

Goddard Space Flight Center

JPL

UNIVERSITY OF MARYLAND

Large Incidents - August 22, 2003

Terra (MODIS)

Aqua (MODIS)

MODIS Active Fire Map

Sensor Planning Services (SPS)

EO-1 (ALI & Hyperion)

2006 AGU FALL MEETING

A Service Oriented Architecture to Enable Sensor Webs

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Introduction

- Lower cost of new Earth science products by:
 - Sharing open source science algorithms
 - Creating standard interfaces for tasking sensors via a service oriented architecture
 - Making sensor capabilities, data sources and algorithms discoverable on the Internet
 - Allowing users to create new algorithms out of existing algorithm components
- Enable rapid and cost-effective reconfiguration of new sensor webs via this architecture

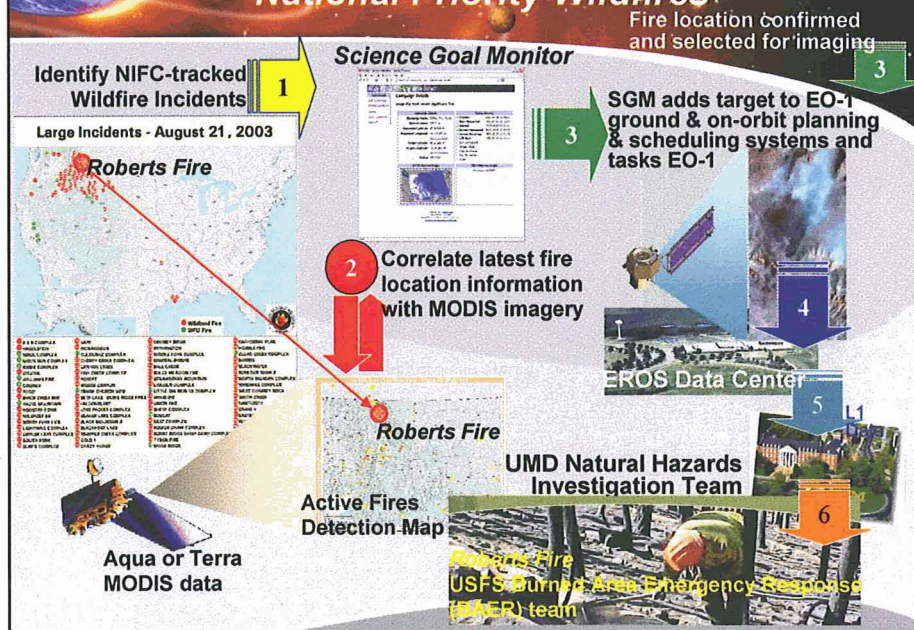
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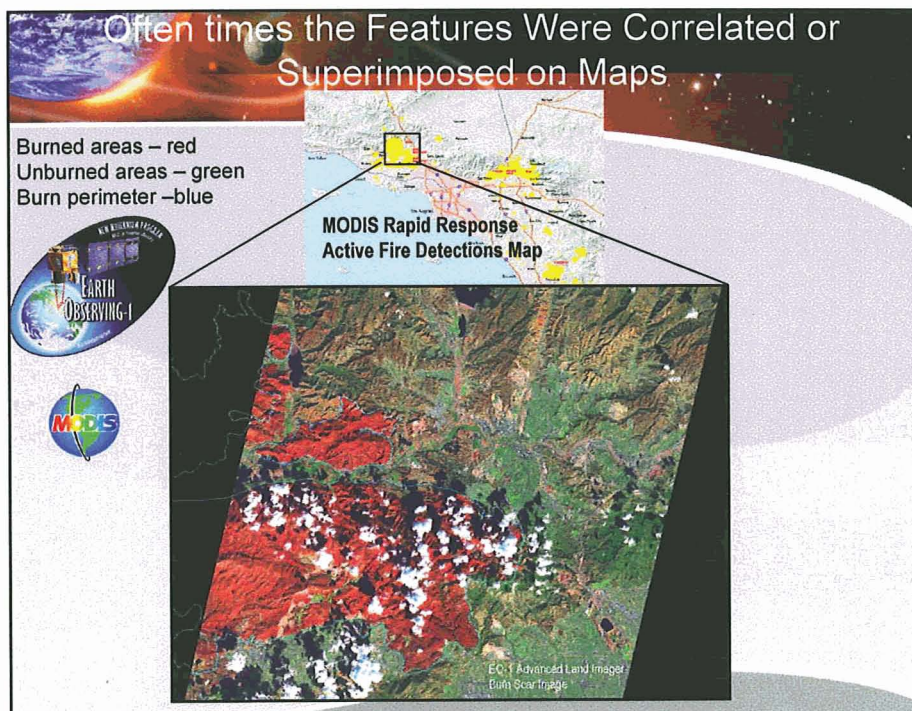
Current Way vs. New Way

