

FOUR GENERATIONS OF SATELLITE GROUND SYSTEM PROTOTYPES

Ground System Architectures Workshop 97

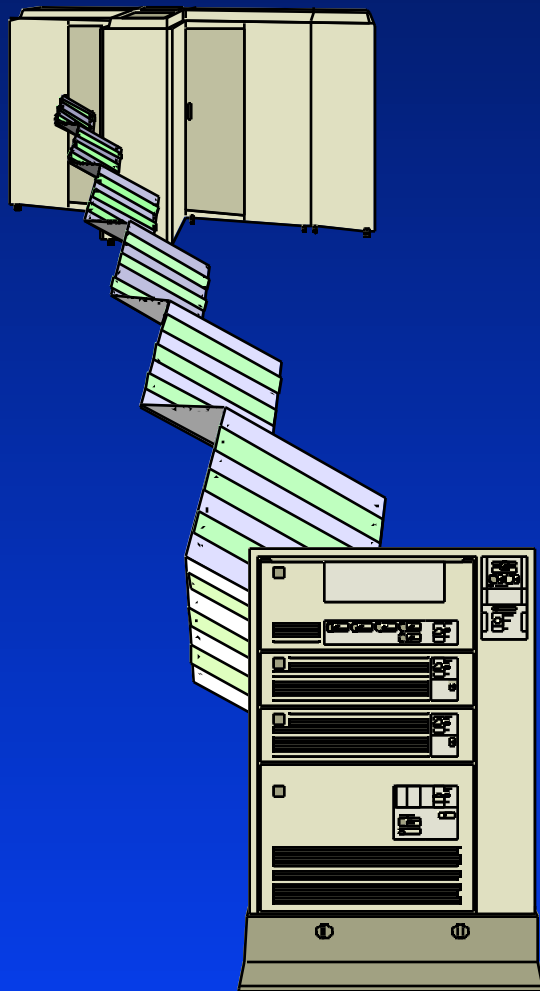
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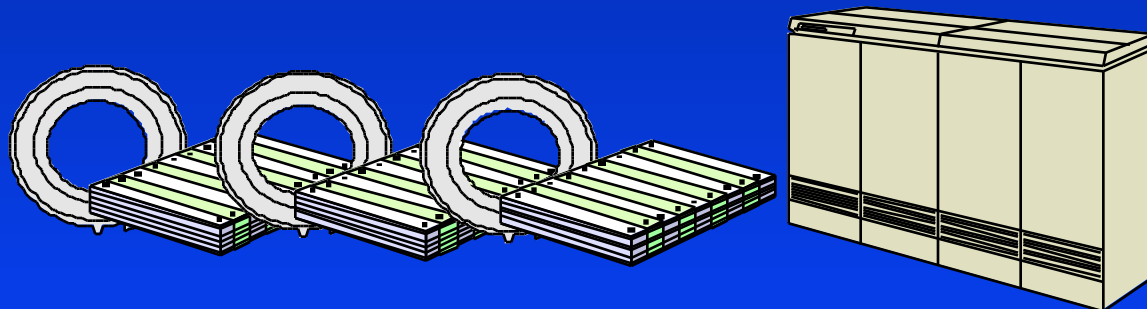
Agenda

- In the Age of Mainframes
- 1993: CSC Integrated Ground Support System
- 1994: Eagle Testbed
- 1995: Integrated Monitoring, Analysis, and Control COTS System
- 1996: Bench, I&T, and Operational System
- Principles of COTS Integration
- Future Directions

In the Age of Mainframes



- Physically separate institutional functions
- Data often transmitted on tapes and paper
- Batch processing
- Complex interfaces
 - between systems
 - between organizations
- Millions of lines of legacy software
 - expensive to maintain
 - custom developed, mission by mission





Time for an Inspiration:

