Division of Responsibility

- **GLAST Mission**
  - Scott Lambros

- **LAT**
  - Large Area Telescope
    - Peter Michelson

- **EGSE**
  - Electronics Ground Support Equipment
    - Gunther Haller

- **I&T&C**
  - Integration and Test and Calibration
    - Elliott Bloom

- **IOC**
  - Instrument Operation Center
    - Scott Williams
EGSE Deliverables (Electronics + I&T&C support)

- I&T test-stand software support
  - Engineering Model 1 (EM1)
  - Engineering Model 2 (EM2)
  - Qualification Unit (QU), Calibration Unit (CU)
  - Flight Unit (FU)

- Software support for various incarnations of test-stands
  - Infrastructure (Workstations, networking, crates, etc.)
  - Test executive
  - Graphical User Interfaces (GUIs)
  - Databases and tools
  - Analysis tools
  - Data archiver
  - Test procedure design and implementation
  - Code management and release control
EM1 EGSE Configuration

- Subsystem (or simulator)
- TEM
- VME/cPCI Chassis
- LAT-COMM
- CPU
- DC Power
- Online Workstation
- Ethernet Router and Firewall
- Back door debug RS-232
- Main Data Flow 100BaseT
- 100BaseT
- WAN
- Central Database
EM2, QU, FU EGSE Configurations

- Cal Unit or LAT or simulator
- TEMs
- EP
- GTM
- SIU
- T&DF System

EGSE
- CPU
- 1553
- SolidStateRec I/F
- I/O
- DC Power
- ePCI Chassis

Online Workstation
- Ethernet Router and Firewall
- Back door debug RS-232

Main Data Flow 100BaseT

Online Workstation
- 100BaseT

Oracle Database
- WAN

Workstation
- GTM
- Online Workstation
- TEMs
EGSE & Online software

• Real-time system (JJ Russell)
  – Embedded processors running the VxWorks RTOS
  – Data acquisition and control by Trigger & Dataflow system
  – Monitoring and control of Housekeeping items
  – Data acquisition from test-stand COTS I/O modules
• Command and Control Software (test executive)
  – Working assumption is that we’ll use Interface & Control System, Inc.’s (ICS) Spacecraft Control Language (SCL)
• Data acquisition, quality verification, archive and distribution
• Data visualization and analysis
  – SCL provides some help with these last two items
  – Third party COTS and Open Source software packages have been, or can be interfaced with SCL to provide the complete solution
## Test Executive Software Decision Matrix

<table>
<thead>
<tr>
<th>Company: Product Name</th>
<th>Contact and phone #</th>
<th>Open Source</th>
<th>Supported Platforms</th>
<th>Export Control</th>
<th>Upfront Cost</th>
<th>website</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colorado U/LASP: OASIS</td>
<td>Randy Davis 1-303-492-6867; Michelle Kelly 303-492-4624</td>
<td>Source is free, but not &quot;open source&quot;- ADA</td>
<td>Solaris 2.5.1 UltraspArc</td>
<td>No</td>
<td></td>
<td><a href="http://lasp.colorado.edu/oasis/oasis.html">http://lasp.colorado.edu/oasis/oasis.html</a></td>
</tr>
<tr>
<td>GSFC: ASSIST</td>
<td>Bill Mocarsky, <a href="mailto:William.L.Mocarsky.1@gsfc.nasa.gov">William.L.Mocarsky.1@gsfc.nasa.gov</a></td>
<td>No-C</td>
<td>Linux, IBM AIX</td>
<td>yes</td>
<td></td>
<td>None found.</td>
</tr>
</tbody>
</table>
FUSE Control Center

- Johns Hopkins University
- Operational more than 2 years
- ICS also responsible for Payload Flight Software, I&T Systems, and Simulators.

INTEGRATED TOOLSET

- SCL
- SAMMI
- O2
- STK
- Orbix
- NDDS
- IDL
Real-Time Command and Control Infrastructure Overview

Using SCL Shared Memory, Commercial Database Product, and Science Processing Applications

Brian Buckley @ ICS, 9/10/01
## SCL Summary

- **Heritage**: 13 year history of mission critical software product development
- **Mature**: eSCL is a proven, stable, Open Source product
- **Agile**: Allows rapid prototyping, deployment, and updates
- **Intelligent**: Automated analysis and decision-making capability
- **Simplicity**: Toolkit provides a centralized approach to encapsulating Design and Logic
Tasks

• SCL in the VxWorks environment
• Interface to test-stand hardware
• Design and build application SCL database schema(s)
• Select a user interface tool
  – Initially text based
  – National Instruments’ LabView
  – Kenesix’ SAMMI
  – ICS’ JAVA based GUI builder (available 11/01)
• Select a local database tool
  – MSAccess
    • Subsystems are starting with this
  – MySQL
  – ProgresSQL
• Provide mechanism to upload local database contents to the Central Database
  – Oracle
  – Located and managed at SLAC
Tasks, continued

