



7th International Symposium Reducing the Costs  
of Spacecraft Ground Systems and Operations  
(RCSGSO)

11 - 15 June 2007

Moscow, Russia

# Reducing Development and Operations Costs Using NASA's "GMSEC" Systems Architecture

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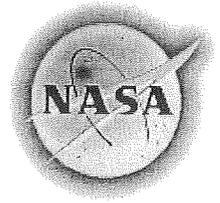
John Bristow

Patrick Crouse

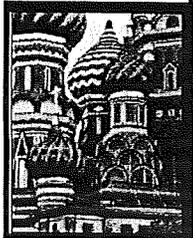
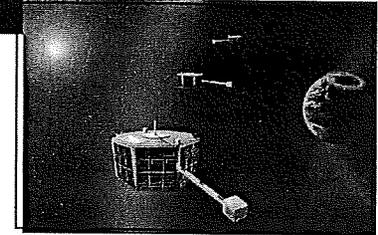
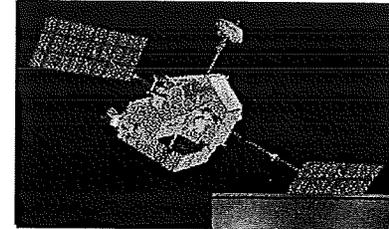
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# NASA/GSFC Mission Background



- NASA/GSFC manages about 30 spacecraft
  - 1/2 at the NASA campus near Washington, DC
  - 1/2 at Universities around the United States
- Typical characteristics . . .
  - Scientific missions in low-earth orbit, a few in deep space
  - Each mission has its own control center and ops team
  - Mission durations of 6 months to 20+ years
- Primary issues
  - Cost of development, ops and maintenance
  - Slow advancement of new capabilities and technologies
  - Little use of commercial software (COTS)



# GMSEC Architecture Approach (Goddard Mission Services Evolution Center)



## ■ Goals

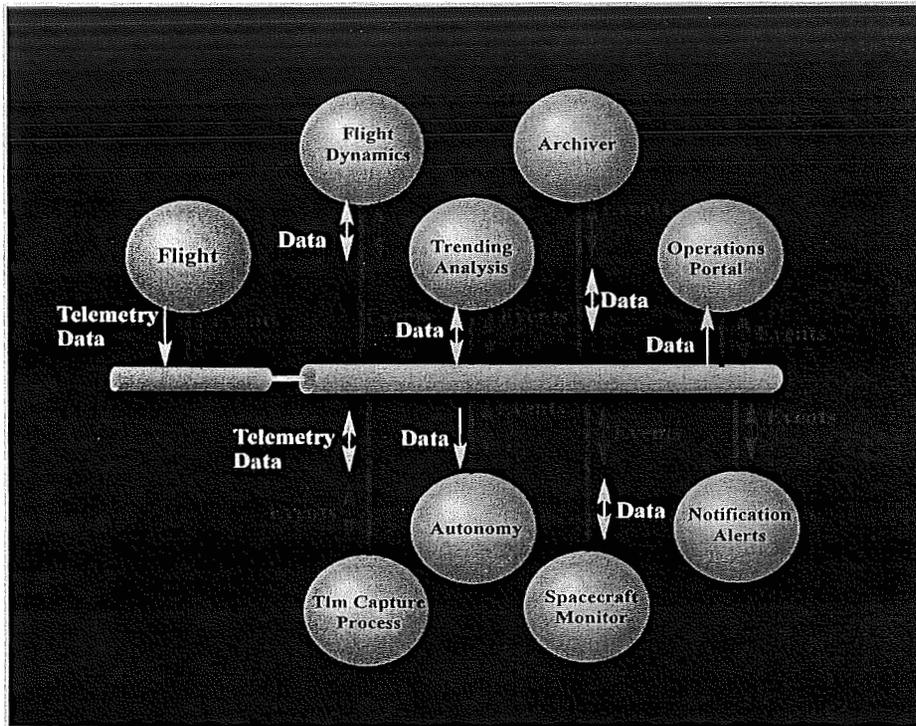
-  Simplify integration and development
-  Facilitate technology infusion over time
-  Support evolving operational concepts
-  Allow for mix of heritage, COTS and new components