The Early Nineties

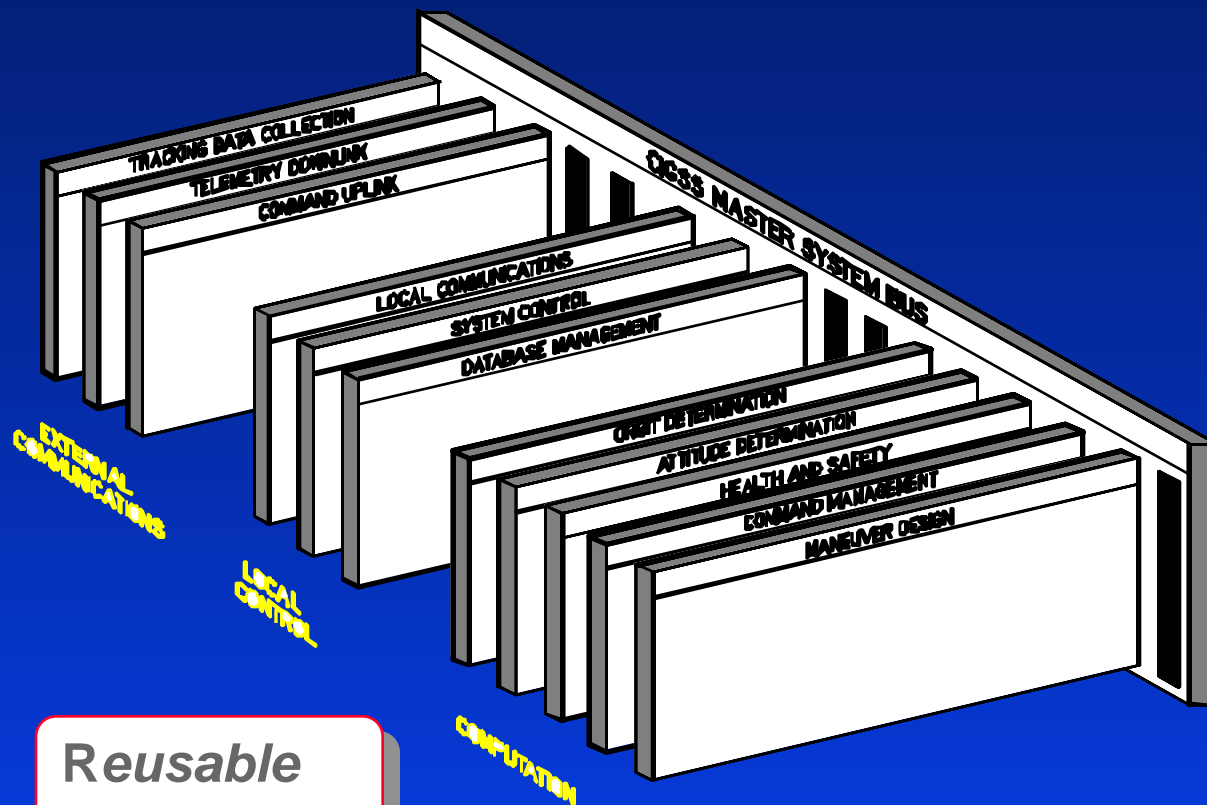
- **New technologies were widely available:**
 - distributed systems of workstations
 - interactive graphical software
 - AI software
- **Cost decreasing, capability increasing**
- **Commercial space was starting to grow**

MANY GROUPS RECOGNIZED THIS POTENTIAL AND SET OUT TO REVOLUTIONIZE SATELLITE GROUND SYSTEMS

1993: *CSC Integrated Ground Support System (CIGSS)*

- Objectives
 - exploit legacy tools developed for NASA, NOAA, and DoD
 - host on RISC-based workstations under UNIX
 - explore techniques and costs of integrating disparate tools
 - explore commercialization possibilities
- CSC internal project
- Prototypes developed in late 1992 and demonstrated throughout 1993
- Utilized data from GSFC's SAMPEX

1993: *CSC Integrated Ground Support System (CIGSS)*



**Reusable
Application
Modules**

FUNCTIONS:

- Telemetry and command (TPOCC)
- Orbit propagation (ODEAS)
- Command Management (CMS)
- Attitude Determination (MTASS)
- Scheduling (UPS, MOPSS)

1993: *CSC Integrated Ground Support System (CIGSS)*

CONCLUSIONS:

- Low cost, rapid rehost and integration were feasible
- Needed to address tracking data stream for orbit determination
- Many similar prototypes were being developed by government agencies and other companies
- Limited commercial prospects for CIGSS
- Numerous applicable COTS tools were available and unfamiliar to us

1994: *Eagle Testbed*

- Objectives
 - explore and evaluate COTS tools
 - explore techniques and costs of integrating disparate tools: COTS tools with each other, COTS tools with legacy tools
 - enhance rapid prototyping process
 - apply to business development
- CSC internal project
- Prototypes developed and demonstrated throughout 1994
- Utilized data from GSFC's SAMPEX

