10th Anniversary GSAW 06 1997 to 2006 Ground System Architectures Workshop

Manhattan Beach, California March 28-30, 2006

# Tool Development for Distributed System Architectures

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## Purpose

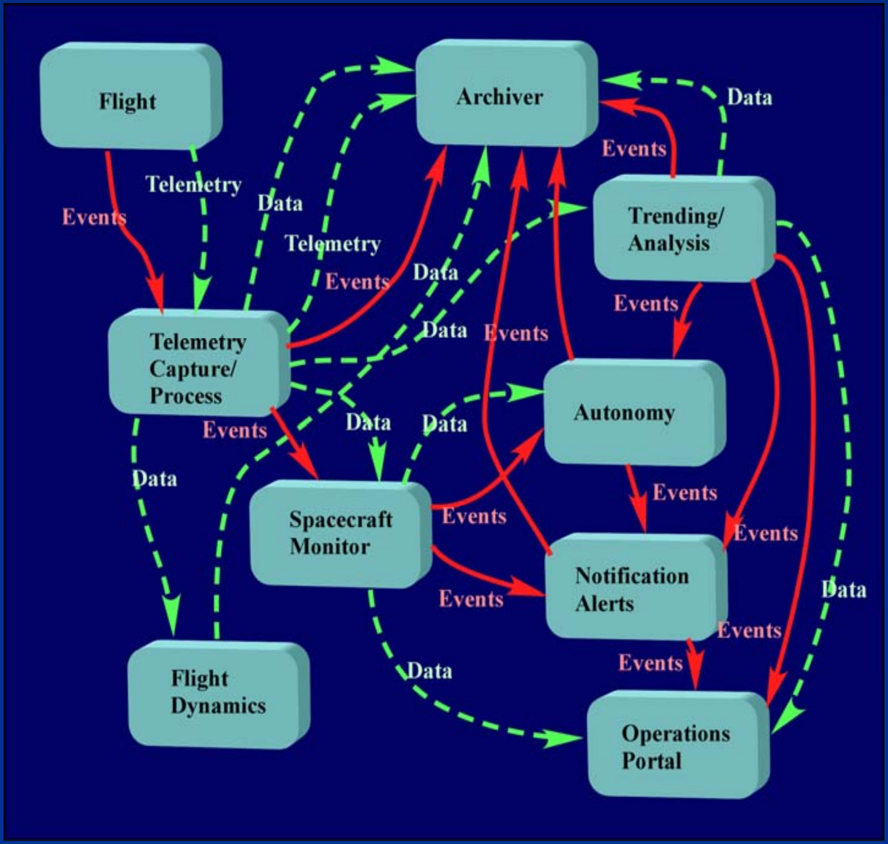
- To show how a message bus architecture facilitates growth and change, and enables opportunities for rapid application development
- To show tools developed at NASA Goddard Space Flight Center for the Goddard Mission Services Evolution Center (GMSEC) architecture

## What is GMSEC

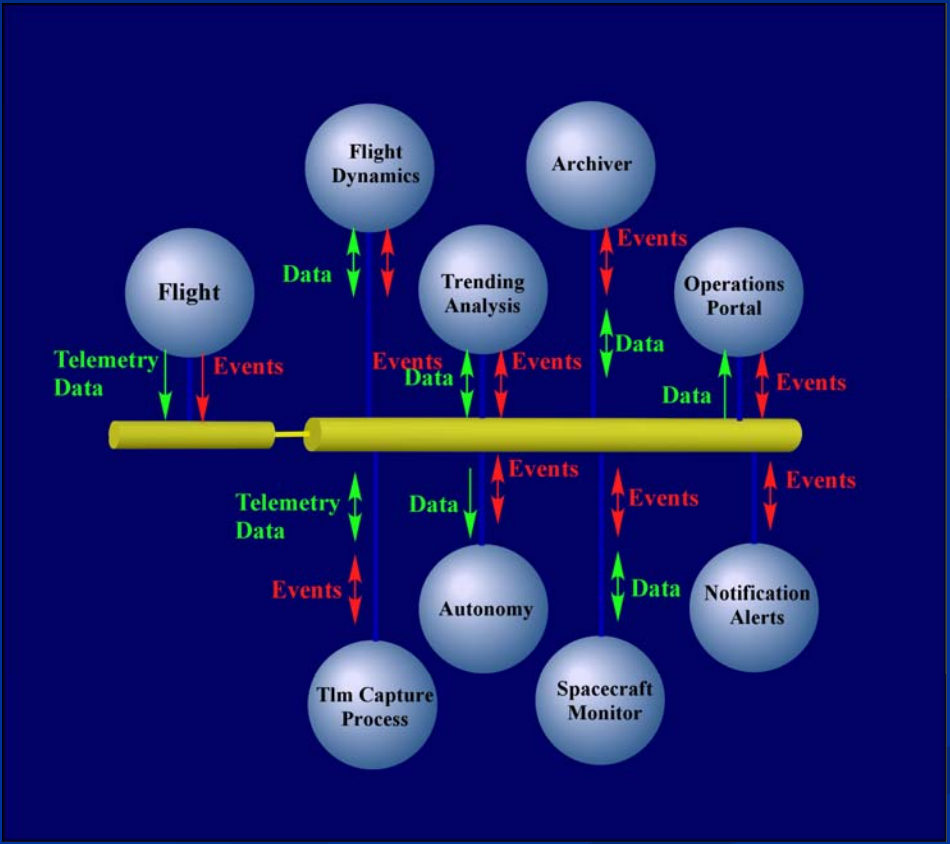
- **GMSEC** (Goddard Mission Services Evolution Center)
  - Developed to improve how NASA would develop and maintain ground data systems for dozens of missions, with a constant stream of missions always in the development phase.
- Four Key System Concepts
  1. Standardize interfaces (<u>not components</u>). Loosely coupled
  2. Utilize a messaging middleware to develop a framework (publish/subscribe)
  3. Provide the user with choices for major functional components
  4. Own the reference architecture and interface standards, allow vendors and development organizations to own and advance their functional areas