## ■ Concepts

-  Standardize interfaces – not components
-  Provide a middleware infrastructure
-  Allow users to choose their products (no single answer)
-  Create a general purpose approach with broad applicability



# GMSEC Publish/Subscribe Communications

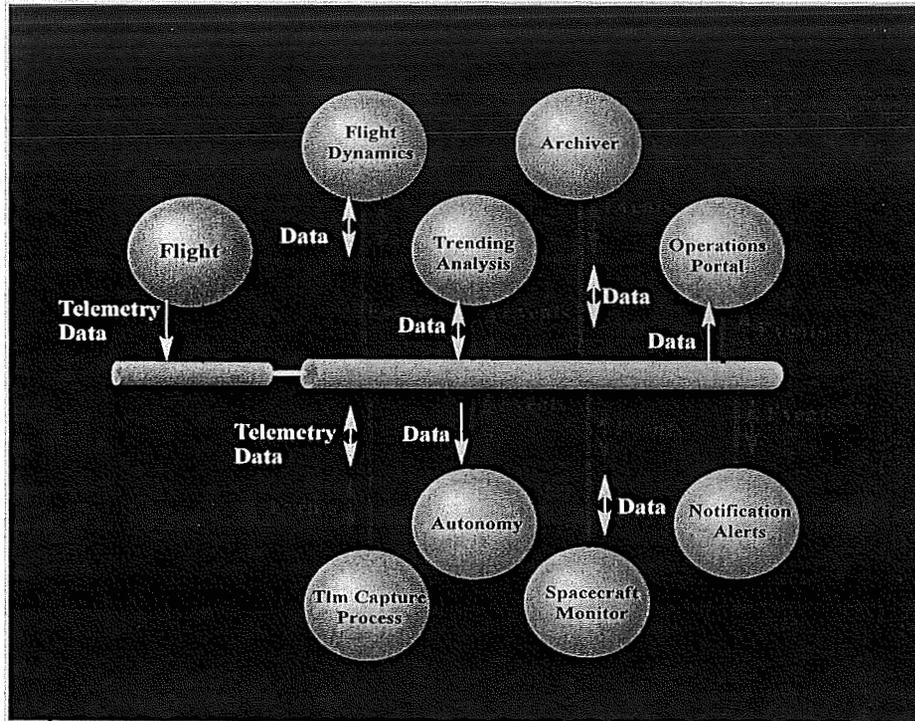


Middleware simplifies integration by having components interface to a bus and not to each other.

- Applications “publish” their data onto the bus
- Other applications “subscribe” to the types of data they are interested in
- The message bus (middleware) routes the data to the requested applications



