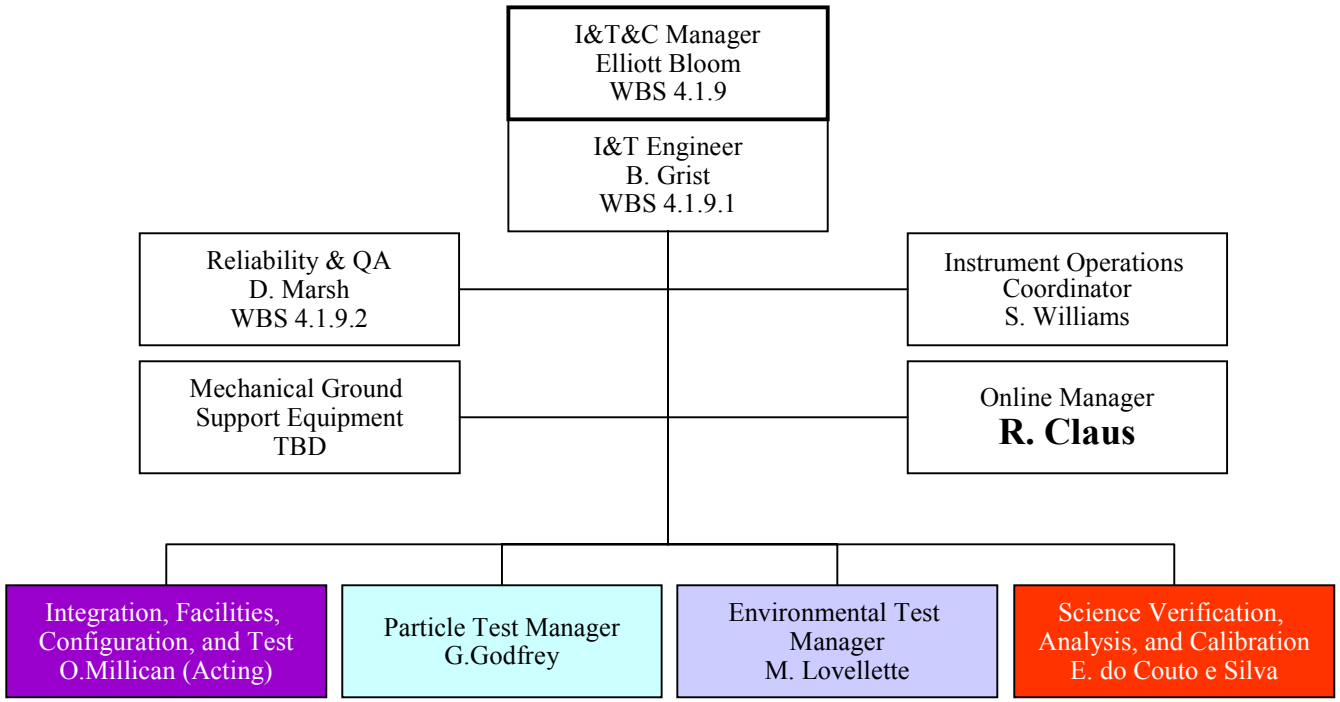
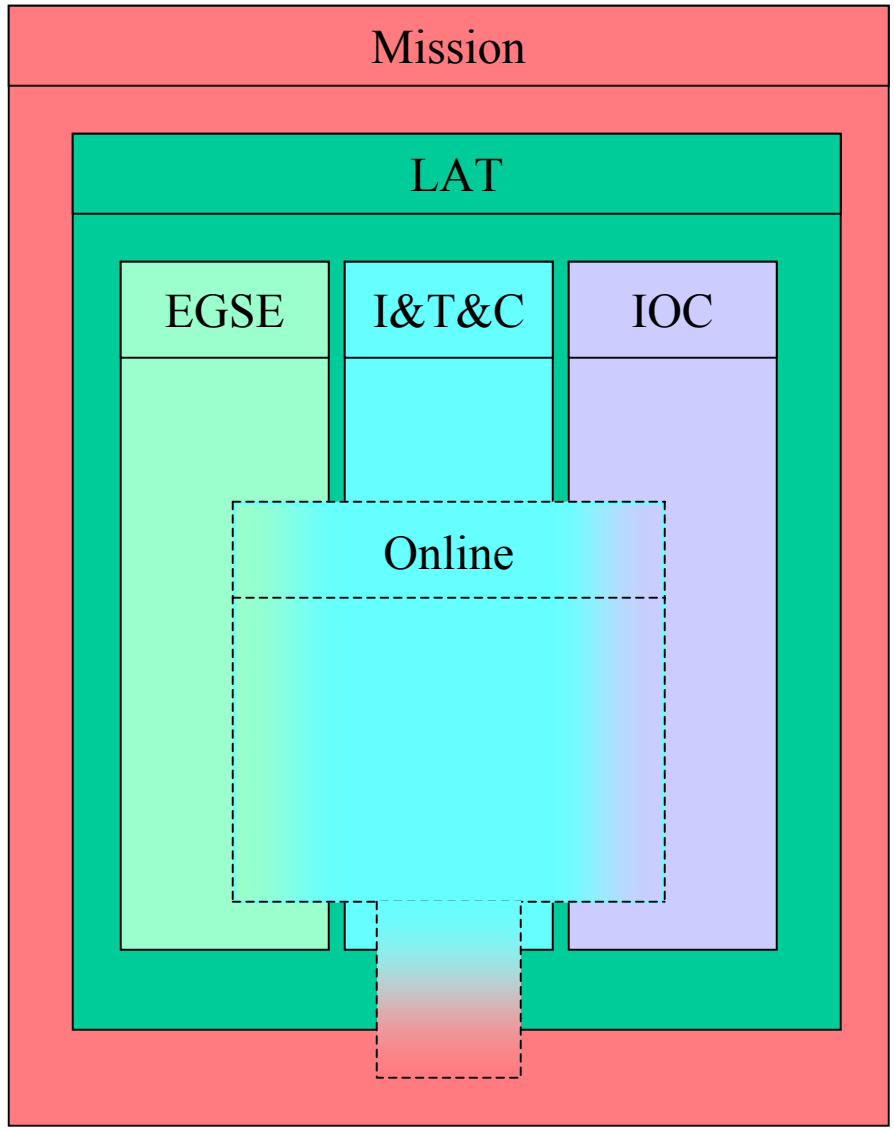
I&T&C Organization Chart



I&T Preparation 4.1.9.3	I&T Preparation 4.1.9.3	I&T Preparation 4.1.9.3	I&T Preparation 4.1.9.3
EM1 Model I&T&C	EM1 Model I&T&C		EM1 Model I&T&C
Calibration Unit I&T 4.1.9.4	Calibration Unit I&T 4.1.9.4		Calibration Unit I&T 4.1.9.4
Flight LAT I&T 4.1.9.6	Flight LAT I&T 4.1.9.6	Flight LAT I&T 4.1.9.6	Flight LAT I&T 4.1.9.6
Mission I&T Support 4.1.9.7	Mission I&T Support 4.1.9.7	Mission I&T Support 4.1.9.7	Mission I&T Support 4.1.9.7

