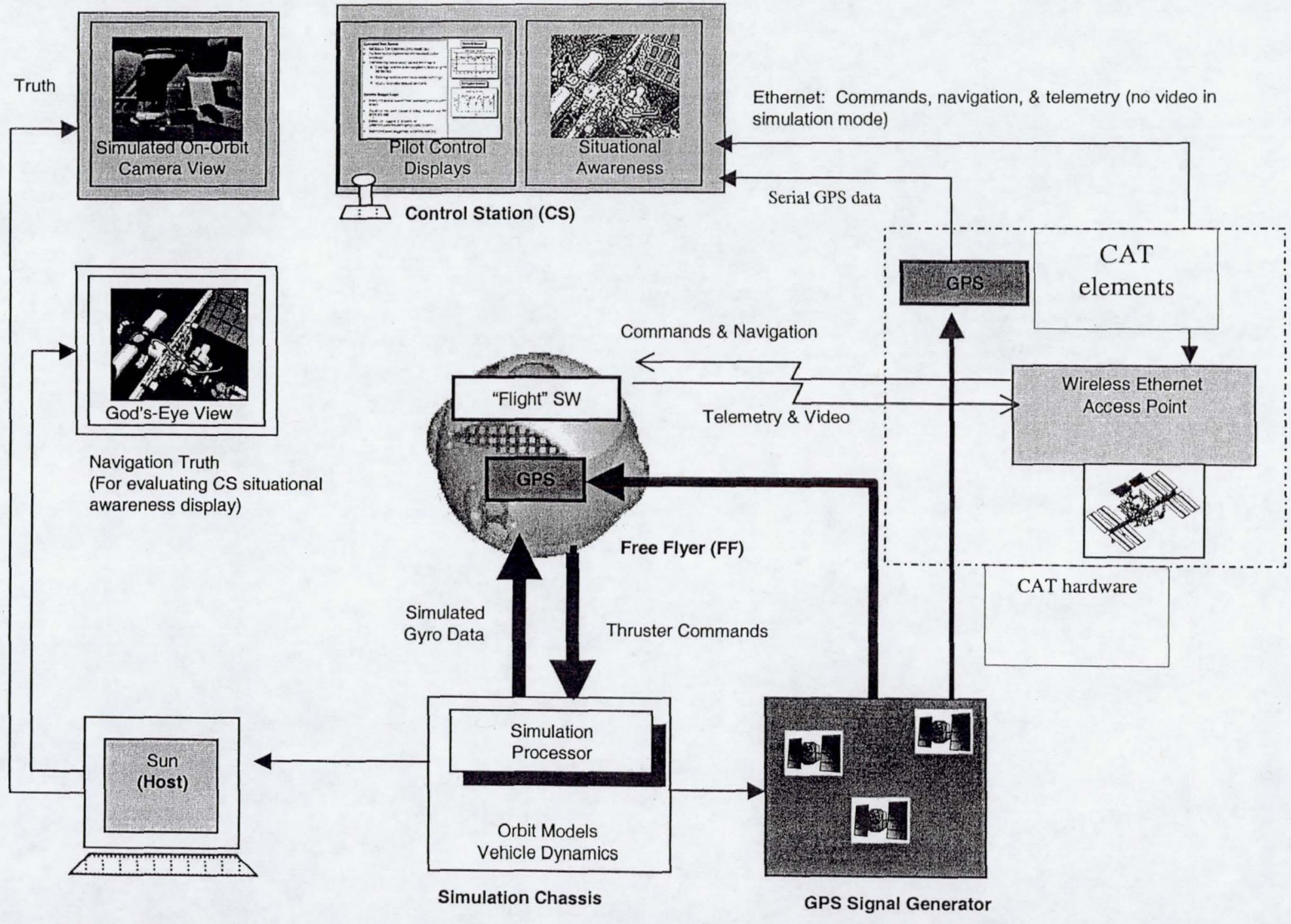
WE ARE HERE

1997	1998	2003	2004	2006	2007
					
AERCam Sprint Flight Test	**AERCam Integrated Ground Demonstration**	**Mini AERCam**	**Phase 1: Enabling Design and Flight System Proposal**	**Phase 2: Flight Test Development**	**Phase 3: Flight Production**
Space flight test vehicle shows feasibility of remotely piloted extravehicular camera	Air-bearing test vehicle has advanced technologies to enhance operational capabilities	Flight-like free-flyer integrated with 6-DOF orbital simulation and air-bearing