## Interface Standards and Middleware Simplifies Architecture

**Traditional Design**
**Socket Connections**



**GMSEC Design**
**Middleware Connections**



## What GMSEC Framework Provides Developers

- Standard API
  - Multiple languages (C, C++, Java, Perl, Python, etc)
  - Multiple middlewares (SmartSockets, Rendezvous, MagicBus, etc)
  - Multiple platforms (Windows, Linux, Solaris, Mac OS)
- Standardized Messages
  - Reduced programming integration (e.g., don't have to worry about the applications, just the messages. In some ways, Similar to blackboards and/or goal based architectures)
  - Reduced system integration (applications can be added/deleted/swapped on the fly)

## What this means for developers

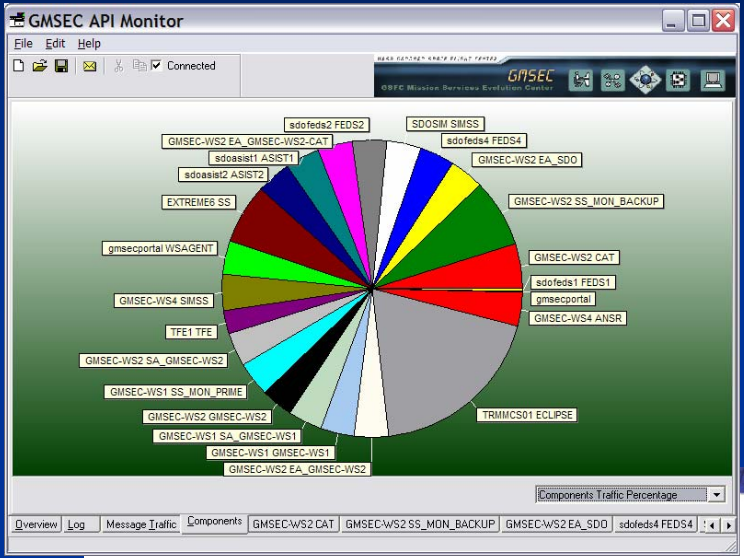
- Tools can be developed with minimal knowledge or impact, on other applications
  - Enables opportunities for developers to quickly, rapidly, and cheaply develop applications for targeted problems and/or system-wide areas.
- Tools can be added, deleted, and updated easily while a system is running
- Generalized tools can easily be developed, with minimal migration effort from mission to mission
- High return on development investment by using the strengths of your team as regards to platform, language, and product knowledge to add value to systems

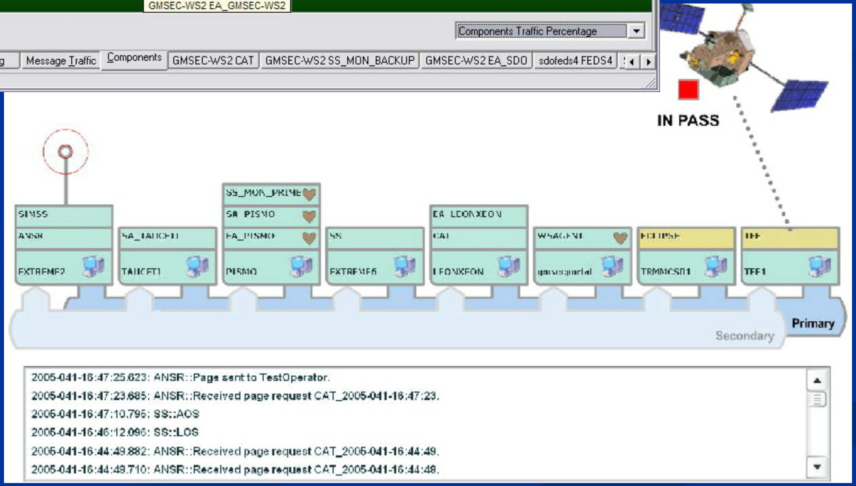
## Types of Tools

- Monitoring applications for displaying components on the bus, their status, and communication statistics.
- Debugging/Simulation applications for recording and then playing back any type of message traffic on the bus.
- Web Services for remotely accessing a GMSEC bus from ANY language, ANY platform, and ANY location.
- Automation applications for automatically scheduling activities or analyzing and reasoning about components and the system.
- Logging and Archiving applications for displaying, reporting, and saving telemetry, event/log, directive, command or any other types of messages from the bus.
- Commanding
- New Middlewares

# Health Monitoring – GSMO, GEDAT, and API Monitor

- System-wide real-time application health monitoring
  - Visual overview of machines and components on the GMSEC bus
  - Monitors published messages on the bus, including heartbeats
- **Required no changes to other applications**
- Extremely small development effort
  - API Monitor – Windows-based Health Monitor and graphs (< .1 FTE)
  - GSMO – Flash-based Overview Display (.1 FTE)
  - GEDAT – Java-based Overview Display .375 FTE)