Division of Responsibility

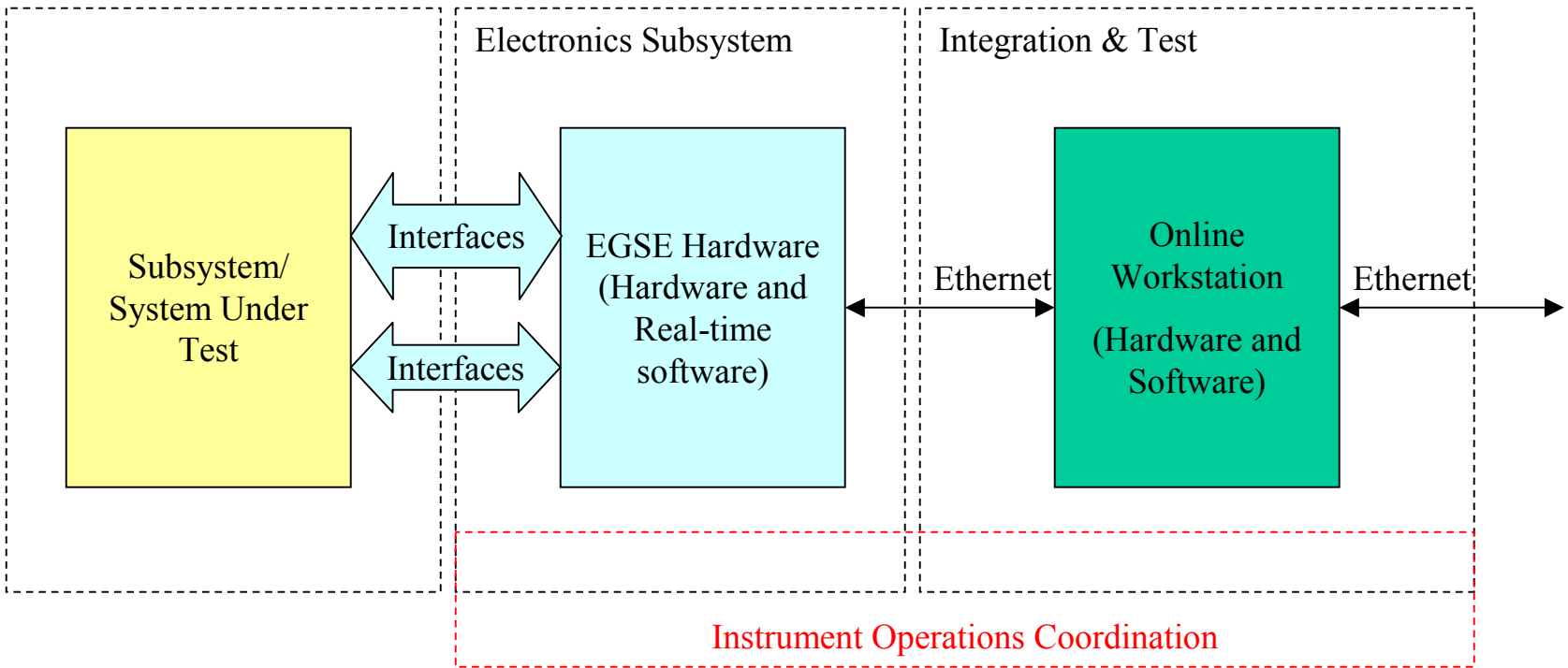
- **GLAST Mission**
  - Scott Lambros
- **LAT**
  - Large Area Telescope
    - Peter Michelson
- **EGSE**
  - Electronics Ground Support Equipment
    - Gunther Haller
- **I&T&C**
  - Integration and Test and Calibration
    - Elliott Bloom
- **IOC**
  - Instrument Operation Center
    - Scott Williams



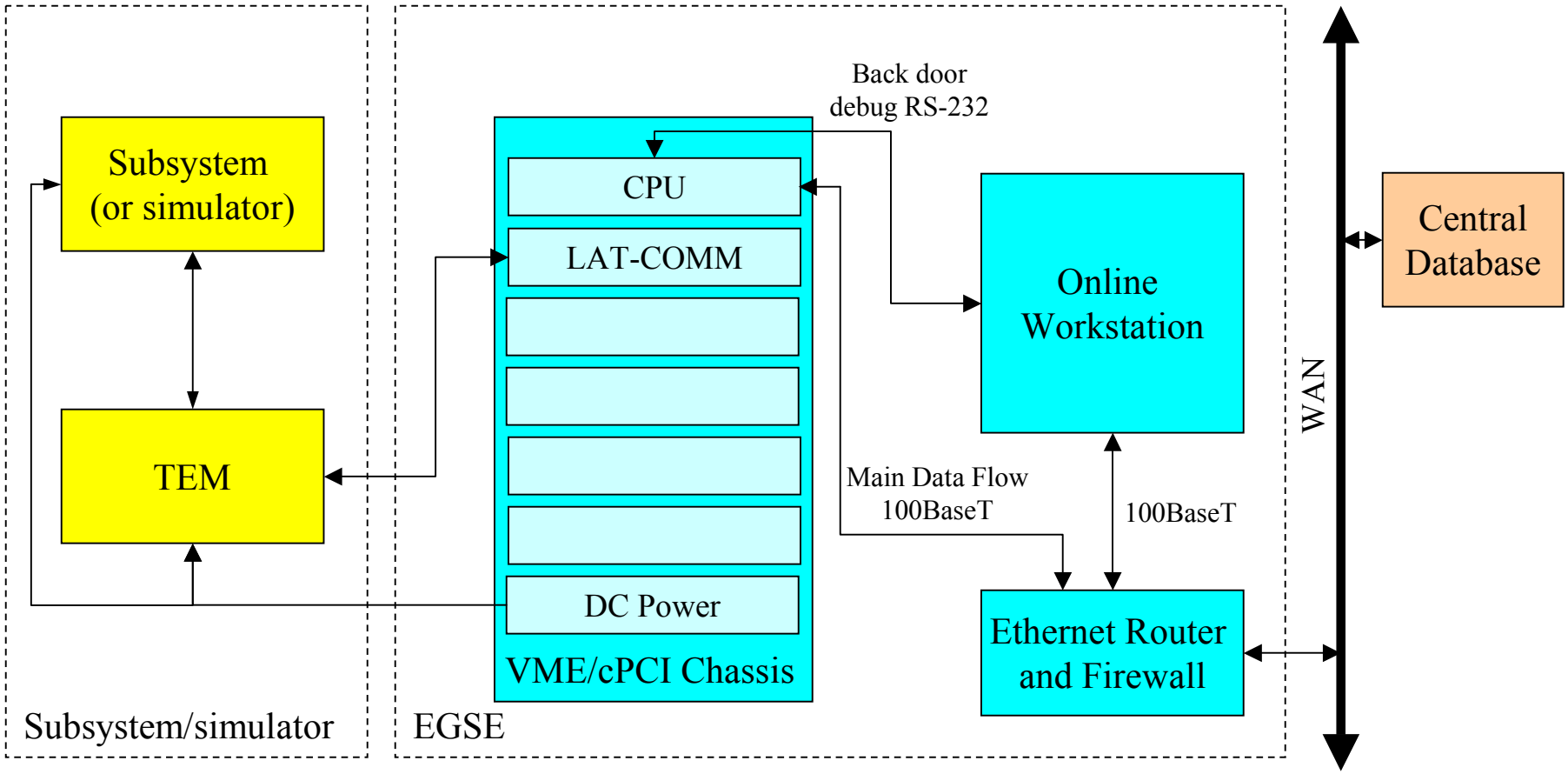
EGSE Deliverables (Electronics + I&T&C support)