- Select data visualization and analysis tool(s)
  - HippoDraw
    - SLAC support
  - ROOT
    - In wide use
  - IDL
    - COTS
- Work with subsystems to construct I&T&C procedures
- Deploy I&T test-stands and software
  - Educate and train end users
- Integrate orthogonal I&T data sources with test-stand data stream
  - Muon telescopes, photon taggers, etc.
- Support Instrument Operations Center (IOC) needs
- Provide code management and version control system
- Fault management
### Subsystem I&T Test-stand Requirements and Schedule*

<table>
<thead>
<tr>
<th>Test-stand</th>
<th>Type</th>
<th>Number of instances</th>
<th>Release date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development support</td>
<td>EM1</td>
<td>2</td>
<td>11/01</td>
</tr>
<tr>
<td>Subsystem support</td>
<td>EM1</td>
<td>7 + 6 NRL</td>
<td>3/02</td>
</tr>
<tr>
<td>Integration Testing</td>
<td>EM1</td>
<td>2</td>
<td>6/02</td>
</tr>
<tr>
<td>SLAC DAQ hardware development</td>
<td>EM2</td>
<td>1</td>
<td>9/02</td>
</tr>
<tr>
<td>Flight Software Testbed</td>
<td>EM2+</td>
<td>1</td>
<td>12/02</td>
</tr>
<tr>
<td>Calibration/Qualification</td>
<td>QU</td>
<td>2</td>
<td>4/03</td>
</tr>
<tr>
<td>Flight Unit I&amp;T</td>
<td>FU</td>
<td>2</td>
<td>8/03</td>
</tr>
</tbody>
</table>

* From Scott Williams GLAST Technical Memorandum GTM023a

R. Claus
Summary

• Working hard to control costs through the use of COTS hardware and COTS or Open Source software
• Initial “Development support” test-stand deadline (11/01) will be difficult to attain, but not out of the question
• Searching for additional high quality labor
• Sensor development version
  – VME crate
  – Motorola MVME-2306 CPU board
    • 333 MHz PPC 604r, 32MB, Ethernet interface
    • VxWorks
  – VME COMmunications Module (LAT-COMM)
  – Tower Electronics Module (TEM)
  – NT workstation

• DAQ development version
  – cPCI crate
  – Expect to select Motorola MCP-750 CPU board
    • 400 MHz PPC 750, 128 MB, Ethernet interface
    • cPCI System Slot
    • VxWorks
  – cPCI LAT-COMM
  – TEM
  – Sun or NT workstation
Engineering Model 2

- Extension of DAQ development version of EM1
  - Complete Trigger & Dataflow system with multiple tower support
    - Global Trigger
    - Event Processor
    - Spacecraft Interface Unit (SIU)
  - Addition of Spacecraft Interface Simulator (SIS)
    - Envisioned to be based on already existing VME test-stand h/w
    - Operator workstation is connected with SIS via ethernet
    - SIS is connected with LAT via MIL-STD-1553
      - SIS is 1553 Bus Controller (PMC card)
      - LAT is 1553 Remote Terminal (cPCI card)
  - Addition of Instrument Power Supply (IPS)
    - Under computer control
    - Monitoring and archiving of housekeeping data
Engineering Model 2+

- Extension of EM2
  - 16 TEMs
  - Inherits SIU
  - Sensor simulator
Qualification Unit & Calibration Unit

• Supports
  – 4 tracker/calorimeter towers
  – 1 ACD
  – Global Trigger
  – Event Processor
  – SIU

• Overlap with EM2+ use implies an additional
  – SIS
  – IPS
  – Workstation

• Used for environmental, beam, etc. tests
  – Hot spares required
Flight Unit

• Independent of QU/CU and other test-stands
• Space qualified hardware
  – BAE RAD-750 cPCI SBC under consideration
  – cPCI MIL-STD-1553 interface
• GSE hardware required
  – SIS
  – IPS
  – Two workstations
SCL Satisfies our Requirements*

- Data Archiving
  - Housekeeping and science data
- Data Logging
  - Actions, test reports, run-time logs, scripts
- Telemetry database
- Command database
- Database Interface Compliance (ODBC)
- Out of Tolerance Data
- Data Visualization and Manipulation Interface
  - Control GUI
  - Display of graphs, charts, tables
  - WEB aware
  - Ease of use
- Test Scripts, Command Procedure, and Operations Sequences
  - Rich scripting language
  - Multithreading capability

* LAT Electrical Ground Support Equipment Level 3 Specification (Doc # LAT-SS-00XXX-P1)
SCL Satisfies Requirements (cont’d)

• Resource Priorities
  – Capable of scheduling and prioritizing scripts
• Version Control
  – Run log recording of system component version numbers
• Open Source
• Operating System
  – Windows NT/2000, Sun Solaris, Linux, etc. supported
• Messaging service
  – Pagers, PDAs, cell phones
• Not Export Controlled
Concerns