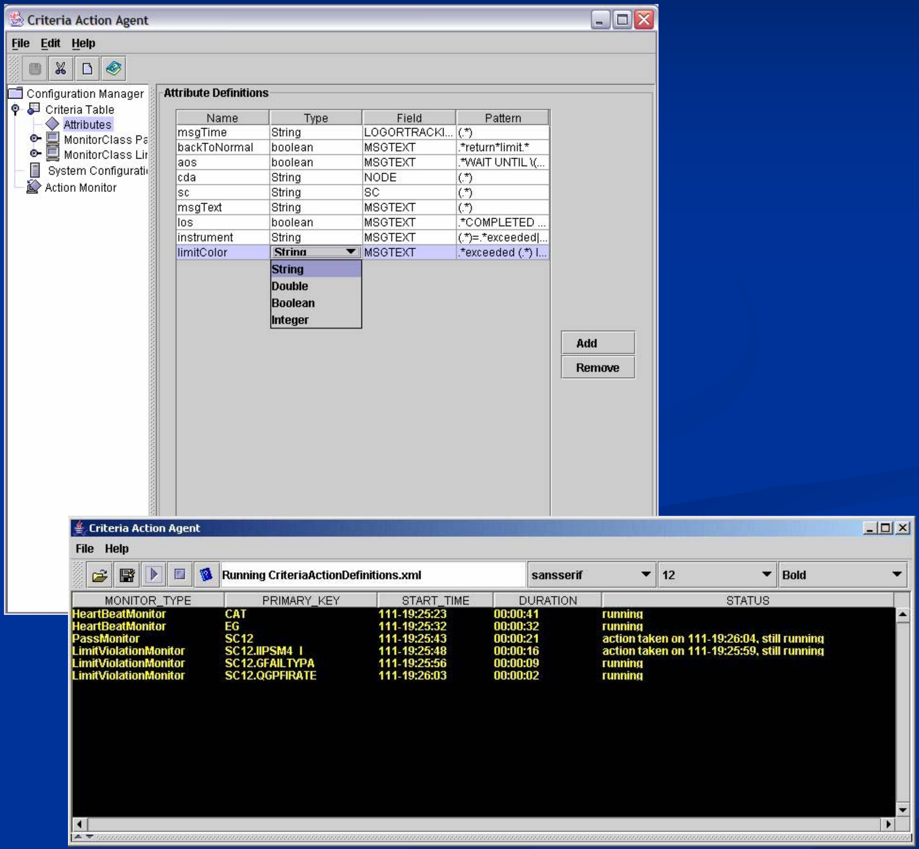




```
2005-041-16:47:25.623: ANSR::Page sent to TestOperator.
2005-041-16:47:23.685: ANSR::Received page request CAT_2005-041-16:47:23.
2005-041-16:47:10.796: SS::AOS
2005-041-16:46:12.096: SS::LOS
2005-041-16:44:49.882: ANSR::Received page request CAT_2005-041-16:44:49.
2005-041-16:44:49.710: ANSR::Received page request CAT_2005-041-16:44:48.
```

## Analysis & Response – System Agents & Criteria Action Table (CAT)

- Rule based fault detection and response
  - Provides more automation and autonomy to mission operations
  - Monitors Heartbeat and System Agent messages to automate detection of anomalous conditions
  - Works with System Agents to detect and respond (failovers) to problems
- **Required no changes to other applications**
- Moderate development effort: System Agents (.1 FTE), CAT (1.5 FTE)



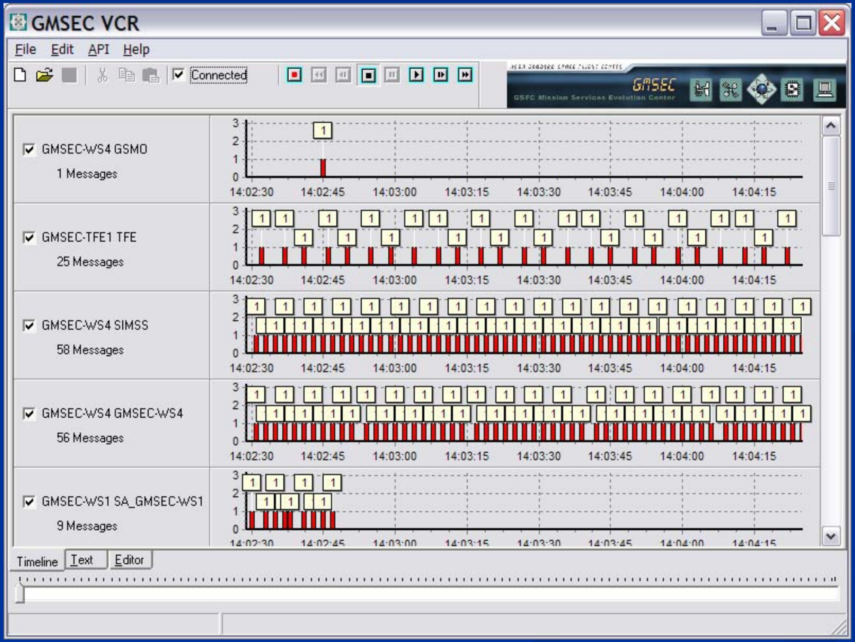
| Name | Type | Field | Pattern |
|---|---|---|---|
| msgTime | String | LOGORTRACKI... | (.*) |
| backToNormal | boolean | MSGTEXT | .*return*limit.* |
| aos | boolean | MSGTEXT | .*WAIT UNTIL \(... |
| cda | String | NODE | (.*) |
| sc | String | SC | (.*) |
| msgText | String | MSGTEXT | (.*) |
| los | boolean | MSGTEXT | .*COMPLETED ... |
| instrument | String | MSGTEXT | (.*)=.*exceeded\|... |
| limitColor | String | MSGTEXT | .*exceeded (.*) l... |