# GMSEC Publish/Subscribe Communications

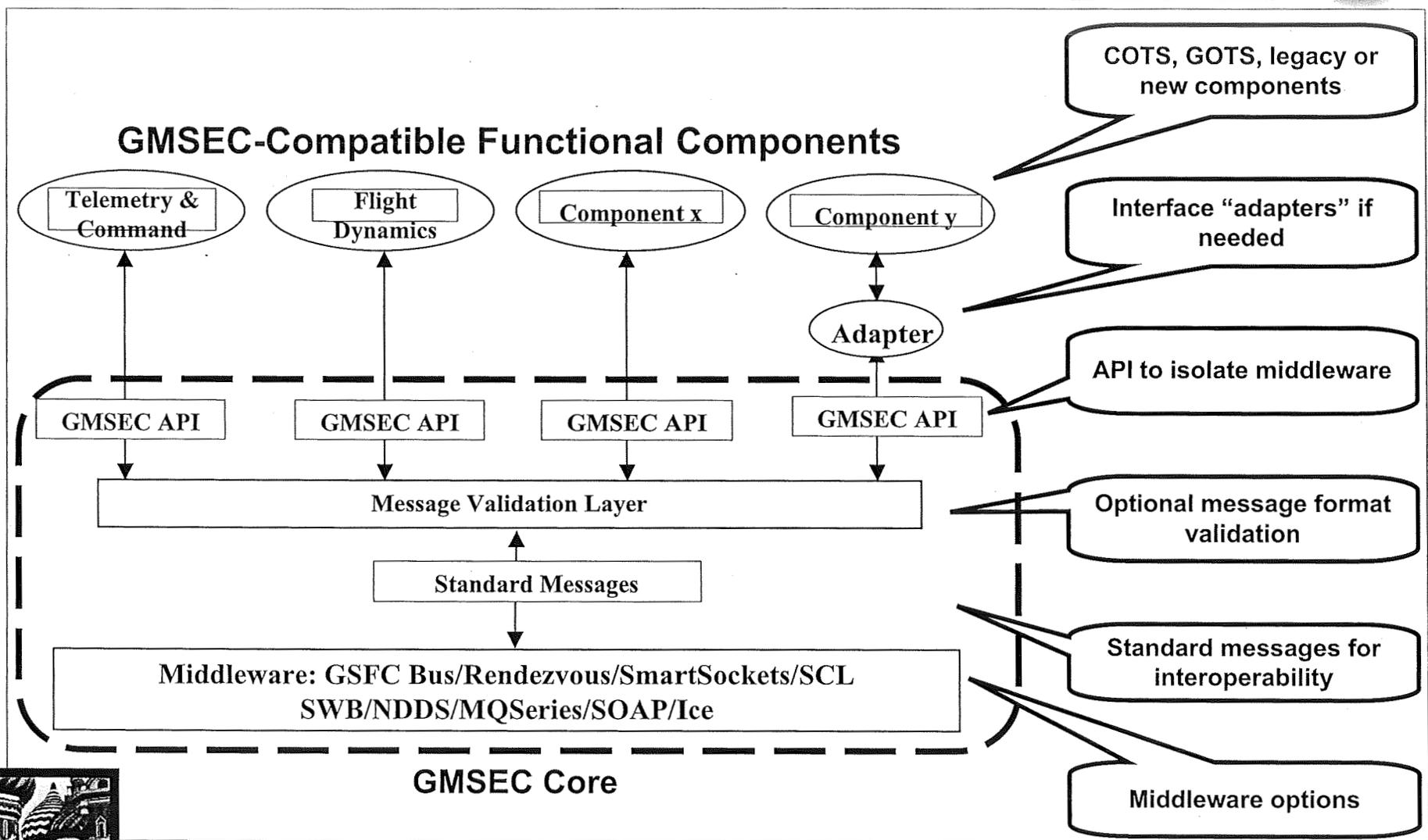