- 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

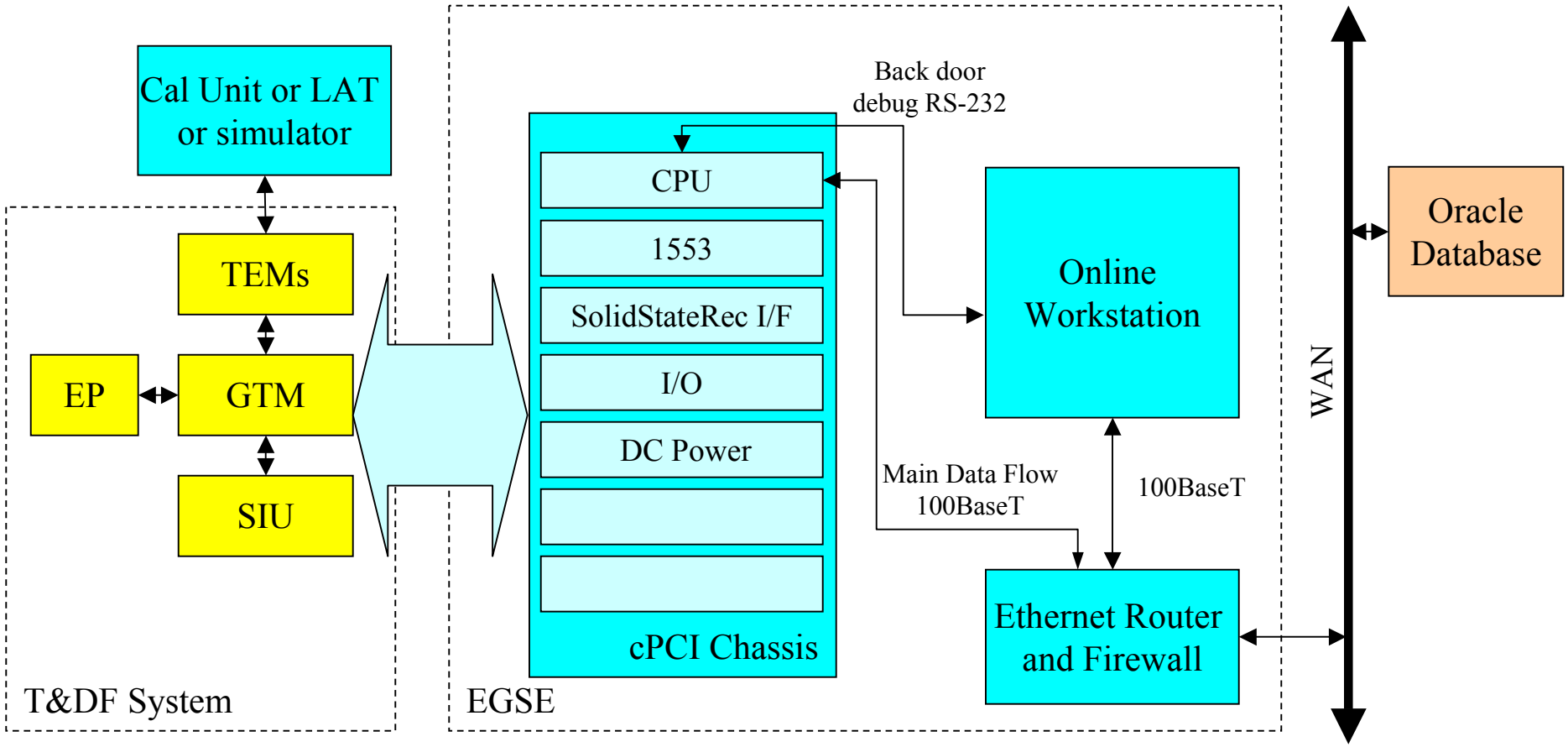
Test-stand Architecture



EM1 EGSE Configuration



EM2, QU, FU EGSE Configurations



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

Company: Product Name	Contact and phone #	Open Source	Supported Platforms	Export Control	Upfront Cost	website
Colorado U/LASP: OASIS	Randy Davis 1-303-492-6867; Michelle Kelly 303-492-4624	Source is free, but not "open source"- ADA	Solaris 2.5.1 Ulatrasparc	No		http://lasp.colorado.edu/oasis/oasis.html
Harris Corp: OS - Comet	Trip Carter 303-738-9122, Cell 303-884-8495, wcarte08@harris.com	No-C	Unix	yes		http://www.sticomet.com/products.asp
Interface ControlSystems: SCL	Brian Buckley 321-723-0399, buckley@interfacecontrol.com	Yes- C, C++, Java	NT, Solaris VX, Redhat Linux+Realtime Extensions	no		http://www.interfacecontrol.com/aerospace.htm
Talarian: Smart Sockets (formally RT - Works	Abraham Glazer, 650-695-8050x104,abraham.glazer@talarian.com	No - C	NT, Solaris, Linux	no		http://www.talarian.com/
GSFC: ITOS	Bill Mocarsky, William.L.Mocarsky.1@gsfc.nasa.gov	No - C	Linux, Solaris, Free BSD	yes		http://itos.gsfc.nasa.gov/
GSFC: ASSIST	Bill Mocarsky, William.L.Mocarsky.1@gsfc.nasa.gov	No-C	Linux, IBM AIX	yes		None found.