Running CriteriaActionDefinitions.xml — sansserif — 12 — Bold

| MONITOR_TYPE | PRIMARY_KEY | START_TIME | DURATION | STATUS |
|---|---|---|---|---|
| HeartBeatMonitor | CAT | 111-19:25:23 | 00:00:41 | running |
| HeartBeatMonitor | EG | 111-19:25:32 | 00:00:32 | running |
| PassMonitor | SC12 | 111-19:25:43 | 00:00:21 | action taken on 111-19:26:04, still running |
| LimitViolationMonitor | SC12.IIPSM4 I | 111-19:25:48 | 00:00:16 | action taken on 111-19:25:59, still running |
| LimitViolationMonitor | SC12.GFAILTYPA | 111-19:25:56 | 00:00:09 | running |
| LimitViolationMonitor | SC12.QGPFIRATE | 111-19:26:03 | 00:00:02 | running |

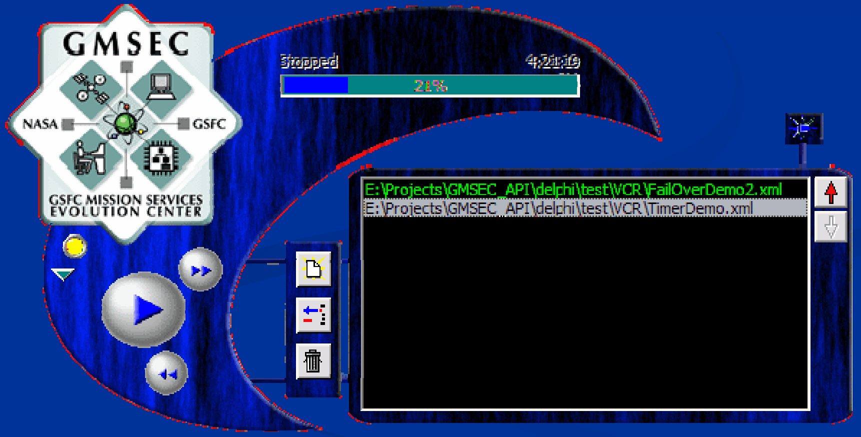
## Simulation, Presentation and Testing Tools – GMSEC VCR

- Recording and playback of published messages
  - Extremely helpful in debugging and simulations
  - Similar to a multitrack tape recorder where each component is a separate track.
  - VCR Functions (Record, Play, Stop, Pause, Step Forward, Step Backward, etc) and Editing Functions (Add, Edit, Delete messages)
- **Required no changes to other applications**
- Extremely small development effort (< .1 FTE)



## Simulation, Presentation and Testing Tools – GMSEC Symphony

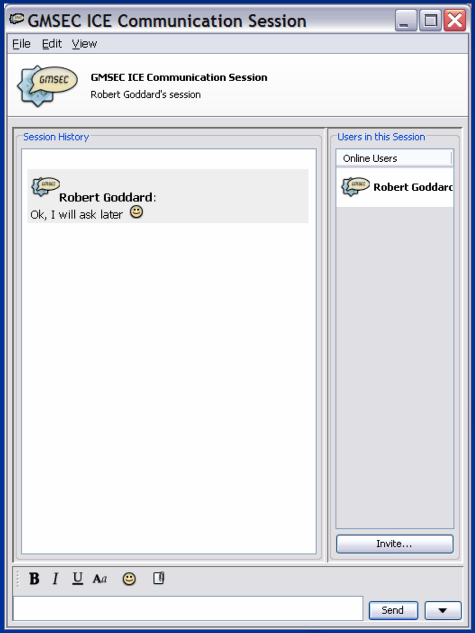
- Playback of lists of recorded sessions
  - Excellent for presentations
  - Uses a familiar paradigm for managing and playing back a play list of GMSEC VCR files
  - Manage a "play list" of VCR files: Add, delete, and reorder your playlists and save them for later
  - Play each VCR file in sequence, loop them, pause after playing each file, and jump to specific points in a file
- **Required no changes to other applications**
- Extremely small development effort (1 week)



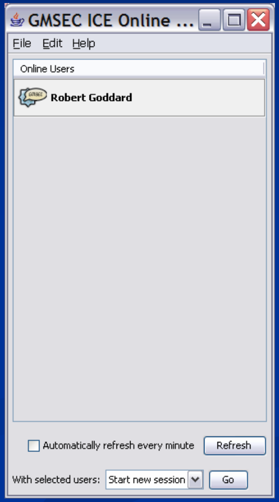
```
E:\Projects\GMSEC_API\delphi\test\VCR\FailOverDemo2.xml
E:\Projects\GMSEC_API\delphi\test\VCR\TimerDemo.xml
```

## Simulation, Presentation and Testing Tools – GMSEC Integrated Communications Environment (ICE)

- Text conferencing solution using the GMSEC Bus
  - As secure as your network
  - Provides Full-featured text conferencing with graphical "emoticons", WYSIWYG text editor, file attachments, and user icons
  - Can be used as an application or in a browser and part of GMSEC Portal
- **Required no changes to other applications**
- Extremely small development effort (.1 FTE)