table. Demonstrates visual inspection with miniaturized hardware in high fidelity test environment.	Enabling design effort for Shuttle inspection provides enhancements to Mini AERCam and allows development of flight system proposal	Build and flight test engineering unit. Rapid flight design implemented based on mature technology demonstrator, with integration of laser depth measurement as planned in phase I	Begin production of flight units if approved by Program after successful DTO

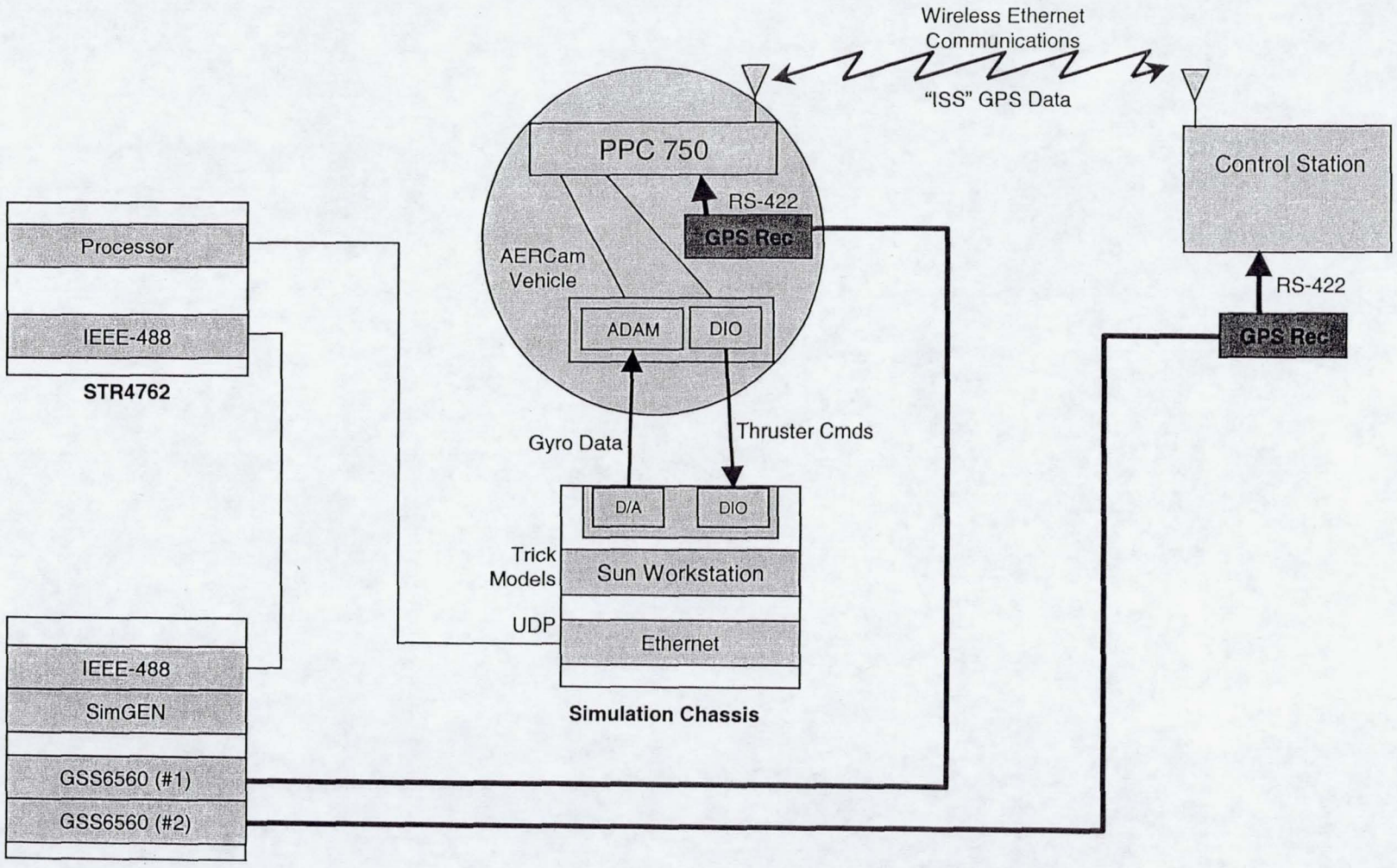
Full Vehicle (Exploded View)