1994: *Eagle Testbed*

TOOLS

- Satellite Tool Kit
- Altair MCS
- RTworks
- Probe
- PVWave
- Microcosm
- OS Comet

CAPABILITIES

- Telemetry processing
- Command
- Command management
- Orbit determination
- Attitude determination
- Scheduling
- Trending and engineering analysis

1994: *Eagle Testbed*

CONCLUSIONS:

- COTS tools provide most functionality needed for satellite ground support
- Scheduling is the principal shortfall
- Tools not designed for satellite support have many applications
- Disparate tools can be integrated
 - loose integration is fastest, limits data rates
 - avoid glueware (3GL code)
 - construct the HCI to deal with duplicate functionality
- ***Controlling a real satellite is essential for credibility***

1995: *Integrated Monitoring, Analysis, and Control COTS System (IMACCS)*

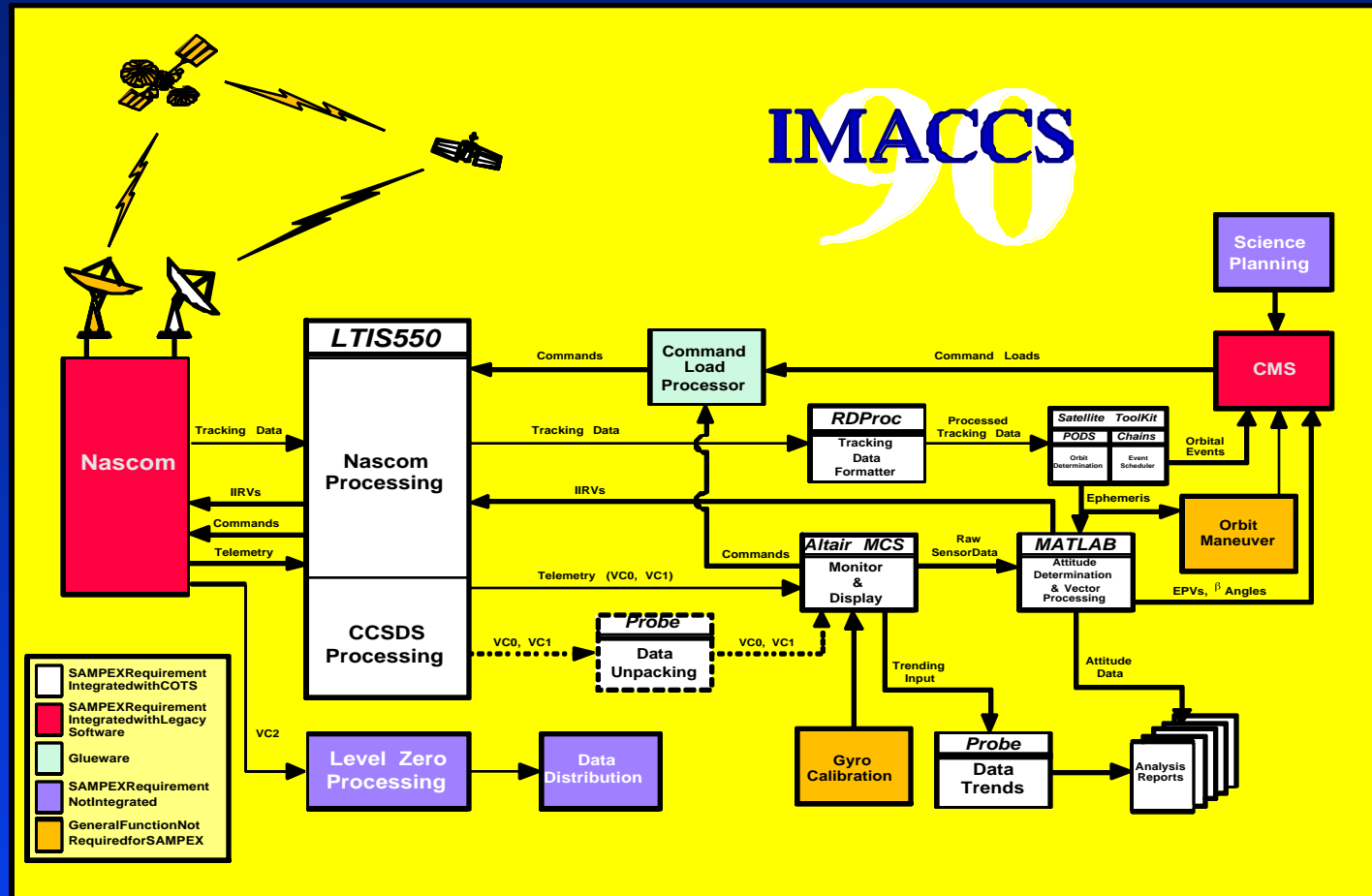
- Approached GSFC in February 1995
 - proposed a parallel ground system for SAMPEX
 - proposed to complete project in 90 days
- Proposal accepted and project completed in 90 days
 - prototype met 85 percent of SAMPEX requirements
 - 5000 SLOC of (3GL) glueware
 - successfully commanded vehicle
- Extended in February 1996
 - direct antenna and RF connection
 - automation and autonomy features added