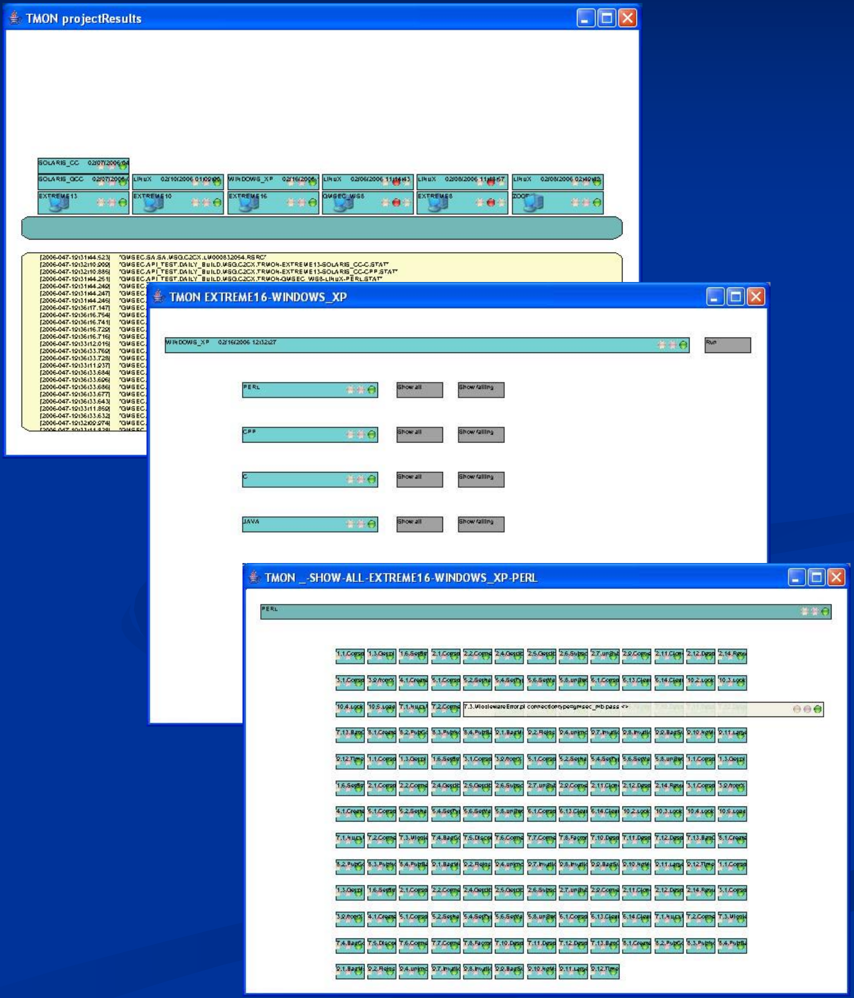


Robert Goddard:
Ok, I will ask later ☺



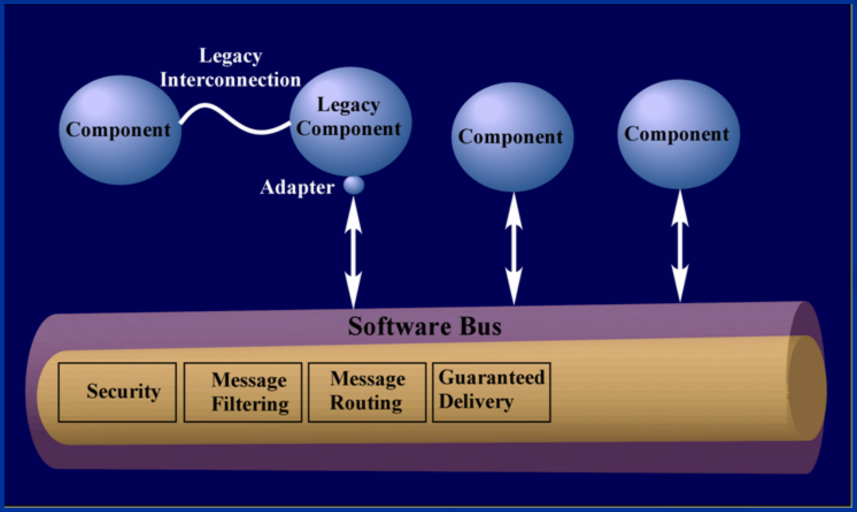
## Simulation, Presentation and Testing Tools – GMSEC Testing Suite

- Automated Testing Suite for GMSEC API run on a daily basis
  - Tests the latest development version of source code
  - Daily builds and tests, generate result reports
  - Total of 91 test cases per middleware wrapper
    - Currently Releasing/Supporting
      - 3 wrappers * 4 languages * 6 platforms
    - 6552 test permutations to execute for the entire suite
- Moderate development effort (.5 FTE)


TMON projectResults
TMON EXTREME16-WINDOWS_XP
PERL
CPP
C
JAVA
Show all
Show failing
Run
TMON _-SHOW-ALL-EXTREME16-WINDOWS_XP-PERL

## Middleware and Bridges – GMSEC Message Bus (MagicBus)

- Light weight middleware implementation
  - Supports all messaging capabilities of the GMSEC API.
  - Excellent for development period and small systems
  - Easy to use and configure
- **Required no changes to other applications**
- Small development effort (.375 FTE)

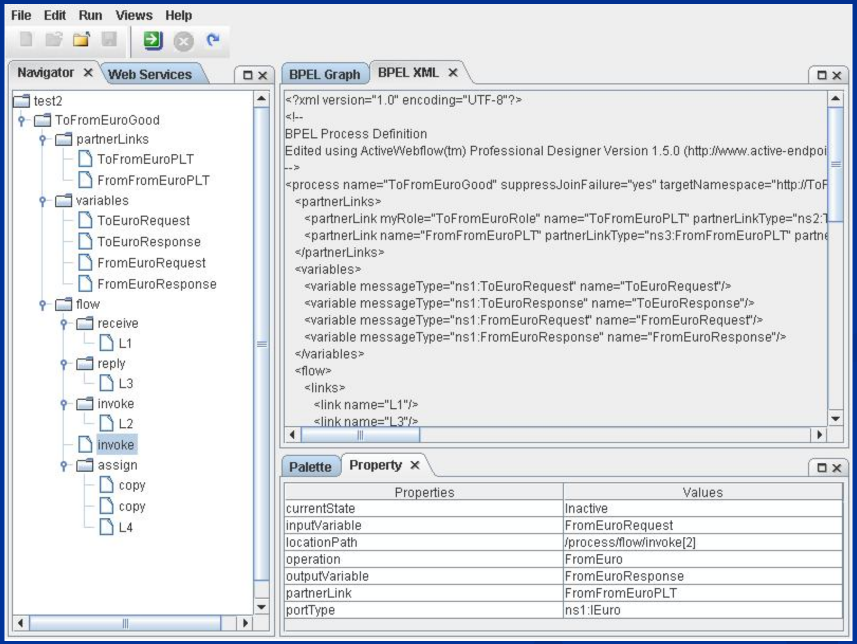


## Middleware and Bridges – GMSEC Bridge

- Bridges two GMSEC buses to make one virtual bus
  - Transparently bridges messages between two (or more) GMSEC buses
  - Provides message filtering
- **Required no changes to other applications**
- Small development effort (.3 FTE)