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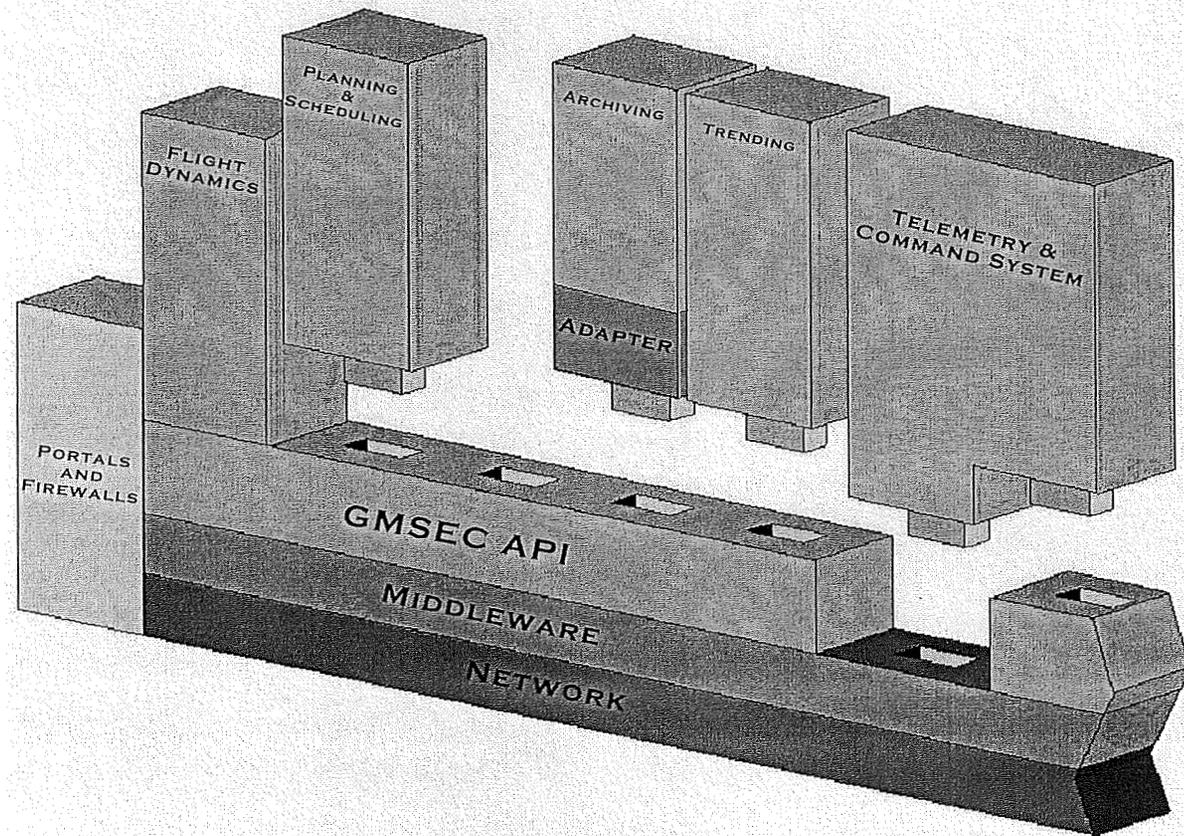
# GMSEC Facilitates Plug-and-Play