1995: *Integrated Monitoring, Analysis, and Control COTS System (IMACCS)*

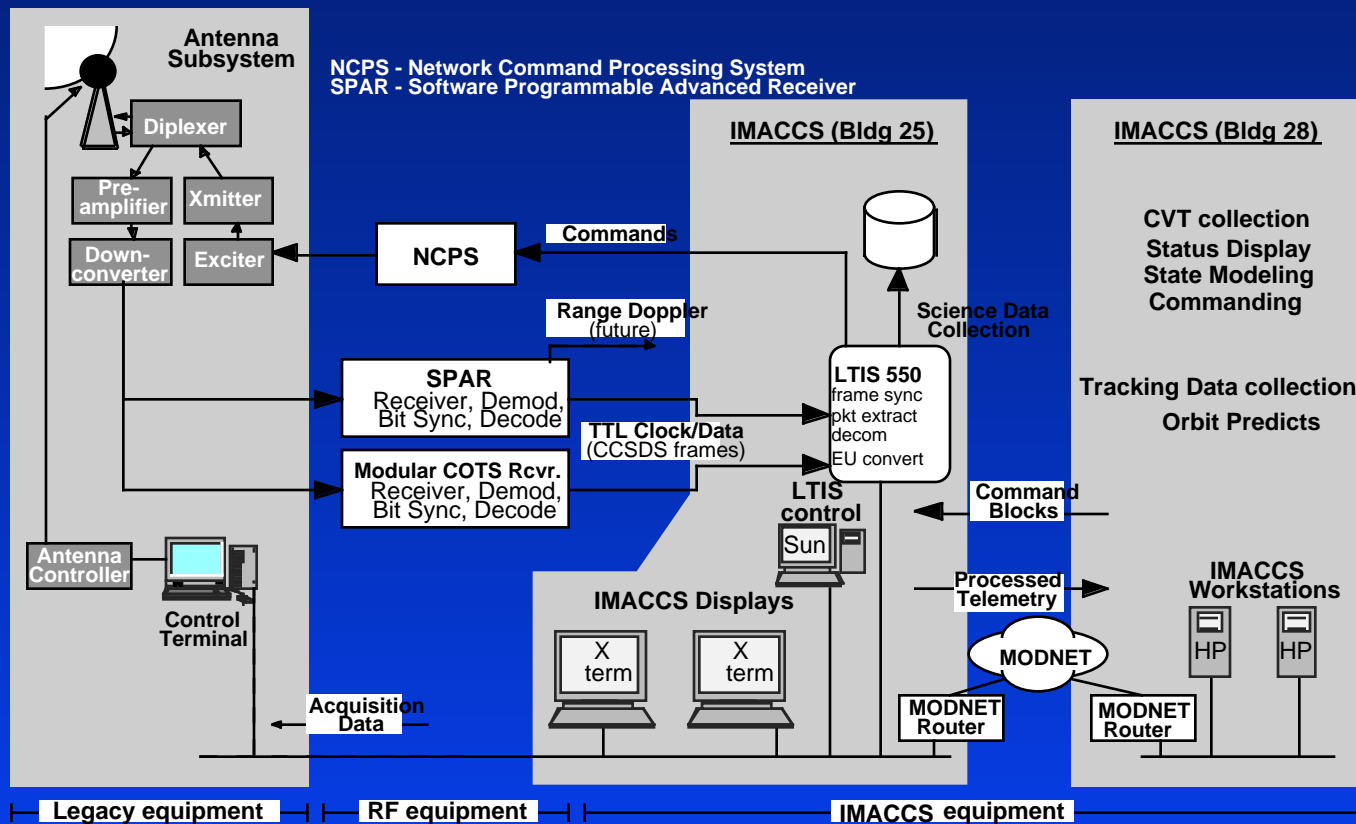
IMACCS Functionality

- Read NASCOM blocks
- Export commands and acquisition data
- Produce health and safety displays
- Generate commands
- Monitor selected telemetry items
- Analyze data trends
- Determine attitude
- Determine orbit
- Produce acquisition data
- Predict orbital events
- Execute automated pass monitoring

1995: Integrated Monitoring, Analysis, and Control COTS System (IMACCS)



1995: *Integrated Monitoring, Analysis, and Control COTS System (IMACCS)*



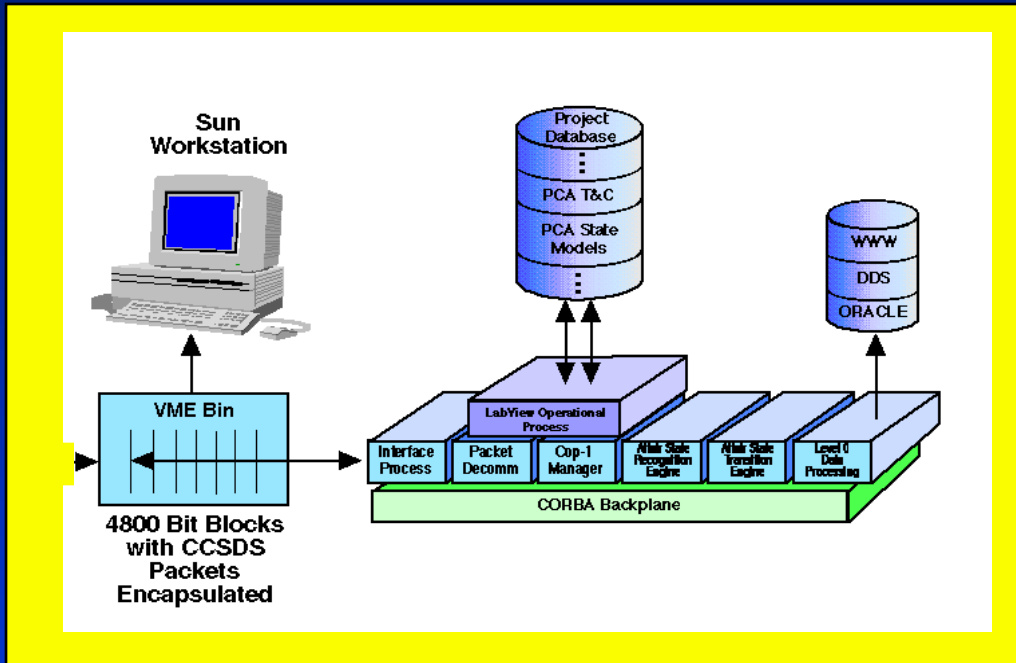
1995: *Integrated Monitoring, Analysis, and Control COTS System (IMACCS)*

- Confirmed that COTS-based ground systems are feasible for scientific satellites
- Used now as a testbed for automation and autonomy experiments
- Set the local standard (90 days) for rapid development
 - integrated product teams
 - new management approached
- Technology base for re-engineering of ISTP missions
 - five satellites, 3 operated at GSFC
 - goal: reduce current operations costs by 70 percent
 - deadline: 1 October 1997

1996: *Bench, Integration, and Operational System (BIOS)*

- Capture spacecraft data structures at all development stages
 - input and output words at the component level
 - collect these words into telemetry and command
 - flexibility for I&T
 - safety and automation for on-orbit operations
- Exploit new COTS tools
 - CORBA (Orbix product)
 - LabView (Windows 3.11, Windows NT, Unix)
- Add functionality omitted from IMACCS
 - LZP and data distribution
 - command management