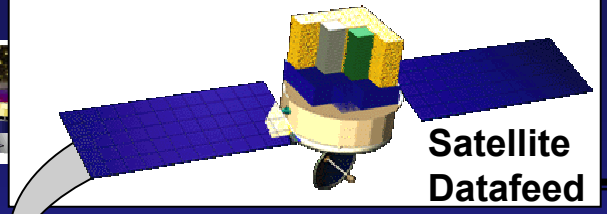
FUSE Control Center

- 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



Real-Time Sensor Data

eSCL Statistics

User Profiles

Data Acquisition & Decom

Web Browser

Web Browser

Web Browser

SCL Shared Memory

ODBC-Compliant Server DB

PROFILE

Events

Current Values

Derived Values

Current Values

ODBC

Interface, e-mail address

ODBC-Compliant Server DB

Sensor Data

Trigger

eSCL

Messaging Services

Alerts

Events

Events

Commands

Monitor & Calibrate Sensors

Sensor Interface

External (Science) Processing

Science Characterization

Health & Science Rules

Commands

Uplink Interface

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

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*

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

* From Scott Williams GLAST Technical Memorandum GTM023a

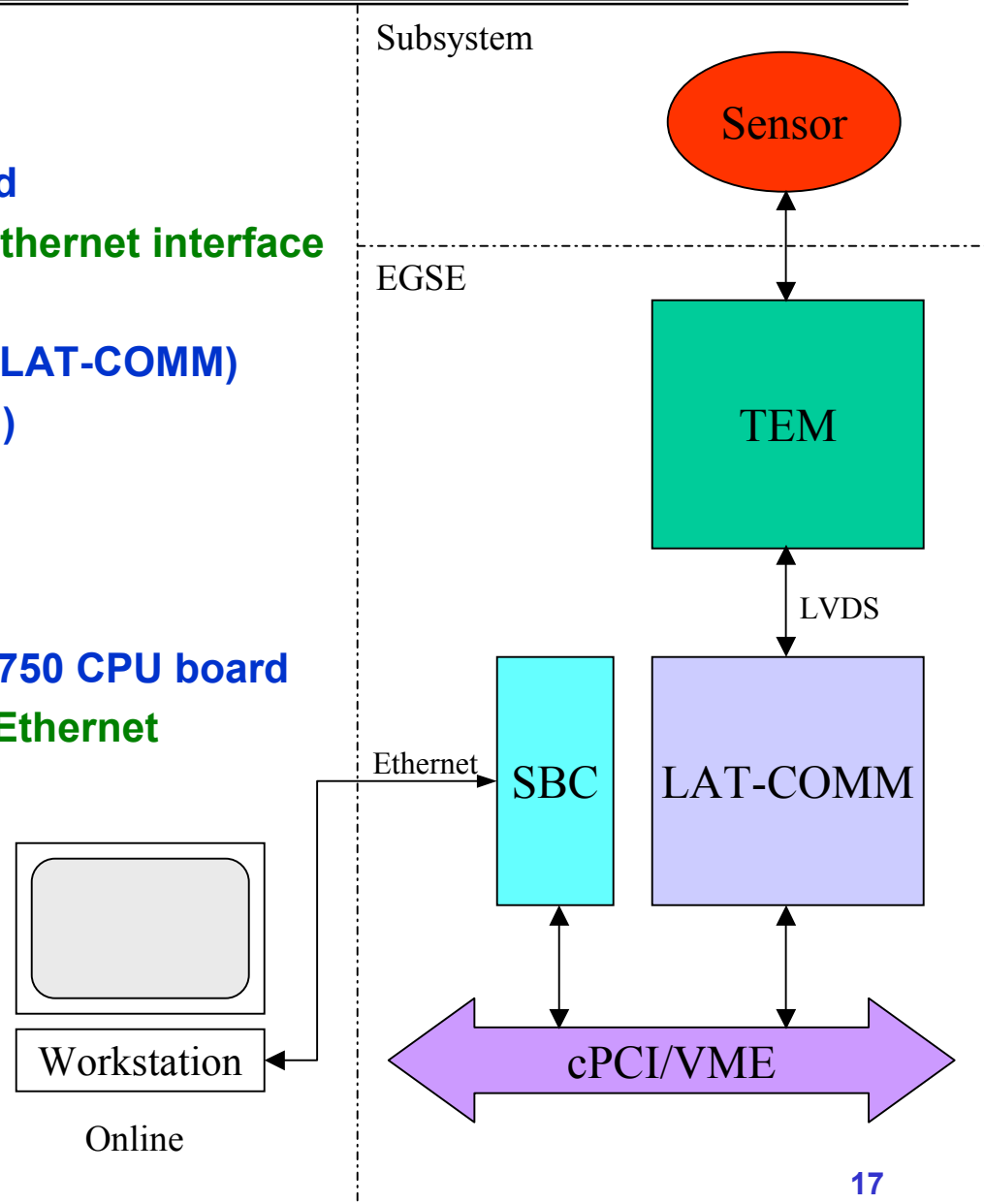
Summary

- 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

End

Engineering Model 1

- **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)

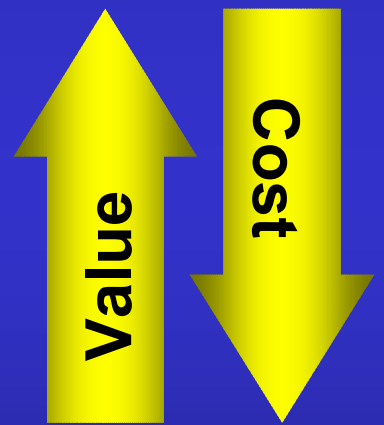
What We Do

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

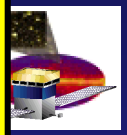
- Portable to Common Platforms
  - Windows NT/2000, Solaris, Linux, HP/UX, etc.
- Industry standards
  - TCP/IP, HTTP, FTP, SQL, XML, PKI, SSL, SMTP, etc.
- 3-Tier Architecture
- Java and C++ interfaces
- Real-Time performance
- 24/7 reliability
- Scalability – server farms, multiple hosts
- Load Balancing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



e-Command & Control

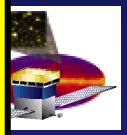
Core Components:

- 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

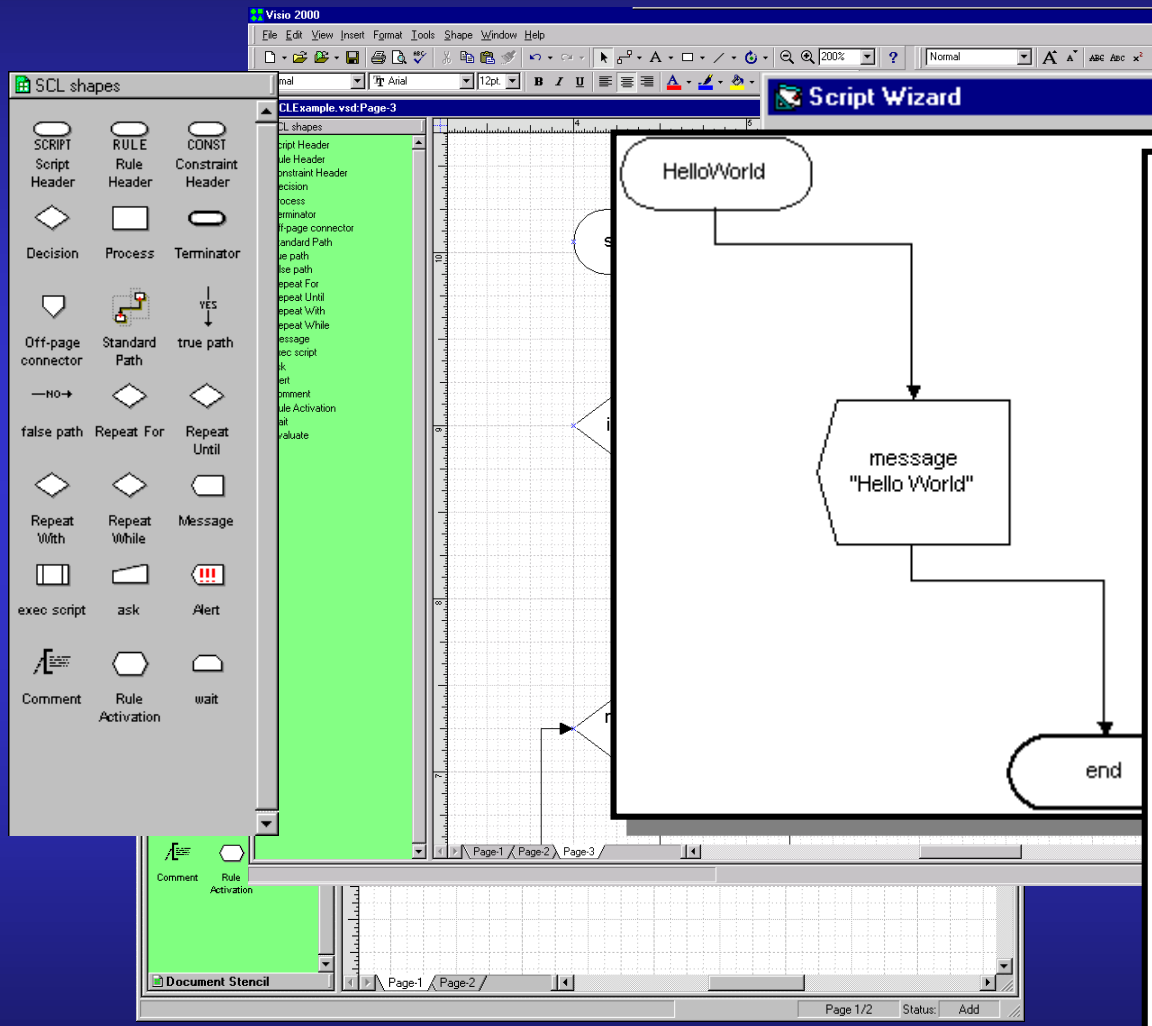
- Embrace SML/XML for a common data definition format
- Authenticate and Profile Users
- Web-based registration for events
- Modeling of and Validation of the System
- Data acquisition and decommutation
- Archive & Playback
- Real-Time Monitoring and Commanding
- e-mail alerts: desktop, cell phone, pager, 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