## Middleware and Bridges – GMSEC Web Services

- Exposes GMSEC Bus through web services
  - Enables integration of GMSEC system architectures with non-GMSEC systems
  - Enables GMSEC enabled applications for new platforms and languages
  - Can be integrated into web applications for the GMSEC portal with zero-configuration for clients
- **Required no changes to other applications**
- Extremely small development effort (.2 FTE)



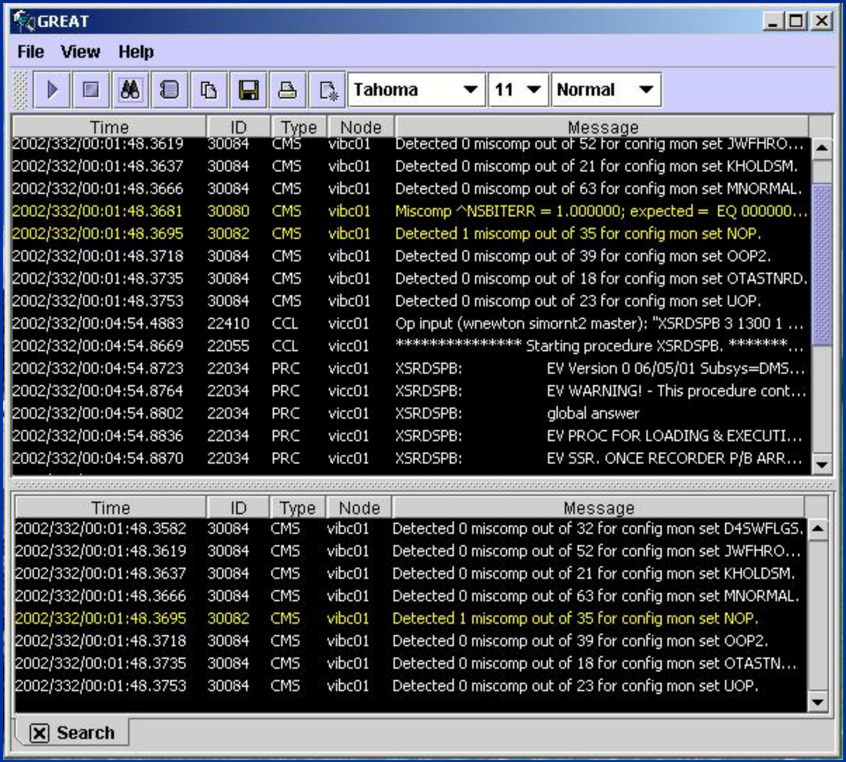
```
test2
  ToFromEuroGood
    partnerLinks
      ToFromEuroPLT
      FromFromEuroPLT
    variables
      ToEuroRequest
      ToEuroResponse
      FromEuroRequest
      FromEuroResponse
    flow
      receive
        L1
      reply
        L3
      invoke
        L2
      invoke
      assign
        copy
        copy
        L4
```

```
<?xml version="1.0" encoding="UTF-8"?>
<!--
BPEL Process Definition
Edited using ActiveWebflow(tm) Professional Designer Version 1.5.0 (http://www.active-endpoi
-->
<process name="ToFromEuroGood" suppressJoinFailure="yes" targetNamespace="http://ToF
  <partnerLinks>
    <partnerLink myRole="ToFromEuroRole" name="ToFromEuroPLT" partnerLinkType="ns2:T
    <partnerLink name="FromFromEuroPLT" partnerLinkType="ns3:FromFromEuroPLT" partne
  </partnerLinks>
  <variables>
    <variable messageType="ns1:ToEuroRequest" name="ToEuroRequest"/>
    <variable messageType="ns1:ToEuroResponse" name="ToEuroResponse"/>
    <variable messageType="ns1:FromEuroRequest" name="FromEuroRequest"/>
    <variable messageType="ns1:FromEuroResponse" name="FromEuroResponse"/>
  </variables>
  <flow>
    <links>
      <link name="L1"/>
      <link name="L3"/>
```

| Properties | Values |
|---|---|
| currentState | Inactive |
| inputVariable | FromEuroRequest |
| locationPath | /process/flow/invoke[2] |
| operation | FromEuro |
| outputVariable | FromEuroResponse |
| partnerLink | FromFromEuroPLT |
| portType | ns1:IEuro |

## Logging and Archiving – GMSEC Reusable Events Analysis Toolkit (GREAT)

- Log Archiver and Reporting Tool
  - Provides a software toolkit to archive, process, display, and analyze standard event log messages
  - Provide mission operations tool that is highly portable across platforms and applicable to multiple missions
- **Required no changes to other applications**
- Moderate development effort (.5 FTE – first version)