	Current Way	Vision for New Way
Method to develop new algorithms	Custom	Open source building blocks
Interoperability	Low	High
Time to create & implement new algorithms/service chains	Months	Minutes
Cost to create & implement new algorithms/service chains	High	Low
Data storage and transfer requirements	High: Store/archive and transfer all sensor data	Modest to Low: Filter and transfer only needed features; archive virtual products
Ease of finding and reusing existing algorithms	Difficult	Easy with automatic discovery

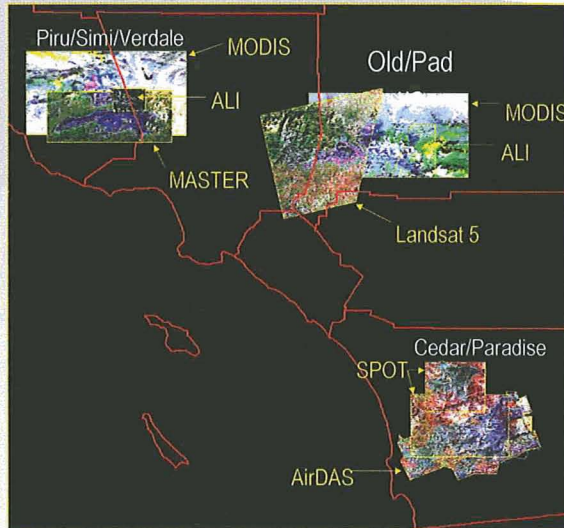
3

Our First Sensor Web Experiment with EO-1 National Priority Wildfires:





Also Needed to Implement Horizontal Sensor Data Fusion Across Multiple Sensors such as for This Set of Images of Southern California Wildfires



Assets used:

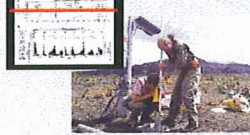
- EO-1
- SPOT
- Aqua & Terra (MODIS)
- Terra (ASTER)
- Landsat 5
- MASTER
 - Aircraft (ER-2) based MODIS & ASTER
- AirDas
 - Airborne Infrared Disaster Assessment System

7

EO-1 Volcano Sensor Web Experiment



Univ of Hawaii Volcano Alert Webpage



In Situ Networked Sensors
Kilauea, Hawaii

Targets loaded to EO-1 tasking website and ultimately uplinked to EO-1 on-board planning & scheduling system (CASPER)



ASPEN monitors volcanic "hot spots" from MODIS, AVHRR imagery & Insitu sensors



On-board thermal detection algorithms

- Re-image in < 8 hours
- Create browse images on-board
- D/L to Hawaii Volcano Observatory



HVO

8



How We Would Like to Do It

- The previous slides depicted a sensor webs that operated in slow motion and were manpower intensive to coordinate images and assemble finished science products
- The following slides are how we would like to do this same or similar processes
 - Discovery of data availability and algorithm availability
 - Automatic tasking of sensors
 - Easy specification of algorithm service chain
 - Automatic execution of service chain
 - Automatic delivery of finished science product to desktop
- First experiments being conducted under auspices of Opengeospatial Consortium (OGC) Webservices Phase 4 (OWS-4) testbed

9



User Shielded From Details By Services

- Sensor Planning Service (SPS) details or capability and availability of sensor (whether in-situ or on-orbit) and provides automatic means for user to task sensor
- Sensor Observation Service (SOS) provides observation data to user
- Web Processing Service (WPS) classified desired features
- Web Coverage Service (WCS) places features on map provided by Web Map Service (WMS)
- Language such as SensorML used to self-describe sensor capabilities and availability, thus enabling discovery of services
- Other services as depicted on next slide fill in the architecture to allow the general array of services to work together