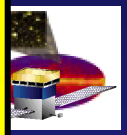
- http://www.interfacecontrol.com/sml/
- XML tag set that is vendor-neutral
- Used to define Command items, Telemetry Items, Packet Definitions, Interprocess Communications Messages, etc.
- All SCL tools are SML compliant
- Data easily exchanged with other vendors
- Submitted to ISO committees for standardization

Visual Script Builder




```
--
-- AutoGenerated Script File
-- This file was automatically generated from the visio document drawing1
-- Created By: dfrank
-- Company:
-- Generated On: 4/11/00 at 10:42:29 AM
-- Description:
--


--
--Script:HelloWorld
--Author:dfrank
--Company:
--Description: My Very First Script
--
script HelloWorld
  message "Hello World"
end HelloWorld
```



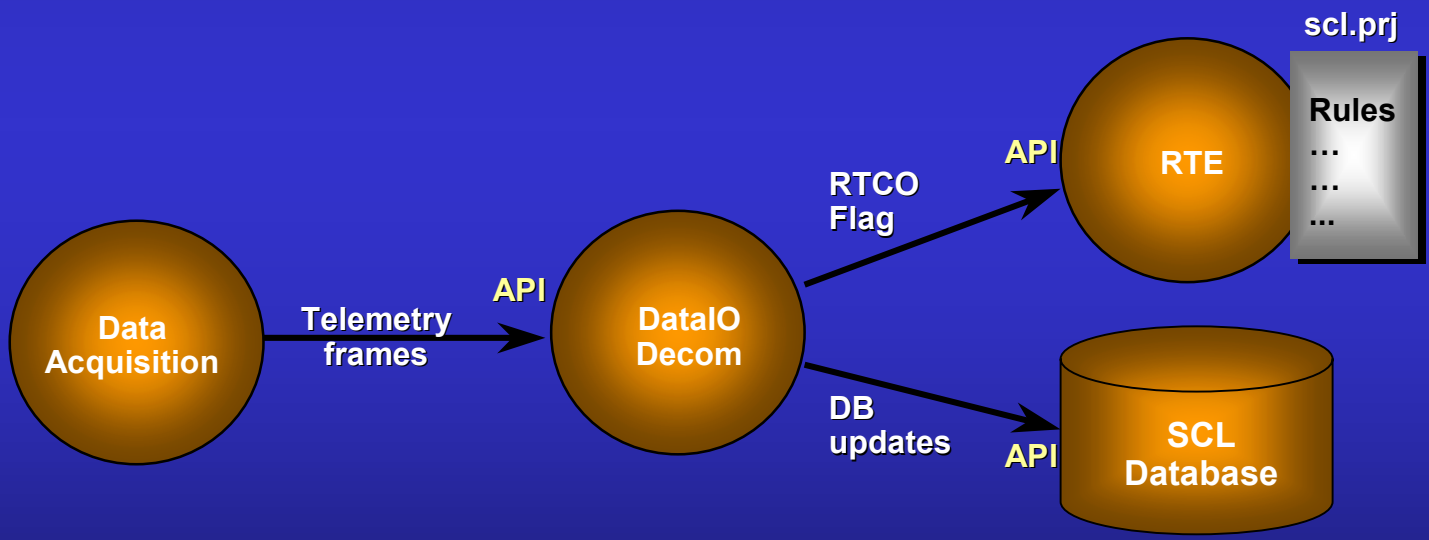
Software Bus Messaging Layer

- 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

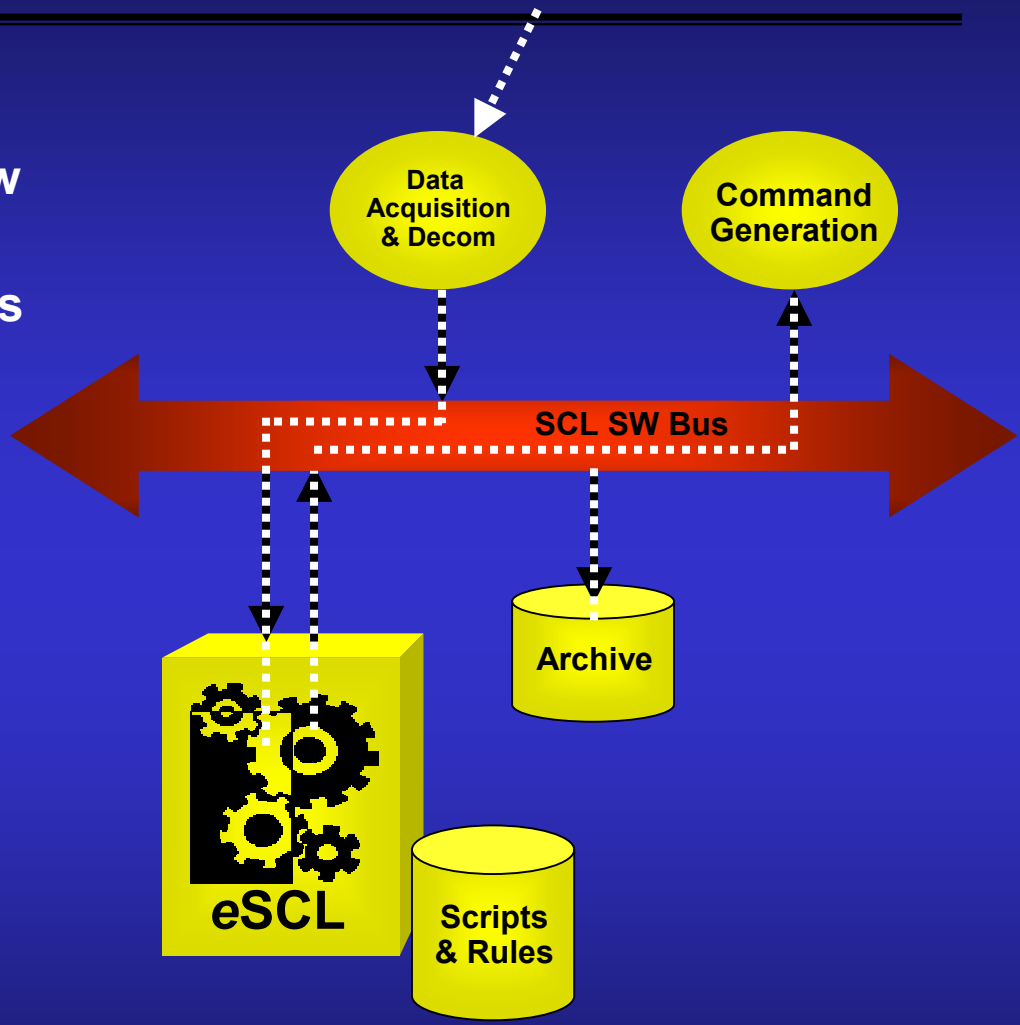
Data Acquisition and Decom

- 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



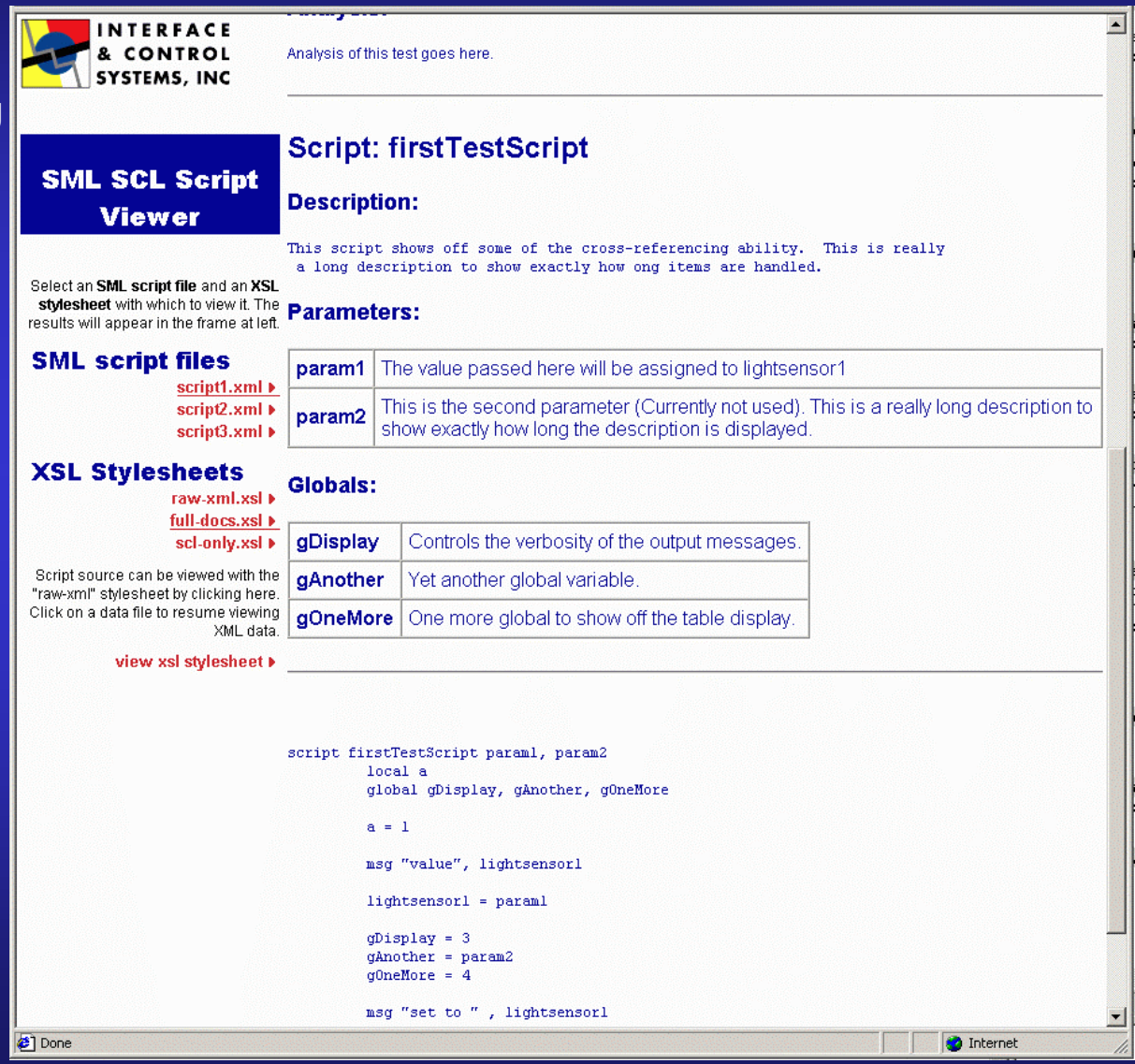
Archive and Playback

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