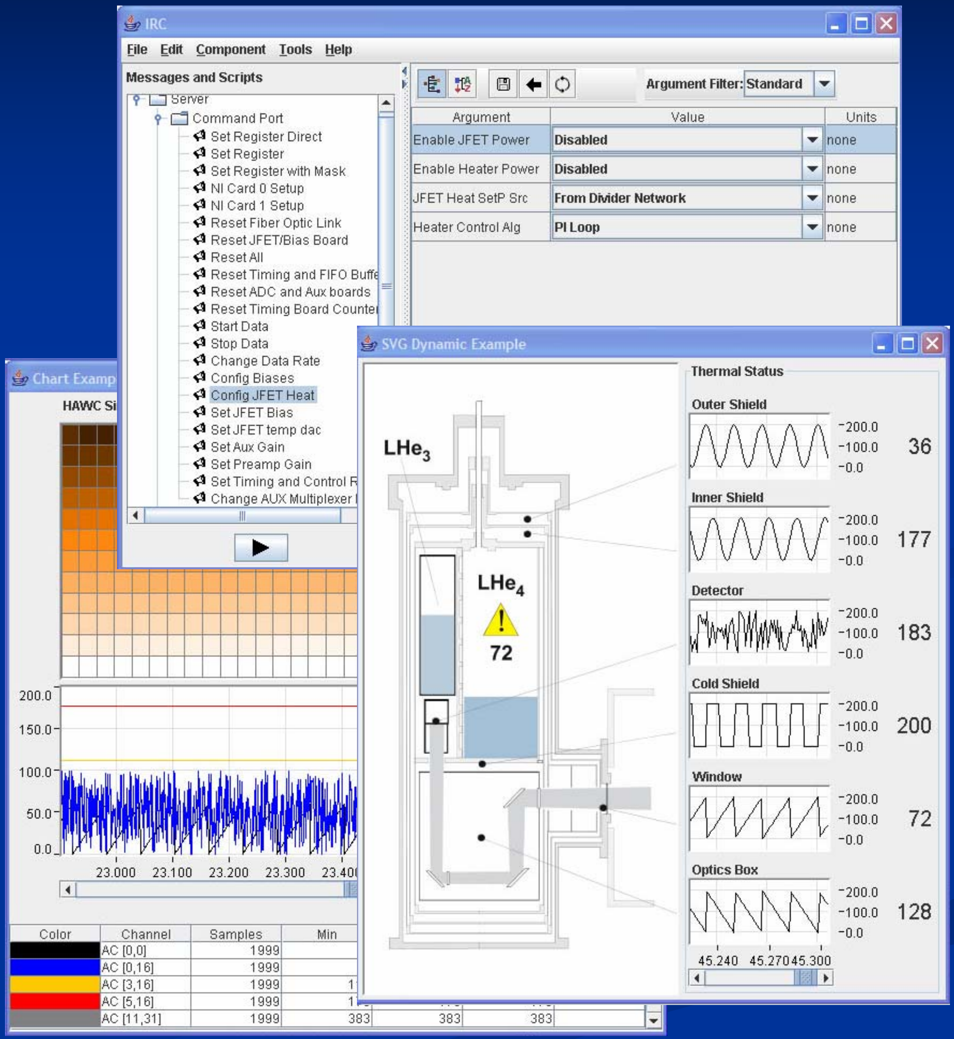


```
Time                   ID     Type  Node    Message
2002/332/00:01:48.3619 30084  CMS   vibc01  Detected 0 miscomp out of 52 for config mon set JWFHRO...
2002/332/00:01:48.3637 30084  CMS   vibc01  Detected 0 miscomp out of 21 for config mon set KHOLDSM.
2002/332/00:01:48.3666 30084  CMS   vibc01  Detected 0 miscomp out of 63 for config mon set MNORMAL.
2002/332/00:01:48.3681 30080  CMS   vibc01  Miscomp ^NSBITERR = 1.000000; expected =  EQ 000000...
2002/332/00:01:48.3695 30082  CMS   vibc01  Detected 1 miscomp out of 35 for config mon set NOP.
2002/332/00:01:48.3718 30084  CMS   vibc01  Detected 0 miscomp out of 39 for config mon set OOP2.
2002/332/00:01:48.3735 30084  CMS   vibc01  Detected 0 miscomp out of 18 for config mon set OTASTNRD.
2002/332/00:01:48.3753 30084  CMS   vibc01  Detected 0 miscomp out of 23 for config mon set UOP.
2002/332/00:04:54.4883 22410  CCL   vicc01  Op input (wnewton simornt2 master): "XSRDSPB 3 1300 1 ...
2002/332/00:04:54.8669 22055  CCL   vicc01  *************** Starting procedure XSRDSPB. *******...
2002/332/00:04:54.8723 22034  PRC   vicc01  XSRDSPB:          EV Version 0 06/05/01 Subsys=DMS...
2002/332/00:04:54.8764 22034  PRC   vicc01  XSRDSPB:          EV WARNING! - This procedure cont...
2002/332/00:04:54.8802 22034  PRC   vicc01  XSRDSPB:          global answer
2002/332/00:04:54.8836 22034  PRC   vicc01  XSRDSPB:          EV PROC FOR LOADING & EXECUTI...
2002/332/00:04:54.8870 22034  PRC   vicc01  XSRDSPB:          EV SSR. ONCE RECORDER P/B ARR...
```

```
Time                   ID     Type  Node    Message
2002/332/00:01:48.3582 30084  CMS   vibc01  Detected 0 miscomp out of 32 for config mon set D4SWFLGS.
2002/332/00:01:48.3619 30084  CMS   vibc01  Detected 0 miscomp out of 52 for config mon set JWFHRO...
2002/332/00:01:48.3637 30084  CMS   vibc01  Detected 0 miscomp out of 21 for config mon set KHOLDSM.
2002/332/00:01:48.3666 30084  CMS   vibc01  Detected 0 miscomp out of 63 for config mon set MNORMAL.
2002/332/00:01:48.3695 30082  CMS   vibc01  Detected 1 miscomp out of 35 for config mon set NOP.
2002/332/00:01:48.3718 30084  CMS   vibc01  Detected 0 miscomp out of 39 for config mon set OOP2.
2002/332/00:01:48.3735 30084  CMS   vibc01  Detected 0 miscomp out of 18 for config mon set OTASTN...
2002/332/00:01:48.3753 30084  CMS   vibc01  Detected 0 miscomp out of 23 for config mon set UOP.
```