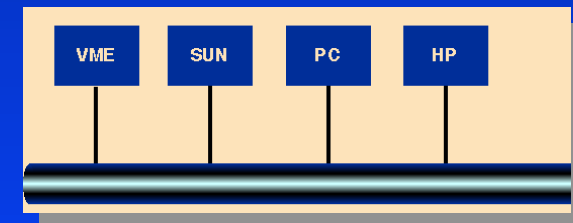
1996: *Bench, Integration, and Operational System (BIOS)*



BIOS processes communicate through CORBA backplane

Heterogeneous Platforms:

- PCs (NT & Windows 3.1)
- Unix workstations
- Macs



1996: *Bench, Integration, and Operational System (BIOS)*

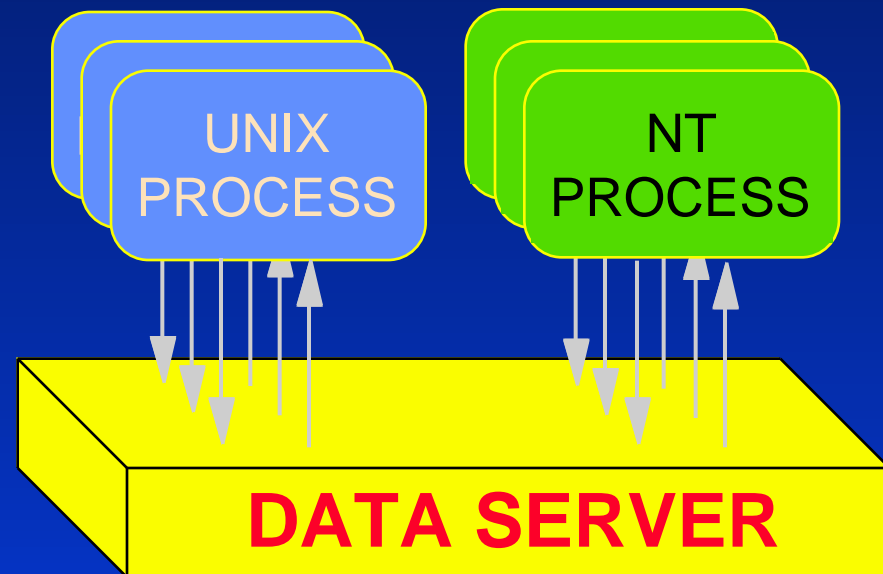
- Basic prototype complete
 - utilizes XTE PCA interface for bench hardware
 - XTE commands and telemetry
- Various data serving approaches being tested under CORBA
 - packet server
 - point server
- BIOS demonstrates a process as well as a prototype

Principles of COTS Integration

- Close vendor relationships are vital
- *Loose integration* is our principal approach for current tools
- Cost and schedule benefits are significant only when the tools are 4GL or higher
- Operationally experienced engineers are essential for taking maximum advantage of this technology

Principles of COTS Integration

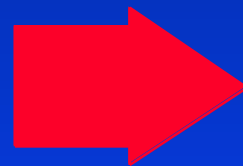
- Passes data among processes in system
- Provides network transparency
 - processes can be on any network node
 - ideally permits multiple operating systems
- Commercially available
 - RTserver
 - OS/Comet



A DATA SERVER IS THE COMMON ELEMENT OF AN INTEGRATED GROUND SYSTEM ARCHITECTURE

Principles of COTS Integration

- Second generation architecture
- Foundation for prototypes
- Object neutral
 - allows for non-OO COTS and NDI tools
 - allows evolution to full OO system
- Three tier generalized architecture
- Data server



Global Services (WAN)	<ul style="list-style-type: none">• <i>system management service interface</i>• <i>management protocols</i>• <i>support utilities</i>• <i>network enabled applications</i>
Local Area Services (LAN)	<ul style="list-style-type: none">• <i>system management group domains</i>• <i>system management physical domains</i>• <i>application domains</i>
Platform Services	<ul style="list-style-type: none">• <i>system management agents</i>• <i>management interface</i>• <i>platform utilities</i>• <i>dependent applications</i>

Future Directions

- Focus on scheduling
- Alter view of spacecraft
 - spacecraft is a LAN (middle tier of architecture)
 - components are devices with standard industrial interfaces (SuperMOCA concept)
 - requires more sophisticated onboard processing
- Spacecraft LAN cell is part of total system WAN (top tier of architecture)
 - space-ground link requires attention because of SOL lag and bandwidth limitations
 - security of link is a concern