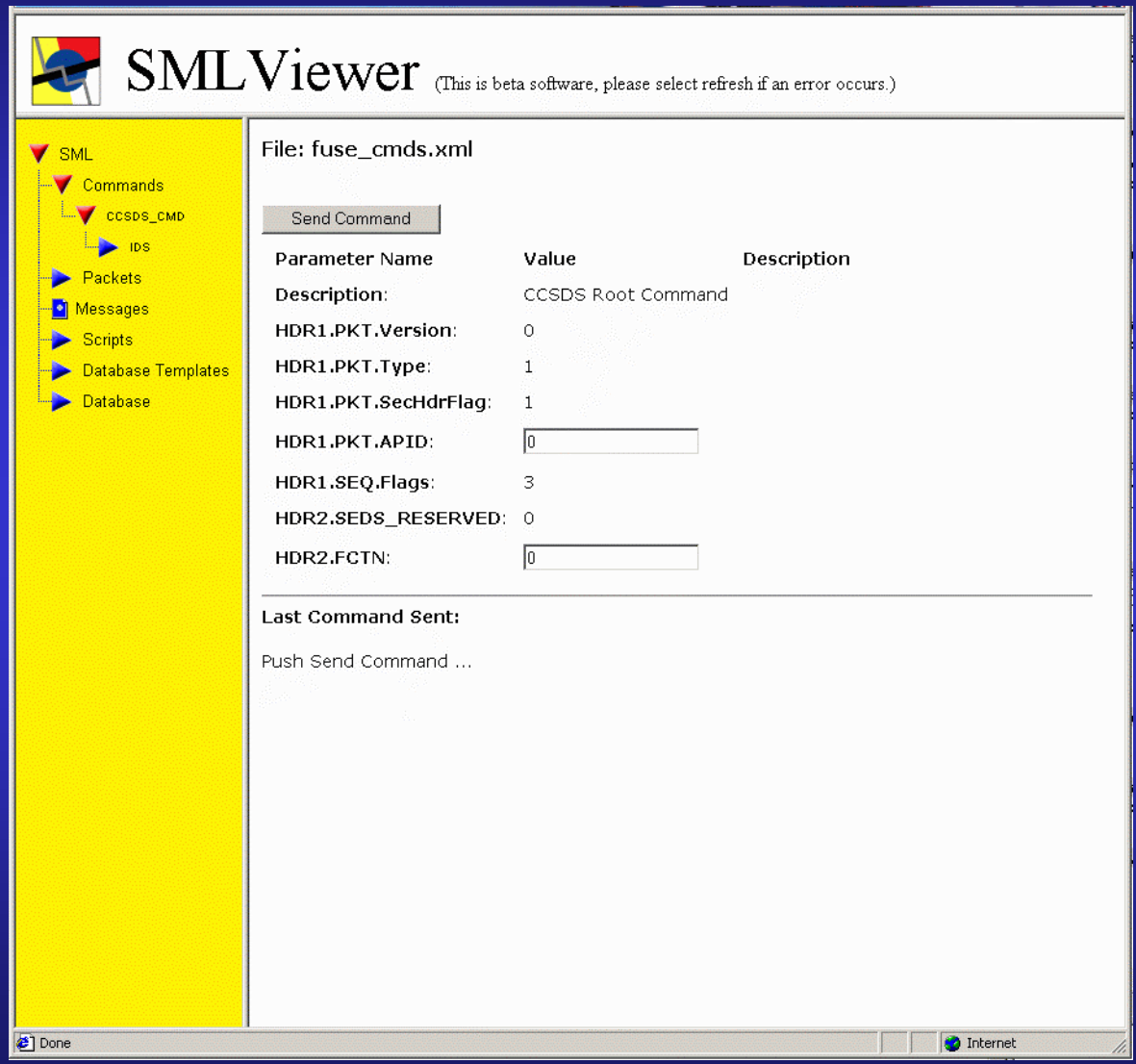
Web-Based SCL Projects

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



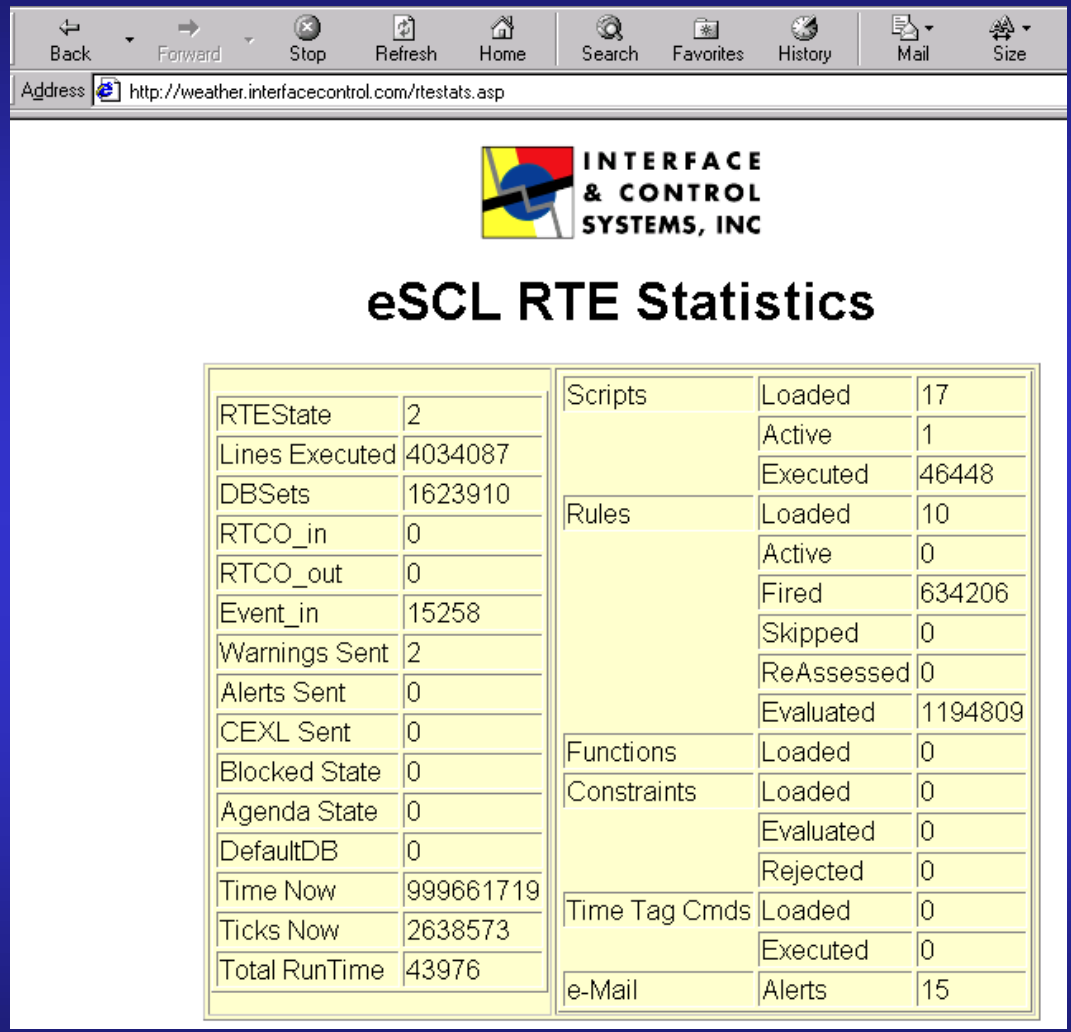
Web-Based Commanding

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



Web-Based Monitoring

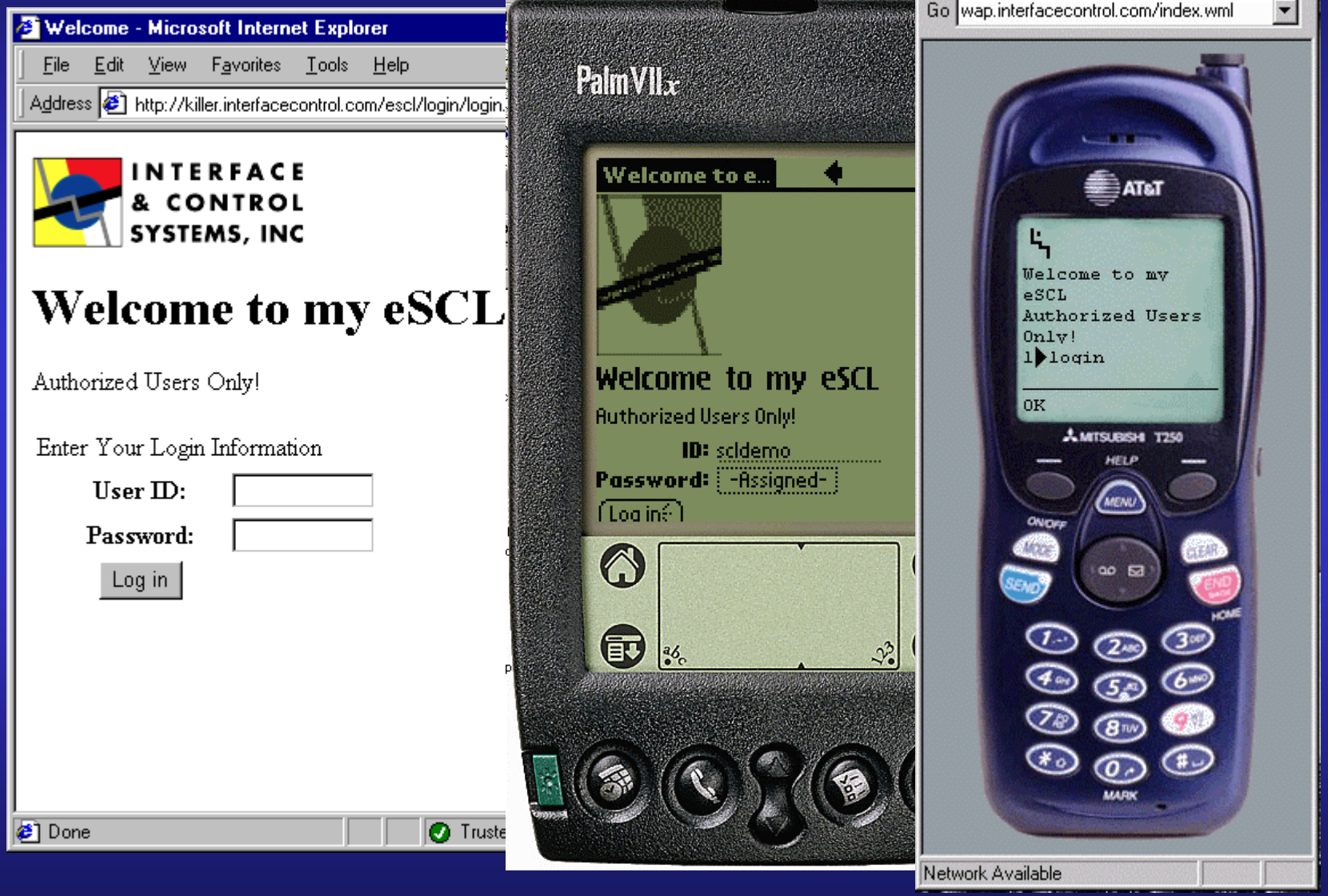
- SCL Database viewed in Browser as Text (today)
- Java Based GUI for gauges, strip charts, and meters (in work)



RTEState	2
Lines Executed	4034087
DBSets	1623910
RTCO_in	0
RTCO_out	0
Event_in	15258
Warnings Sent	2
Alerts Sent	0
CEXL Sent	0
Blocked State	0