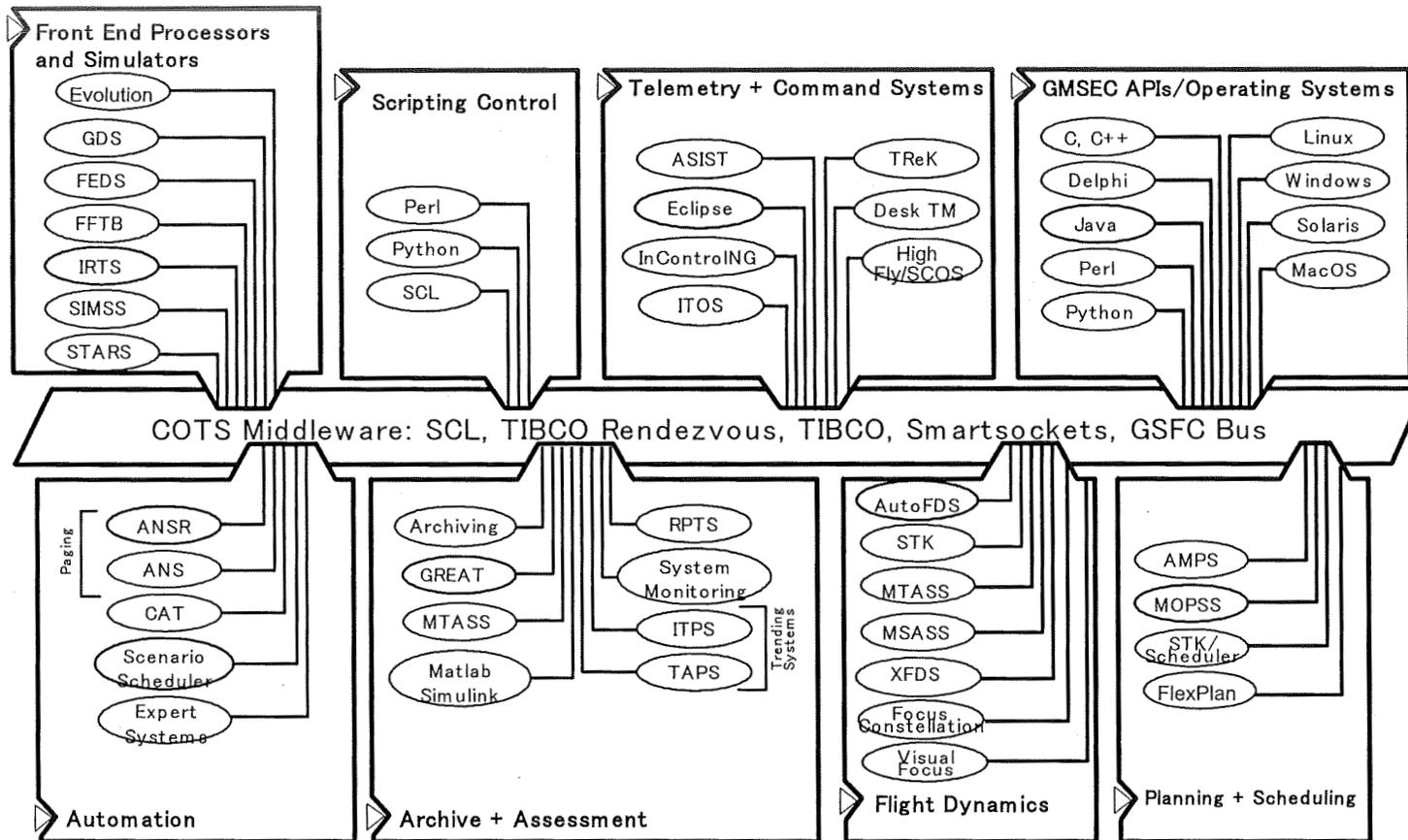
# GMSEC Plug-and-Play Concept



By creating a “framework”, individual applications can be easily integrated into an existing system.



# GMSEC Component Catalog



*Choices are available for many subsystems. The TRMM mission selected catalog components to best meet their reengineering needs. [component names not important]*



# GMSEC System Technical Status



- Began in 2001
- Over 50 components available
- Mature Application Programming Interface (API)
  - Multiple middleware choices
  - Multiple operating systems
  - Multiple programming languages

Components	Telemetry & Command		Automation	Flight Dynamics	
	Planning	Monitoring	Archive & Assessment		Simulators
GMSEC Messages	Telemetry Frame		Log	Directive Request	Directive Reply
	Scheduling	Mnemonic Value		Comp. to Comp. Transfer	
GMSEC API	GMSEC Applications Programming Interface C, C++, Java, Perl, Python, Delphi				
Middleware	Rendezvous	TIBCO SmartSockets	GSFC Bus	ICE	SCL SWB
Operating Systems	Windows	Linux	Solaris	Mac OS X	

## ■ Architecture, API and GSFC Bus

OPEN SOURCE since April 2006

- Automated test package - 24,000+ combinations of middleware, languages, platforms, operating systems