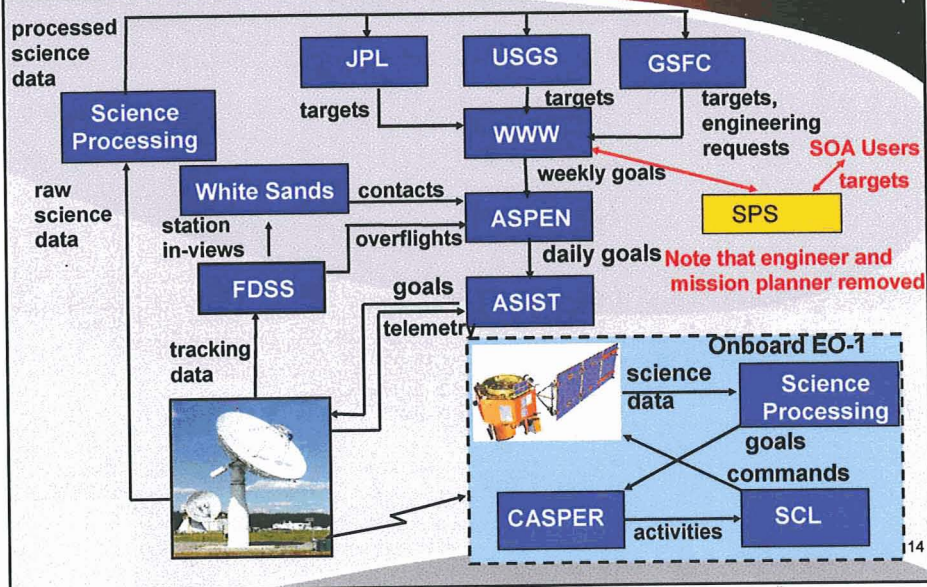
10

Target EO-1 User Scenario for OWS-4

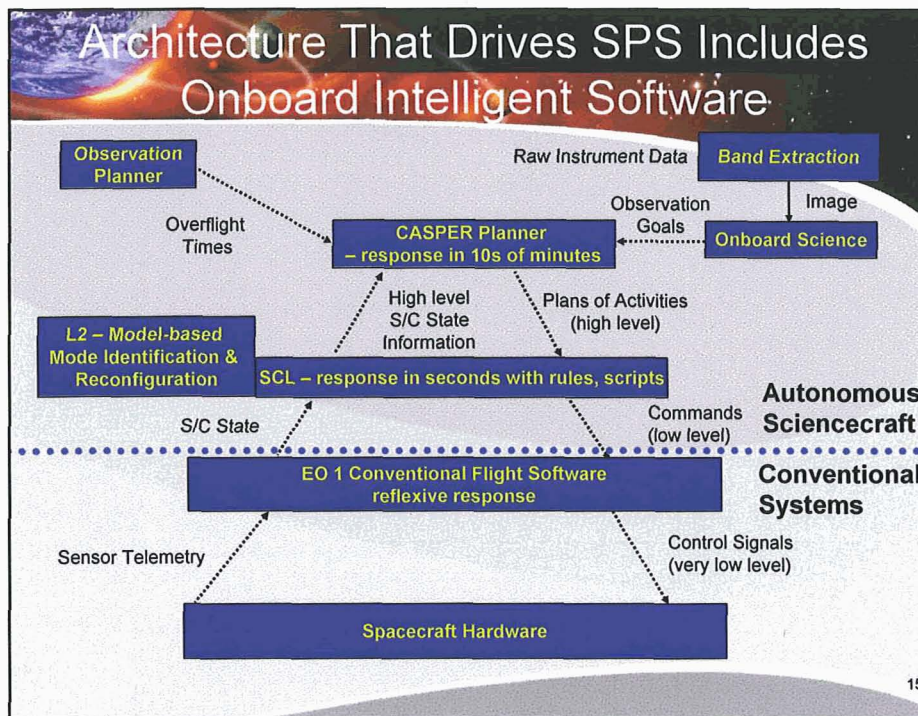
- Department of Homeland Security (DHS) analyst requests satellite imagery in disaster area to validate potential site. Catalog returns EO-1 as possible source via Catalog Services for the Web (CSW).
- Access to high resolution EO-1 data is granted based on user/role permission
- No data is available, so satellite tasking is required and achieved (at no cost to DHS via SPS service).
- Analyst is notified via instant message that Hyperion/ALI data products are available. High resolution imagery is retrieved via SOS, WCS and WFS services.