# Tools modified for GMSEC – Instrument Remote Control (IRC)

- Bridges GMSEC Bus to devices and sensors or Users
  - Enables integration of non-GMSEC devices via Instrument Markup Language (IML) to GMSEC system architectures
  - Enables customized Graphical User Interfaces to GMSEC enabled applications or devices
  - Can be used as an application framework for building customized GMSEC aware client or service applications
- **Required no changes to other applications or device interfaces**
- Extremely small development effort (.1 FTE)



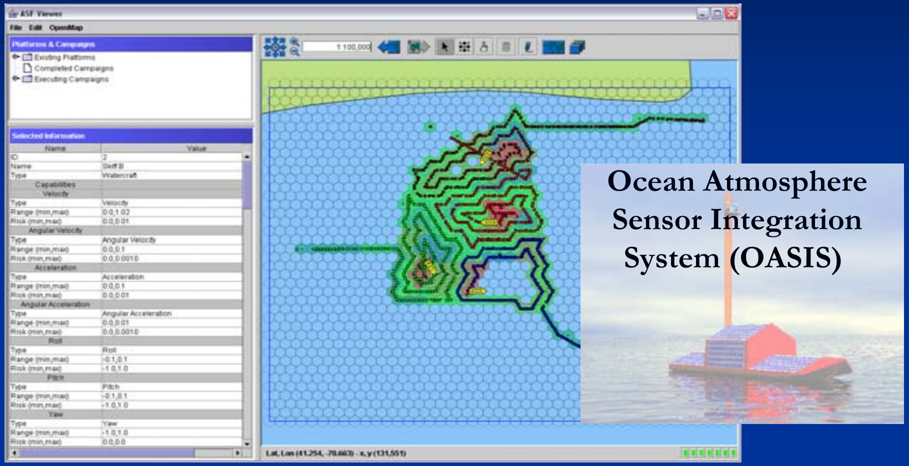
| Argument | Value | Units |
|---|---|---|
| Enable JFET Power | Disabled | none |
| Enable Heater Power | Disabled | none |
| JFET Heat SetP Src | From Divider Network | none |
| Heater Control Alg | PI Loop | none |

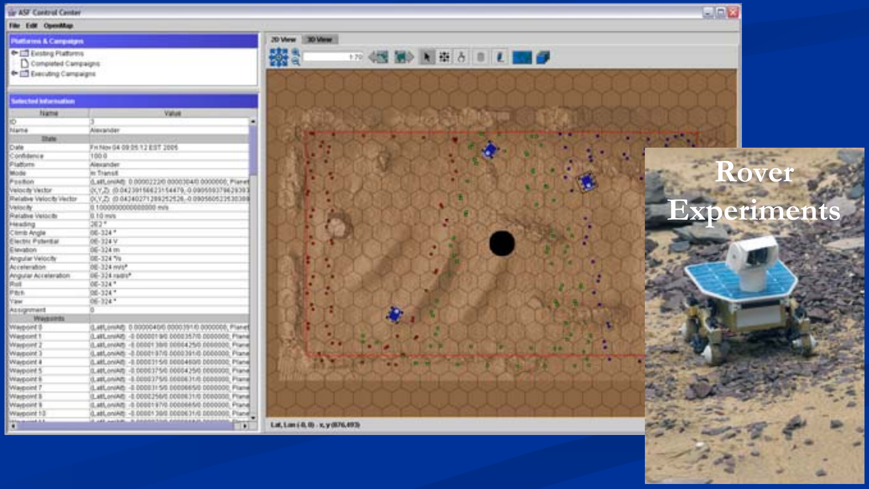
| Color | Channel | Samples | Min | | |
|---|---|---|---|---|---|
| ⬛ | AC [0,0] | 1999 | | | |
| 🟦 | AC [0,16] | 1999 | | | |
| 🟨 | AC [3,16] | 1999 | 1 | | |
| 🟥 | AC [5,16] | 1999 | 1 | | |
| ▨ | AC [11,31] | 1999 | 383 | 383 | 383 |

Tool Development for Distributed System Architectures

# Tools modified for GMSEC – Adaptive Sensor Fleet (ASF)

- Supervisory control system designed to use a collection of heterogeneous robotic platforms to optimally perform observations of dynamic environments driven by high-level goals.
  - provides for observations through high-level goals,
  - supervisory fleet management of robotic platforms (coordination),
  - analysis of environmental science data to use in the decision making process (collaboration),
  - optimal path planning and replanning,
  - identification of science phenomena,
  - and adaptation to dynamic or unknown environments Required no changes to other applications.
- **Required no changes to other applications**
- Adapted for GMSEC with 0.1 FTE (approx. 1 month)





## Summary

- Standardizing interfaces (API and messages) results in
  - Reduced programming integration time
  - Reduced system integration time
- Smart distributed architecture design enables
  - Quick, rapid, and cheap development of applications for targeted problems and/or system-wide areas.
  - High return on investment by using the strengths of your development teams as far as platform, language, and product
  - Independent development of new applications with minimal, or no, impact on other applications and their development teams
  - Added value to system architects by providing a broad suite of tools and applications