Agenda State	0
DefaultDB	0
Time Now	999661719
Ticks Now	2638573
Total RunTime	43976

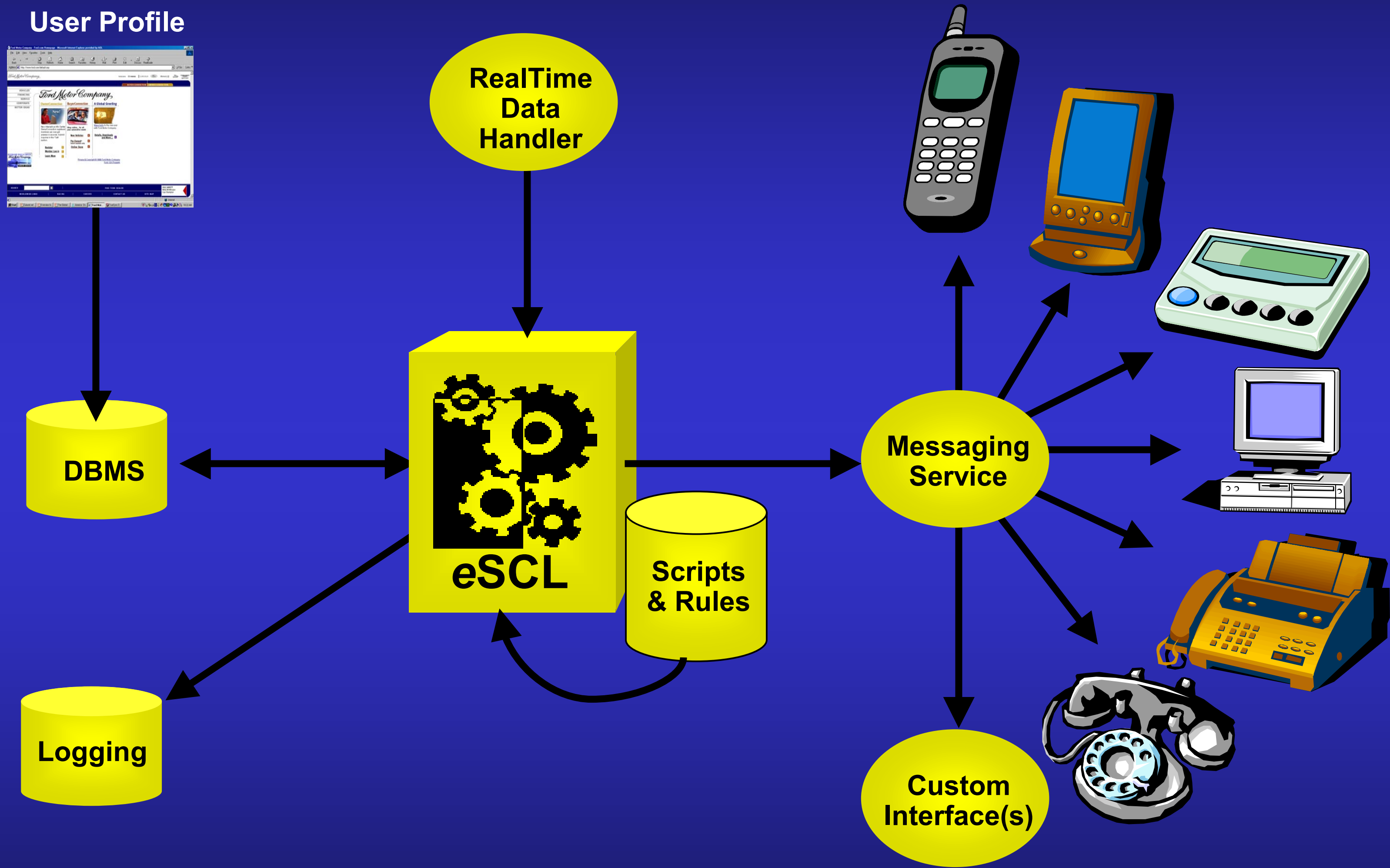
Scripts	Loaded	17
	Active	1
	Executed	46448
Rules	Loaded	10
	Active	0
	Fired	634206
	Skipped	0
	ReAssessed	0
	Evaluated	1194809
Functions	Loaded	0
Constraints	Loaded	0
	Evaluated	0
	Rejected	0
Time Tag Cmds	Loaded	0
	Executed	0
e-Mail	Alerts	15

Deliver Web Data Anywhere



Intelligent Alerts

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



Administration and Reporting

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