13

The Architecture Behind the SPS for EO-1



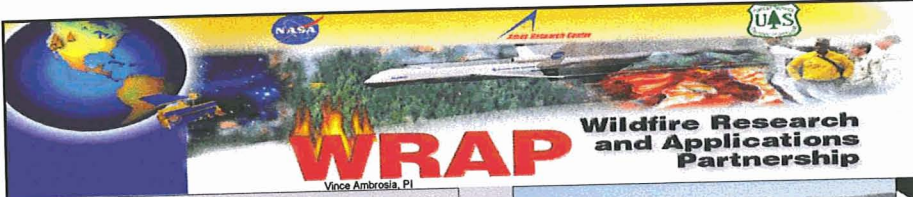
14



Other Targeted Activities:

- Add NASA/Ames Unmanned Aerial System (UAS) to sensor web with services (see next two slides)
- Add a standardized set of sub-services to enable the SPS to be reconfigured in a plug and play manner
- Use Instrument Markup Language (IML) to control various sensors
- Create a variety of WPS as standard services from the already available onboard classifiers used on EO-1 such as thermal, clouds, floods, ice, etc.
- Demonstrate ease of tasking and coordination of multiple assets via SPS's

16



WRAP Wildfire Research and Applications Partnership
Vince Ambrosia, PI

12-Channel Wildfire Scanner Specifications

Channel 1:	0.42 - 0.45 μm
Channel 2:	0.45 - 0.52 μm
Channel 3:	0.52 - 0.60 μm
Channel 4:	0.60 - 0.62 μm
Channel 5:	0.63 - 0.69 μm
Channel 6:	0.69 - 0.75 μm
Channel 7:	0.76 - 0.90 μm
Channel 8:	0.91 - 1.05 μm
Channel 9:	1.55 - 1.75 μm
Channel 10:	2.08 - 2.35 μm
Channel 11:	3.60 - 3.79 μm (VIIRS M12)
Channel 12:	10.26 - 11.26 μm (VIIRS M15)

FOV: 42.5 or 85.9 degrees (selectable)
IFOV: 1.25 mrad or 2.5 mrad (selectable)
Spatial Res.: 3 - 50 meters (altitude dependant)

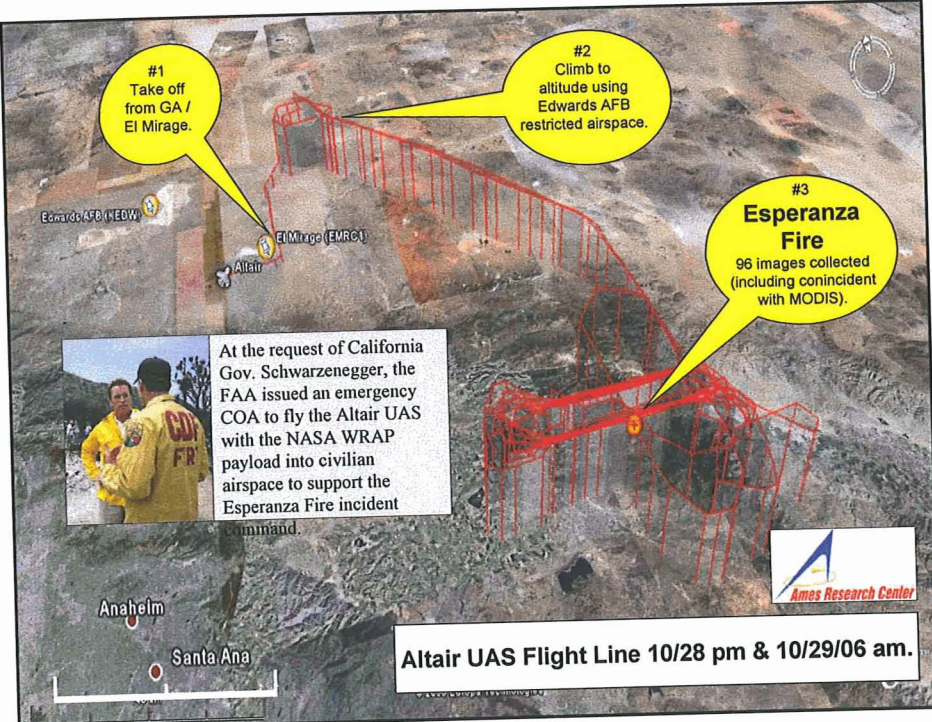


General Atomics Altair UAS

Also compatible with the GA Mariner, Predator-B & Cessna Caravan C208.