# Automation Concepts



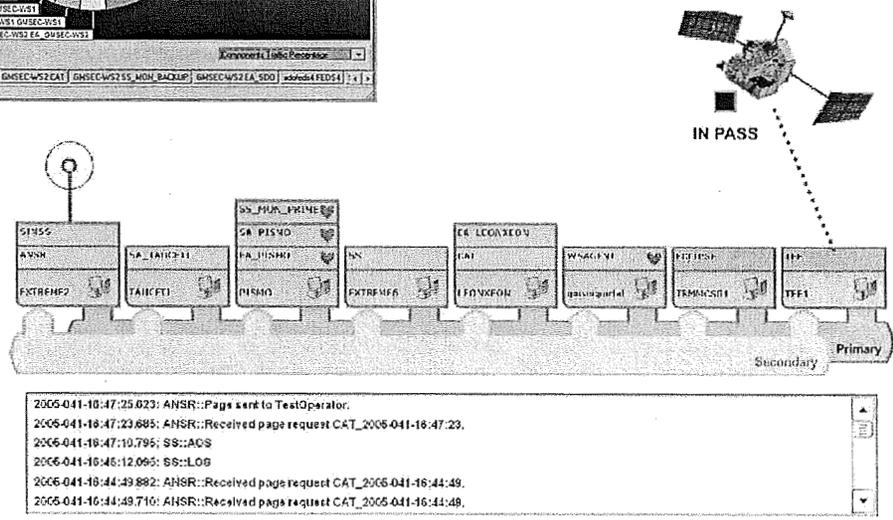
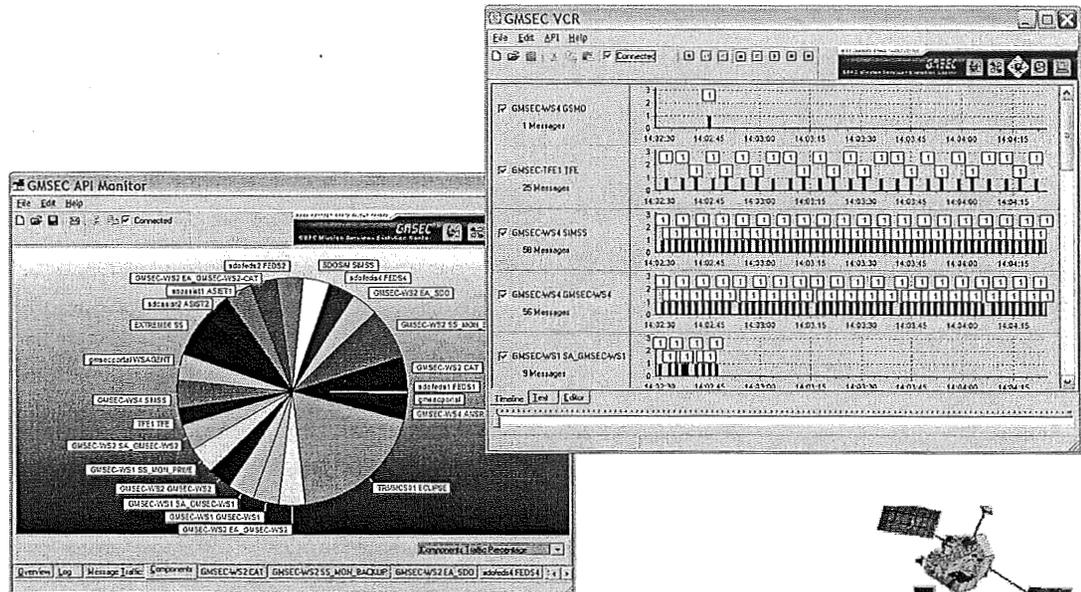
- 3 Each component publishes status messages and accepts control directives
- 3 Common Tools Cross Domain Boundaries
  - 3 Tools can “listen” for status from all components
    - 3 Provides system-wide situational awareness
  - 3 Single tools can direct actions of any number of components
    - 3 Provides system-wide control ability
  - 3 “Criteria-Action Tool” provides ability to define situational awareness rules and corresponding actions
    - 3 Allows for event-driven automation
- 3 **Observation: As users begin to automate, they realize there is even more they can have the system and tools do for them**



# Tool Development is Simplified



- Support tools are easy to develop
- May not require any integration with other components
- Simply monitor messages on the bus
- Examples
  - Performance tool
  - Message replay
  - Configuration display

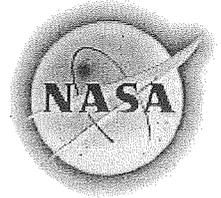


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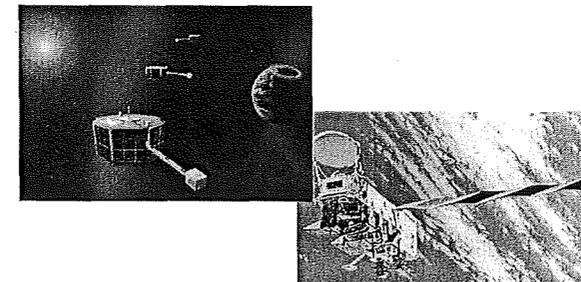
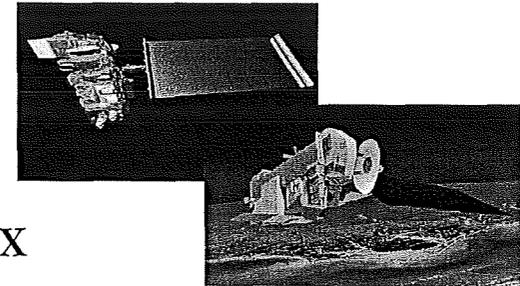
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# GMSEC Operational Status