• Managing SCL training and support costs
• Ability to cooperate with other onboard Spacecraft Control Systems
  – The GLAST spacecraft
  – The GBM instrument
• Footprint of SCL in the embedded system
  – Memory usage
  – CPU usage
• Scalability of SCL to the size of our application
  – Number of SCL database entries
  – Number of rules & constraints to be processed
• JAVA based monitoring and control GUI builder
  – Nominally ready 11/01
    • delays?
  – Initial release
    • buggy?
Manpower

- Myself
- Some loaner labor from EGSE
- Expect to hire at least one other full time person
- Can probably get a postdoc with 50% duty cycle
- Stanford University Research Assistant(s)
What We Do

Multi-platform, **portable** Software Development and Integration for:

- Autonomous command and control software and **embedded systems**
- **Large-scale** ground control software
- Mission planning and operations
- Industrial control systems
- Intelligent e-commerce solutions
- Acquisition, test instrumentation
- Simulation and modeling
- System monitoring and advisory systems
- General systems integration and test
Common Requirements of a e-Business Solution

- Portable to Common Platforms
  - Windows NT/2000, Solaris, Linux, HP/UX, etc.
- Industry standards
  - TCP/IP, HTTP, FTP, SQL, XML, PKI, SSL, SMTP, etc.
- 3-Tier Architecture
- Java and C++ interfaces
- Real-Time performance
- 24/7 reliability
- Scalability – server farms, multiple hosts
- Load Balancing
- Journaling and audit trail
- Plug in capabilities for new, extended, or legacy technologies
e-Command & Control

Core Components:

- eSCL – Rule and Scripting Engine
- Web GUI Builder – Desktops, PDAs, Phones
- Visual Scripting – Drag & Drop logic
- Fault Modeling using the UML Methodology
- Message Broker - Software bus
- Event Queues - load balancing
- Web-Based Commanding (packet formatting)
- Web-Based Monitoring (remote GUI)
- Archive and Playback
- Real-Time software Decom
- Authentication and Encryption Technologies
- ODBC database connectivity
- Real-Time Shared memory database(s)
- Schema examples
- Extended Stored Procedure and Trigger Samples
- .dll and API for event interface
- e-Mail bridge
- XML standards for data interchange
Steps to field an e-Control system

- Embrace SML/XML for a common data definition format
- Authenticate and Profile Users
- Web-based registration for events
- Modeling of and Validation of the System
- Data acquisition and decommutation
- Archive & Playback
- Real-Time Monitoring and Commanding
- e-mail alerts: desktop, cell phone, pager, PDA
- Web-Based Management and Administration
- Web-Based Commanding
- Web-Based Monitoring
- Integration with Commercial Database for Analysis, Reporting, and web-based data dissemination
SML – Spacecraft Markup Language

- XML tag set that is vendor-neutral
- Used to define Command items, Telemetry Items, Packet Definitions, Interprocess Communications Messages, etc.
- All SCL tools are SML compliant
- Data easily exchanged with other vendors
- Submitted to ISO committees for standardization
HelloWorld

message "Hello World"
end HelloWorld
Software Bus Messaging Layer

- Messaging (payload) is independent of protocols
- Enough information is carried to route messages

- Application
  - Software Bus API on top of a parser
- XML
  - XML Messages
- Transport
  - HTTP(S), RPC, ToolTalk, TCP, POP3, SMTP…
- Hardware
  - Ethernet
*Data Acquisition and Decom*

- Data acquired from Front end equipment
- Frames decommutated using tables defined for DataIO
- Data value updated in the SCL Database
- Real Time Change Only (RTCO) packet received by the RTE
- Relevant rules are retrieved, evaluated, and executed
- Well-Defined APIs for each Module…not all required depending on configuration
Archive and Playback

- Archive and Playback of Raw Frames and Changing Data
- Time Tagging and Snapshots
- XML format for storage
Web-Based SCL Projects

- XML embedded in scripts and rules
- Self-documenting using XML style sheets
- Details viewed in Browser
Web-Based Commanding

- XML command definitions
- SCL Command Generator
- Integrated with web browser for “point and click” commanding
Web-Based Monitoring

- SCL Database viewed in Browser as Text (today)
- Java Based GUI for gauges, strip charts, and meters (in work)
Deliver Web Data Anywhere

Welcome to my eSCL

Authorized Users Only!

Enter Your Login Information

User ID: 
Password: 

Log in

Welcome to my eSCL
Authorized Users Only!

ID: sldemo
Password: [Assigned] (Log in)

OR

Welcome to my eSCL
Authorized Users Only!

ID: sldemo
Password: [Assigned] (Log in)

Network Available

Brian Buckley @ ICS, 9/10/01
Intelligent Alerts

Sample COM approach: Pager, cell phone, PDA, desktop, etc.

- User Profile
- DBMS
- RealTime Data Handler
- eSCL
- Scripts & Rules
- Messaging Service
- Custom Interface(s)
- Logging
- Sample .COM approach: Pager, cell phone, PDA, desktop, etc.

Brian Buckley @ ICS, 9/10/01
Administration and Reporting

- Administrative interface using Commercial Database (ODBC)
- Administration and Reporting via the web
- SCL Scripts and Rules can manipulate Database tables