- Targeting input from NIFC, MODIS Rapid Response, and GOES.
- Onboard, real-time geolocation and product generation for both imagery and fire detects.
- Browse and fire detects available via Google Earth interface within ca. 4 minutes.
- Cal/Val coordination with MODIS Land Team and CEOS-LPV.
- Activities in plan with AIST Pls for SensorWeb implementation in concert with MODIS and EO-1.

17



#1
Take off from GA / El Mirage.

#2
Climb to altitude using Edwards AFB restricted airspace.

#3
Esperanza Fire
96 images collected (including coincident with MODIS).

At the request of California Gov. Schwarzenegger, the FAA issued an emergency COA to fly the Altair UAS with the NASA WRAP payload into civilian airspace to support the Esperanza Fire incident command.

Ames Research Center

Altair UAS Flight Line 10/28 pm & 10/29/06 am.



Conclusion

- Integrating sensors with open source, interoperable reusable science services facilitates the vision of Global Earth Observing System of Systems
- Creating these open services, lowers the cost of performing science analysis and creating new methods
- With the OGC or similar standards, any set of sensors can become a virtual sensor web
- Data volume is greatly reduced since only virtual products stored and desired products produced on-demand

19



Glossary

BPEL – Business Processing Execution Language
DSS -- Decision Support System
ebRIM -- Enterprise Business Registry Information Model
SOS – Sensor Observation Service
CSW – Catalog Services For the Web
SPS – Sensor Planning Service
GMSEC – Goddard Mission Services Evolution Center
WCS – Web Coverage Service
IML – Instrument Markup Language
WCTS – Web Coordinate Transformation Service
SAS – Sensor Alert Service (Pub/Sub)
WFS – Web Feature Service
WMS – Web Map Service
WPS – Web Processing Service

20

Backup Slides

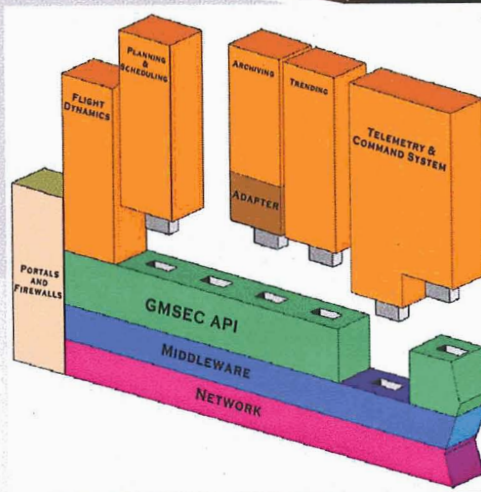
21

Underlying "Plug and Play" Message Bus Architecture-- Goddard Mission Services Evolution Center (GMSEC)

GMSEC architecture provides a scalable and extensible ground and flight system approach

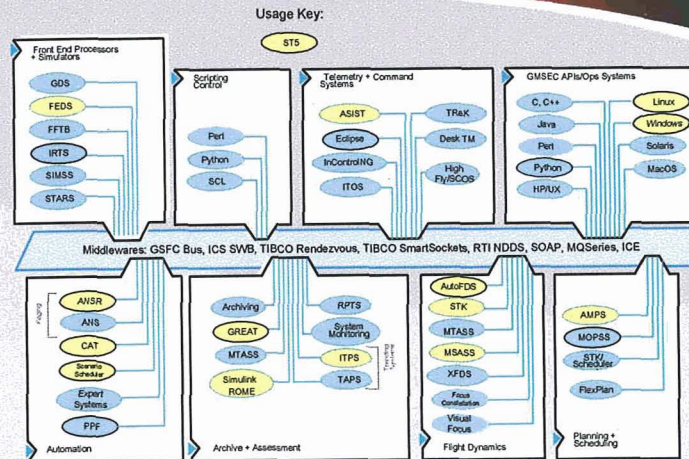
- Standardized messages formats
- Plug-and-play components
- Publish/Subscribe protocol
- Platform transparency
- ST5 first mission to be totally GMSEC compliant

More info at:
<http://gmsec.gsfc.nasa.gov>



22

Example of Rapid Mission Configuration Using GMSEC Interoperable Catalog Components