- First 3 missions each selected a different telemetry and command system
- **Tropical Rainforest Measuring Mission (TRMM)**
  - Automation reduced operations cost by 50%
  - Pathfinder for other Earth Science missions
- **Small Explorer (SMEX) missions – SWAS, TRACE, SAMPEX**
  - Conducted a successful 2-week lights-out operation
  - Pathfinder for low-cost fleet operations & updating existing space science missions
- **ST5 3-Satellite Constellation System - Launched March 2006. 90 day operational period**
  - Demonstrated with subsystem modeling and closed-loop automation
  - Successful 2-week “lights out” operations
- NASA Marshall Space Flight Center using GMSEC operationally for Space Station attached experiments
- **New GSFC missions**
  - Working with 6 future missions



# Lessons Learned / GMSEC Benefits

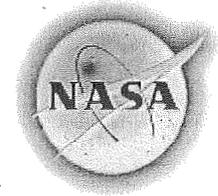
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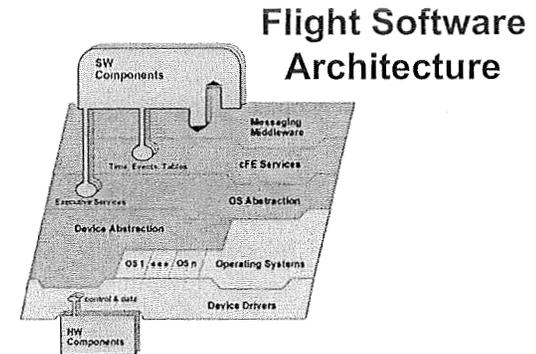
-  Significant reduction in integration time
-  Components added/upgraded without impacting existing system
-  Ideal for using multiple small distributed development teams
-  Allows for new ideas for independent tools and capabilities
-  Missions more willing to adopt the approach if “old favorite” components can still be used
-  Some vendors see message compliance as a way to enter what had appeared to be a closed marketplace
-  Standard message approach provides collaboration possibilities with other organizations
-  The same concepts can apply to ground, flight, or other domains



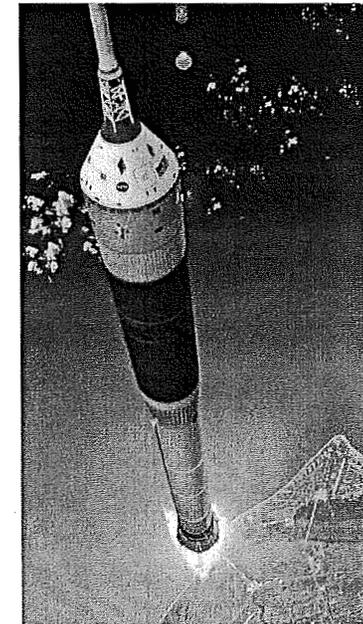
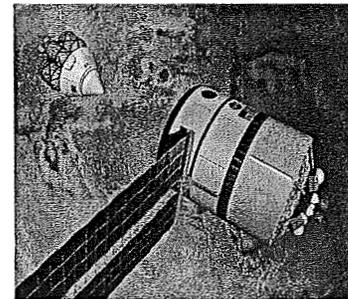
# Future Directions



- Similar approach now being applied to flight software
- GMSEC being used for flight dynamics facility re-engineering
- Concepts being adopted for NASA's Exploration Initiative
- GMSEC Progress Continues
  - Situational awareness
  - Security
  - Automation/autonomy
  - Data mining
  - Network/system performance tools



## NASA's Exploration Initiative



# Conclusions



- GMSEC's message-bus component-based framework architecture is well proven and provides significant benefits over traditional flight and ground data system designs.
- Missions benefit through increased set of product options, enhanced automation, lower cost and new mission-enabling operations concept options.