Mini AERCam Closed-Loop Orbital Testing



Closed-Loop Relative Navigation Testing *



* Current setup with dual GSS6560 chassis

Lessons Learned & Future Plans

- Timing between GSS6560, STR4762 and host simulation is paramount.
- SimGEN 1.07 and 2.0 has on occasion logged duplicate data. Indications show this may be the result of stale data into SimGEN from the protocol translator (STR4762).
- Latest simulation environment is dramatically improved over previous runs. Comparison between host simulation and SimGEN shows differences less than 1.0 mm in position and less than 1.0 mm/s in velocity.
- Updating to SimGEN 2.41.
- Acquiring third chassis for three chassis system to support dual RF GPS receiver onboard AERCam.

NASA JSC GPS Simulator Inventory and Applications

STR2760

- 20 channel, 1 RF output (L1/L2)
- Keyed for P(Y) code
- Dedicated to Shuttle GPS testing at the Shuttle Avionics Integration Laboratory (SAIL)

STR2760

- 40 channel system, 4 RF outputs for attitude determination capability
- Integrated with Honeywell Inertial Sensor/Recorder System (ISRS) for generating Honeywell INS test inputs
- Used for ISS Space Integrated GPS/INS and relative navigation applications (e.g., Mini AERCam)

STR4760

- 64 channel system, 4 RF outputs for attitude determination capability
- Used primarily for ISS Space Integrated GPS/INS (SIGI) and closed-loop ISS Guidance, Navigation, and Control (GN&C) testing

STR4762

- Remote PC for sending real-time simulation data to the STR2760, STR4760, or GSS6560

GSS6560 (dual chassis)

- Rack mounted 12-channel (single RF output) GPS simulator
- Primarily used for standalone and integrated testing for Mini AERCam

and specification
- GSS7700 configurations and options

GPS Modernization

- M-code summary
- SimMCODE - implementation and verification
- L2C and L5 simulation and verification

SimGEN for Windows Update

- Current status and features
- Planned additions

CRPA Test

- Current products
- Embedded Jamming

- Technical specifications
- Configurations

New Product: GSS4730

Customer Papers on a Varie
Interesting Applications

Workshop Activity

» **Register**

Special Secure Session
A separate Secure session will be held on 31 March 2004 hosted by the Naval Res (NRL) in Washington DC and on 5 April at Spirent Federal's Yorba Linda office. U.S clearance is required to attend. **Please note: The Secure Sessions are supplei General Sessions; you can not register for the Secure Session only.**

Topics at the Secure Session include: Simulator Handling & Classification, AIS Plar Considerations, GPS JPO Simulator Requirements, SAAS/SAASM Hardware & Softv Status, SAASM Test Plans, and Modernization Issues & Considerations. There will a opportunity to ask classification and SAASM testing type questions.

» **Register for the 2004 Spirent Federal Systems Simulator Users' Confere**

Spirent Federal Systems, Inc., the supplier of Spirent Communications' GPS (Global Positioning Systems) satellite navigation and network test systems, including the STR4760 and GSS4765. Spirent Federal provides best-of-breed solutions for military and secure test applications.

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