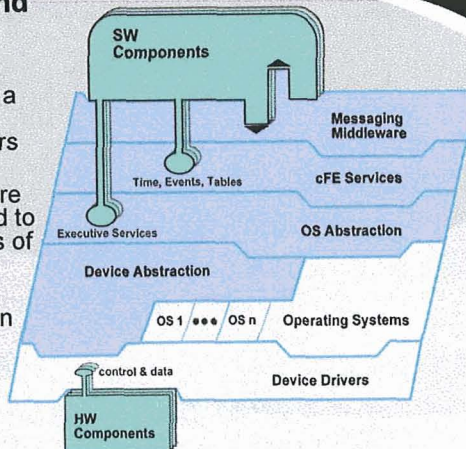
GMSEC approach gives users choices for the components in their system. The ST-5 mission rapidly selected key components from the GMSEC catalog.

23

Core Flight Executive (cFE), an Extension for GMSEC for Flight SW

cFE provides a framework that simplifies the development and integration of applications

- Layered Architecture – software of a layer can be changed without affecting the software of other layers
- Components communicate over a standard message-oriented software bus, therefore, eliminating the need to know the details of the lower layers of inter-networking.
- Software components can be developed and reused from mission to mission.
- Developed by Flight SW Branch at GSFC
- To be used on LRO
- More info at: <http://gmsec.gsfc.nasa.gov>



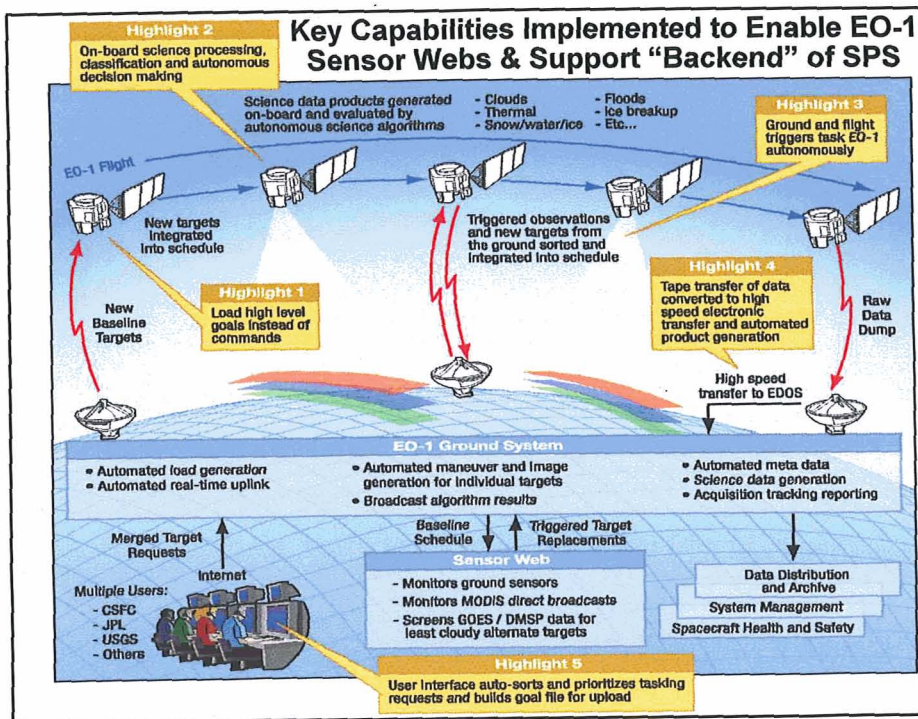
24

Advantages of SOA for Space Sensors

- Networked standardized interface connections, loosely coupled
 - Components connected at run-time
- Enables discovery of services
- Hides details of how service performed (encapsulated implementation)
- Fault tolerant
 - Since connection occurs at run-time, if service not available, a component can find or "discover" an alternative service and if unavailable, can connect to another instance of the service if available
 - Troubleshooting is easier because information is provided at component and services level
- Highly reusable
 - Standardized, networked "plug and play" interfaces
- Scalable
 - Interactions between services and clients independent of location and numbers
- Sustaining engineering for constellation simplified
 - Can initiate new instance of service or alternative service and then disconnect old services

Taken from: Hartman, Hoebel; "Lightweight Service Architectures for Space Missions", SMC-IT 2006, Pasadena, Ca

25



Various EO-1 Sensor Web Experiments Conducted

