EO-1 Mission Autonomy Evolution

AIAA Infotech @ Aerospace 2010
Space Autonomy Session

Daniel Mandl - NASA/GSFC 4/21/10

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Evolution of Automation and Autonomy Software on Earth Observing 1

- Streamlined Earth Observing 1 (EO-1) operations over past 10 years by integrating automation and autonomy
  - Installed Autonomous Science Experiment (ASE) flight software in 2003
  - Added Open Geospatial Consortium (OGC) Sensor Web Enablement (SWE) compatible web service interfaces in 2008
  - Added OGC compatible data processing web service interfaces and software to automate data product production 2008/2009
  - Added Campaign Manager for workflow management to orchestrate the various OGC web services and to provide greater user access to EO-1 in 2008/2009
- Experimenting with OGC standards to provide easier user access to flight software

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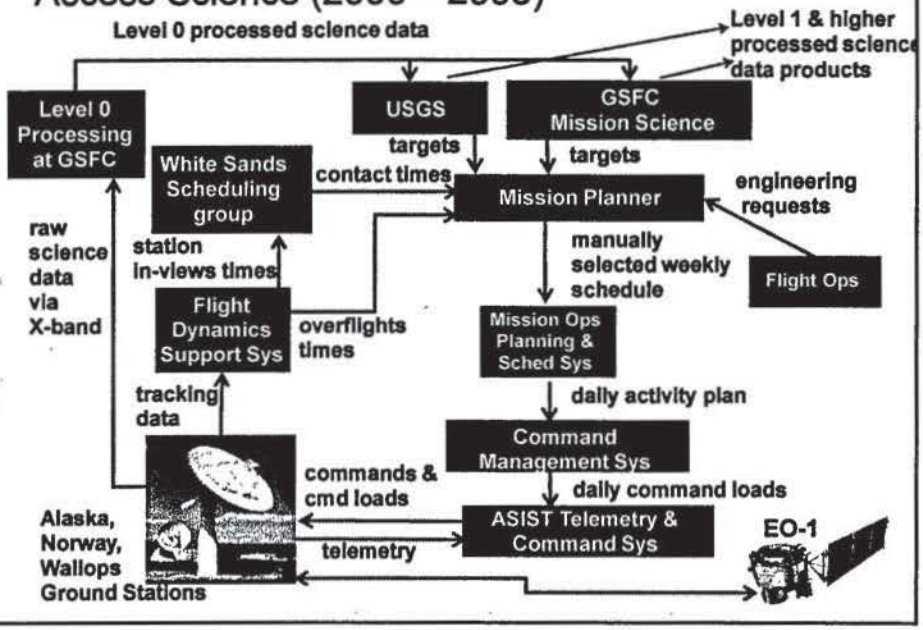
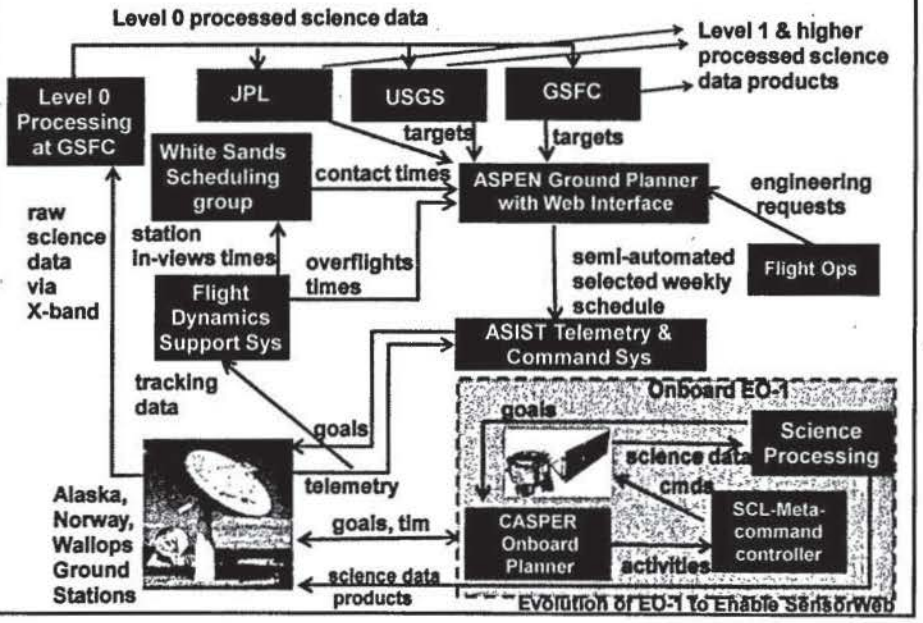
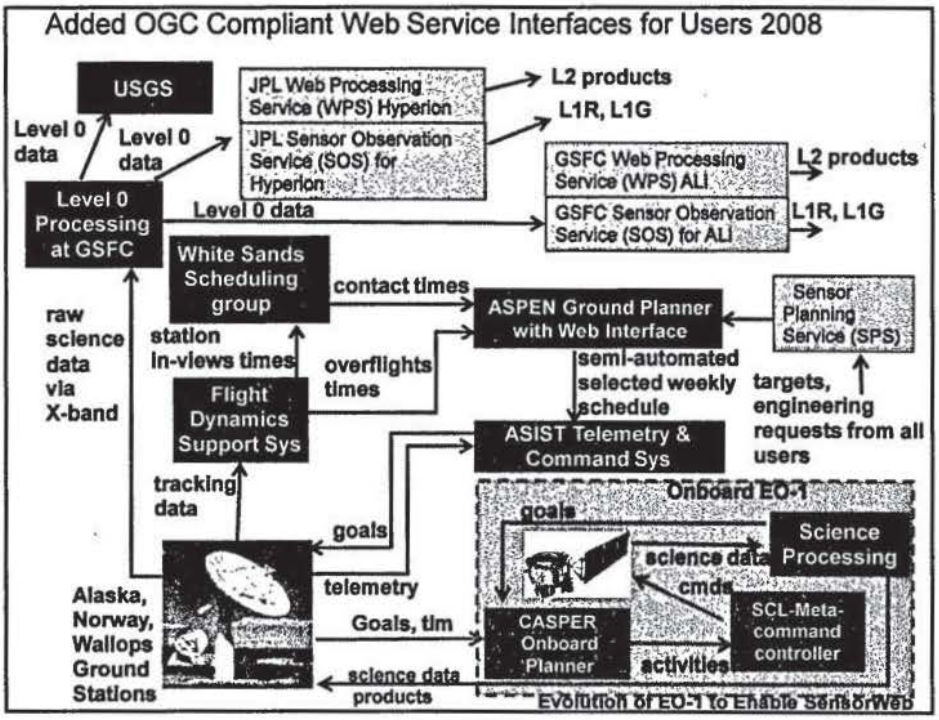
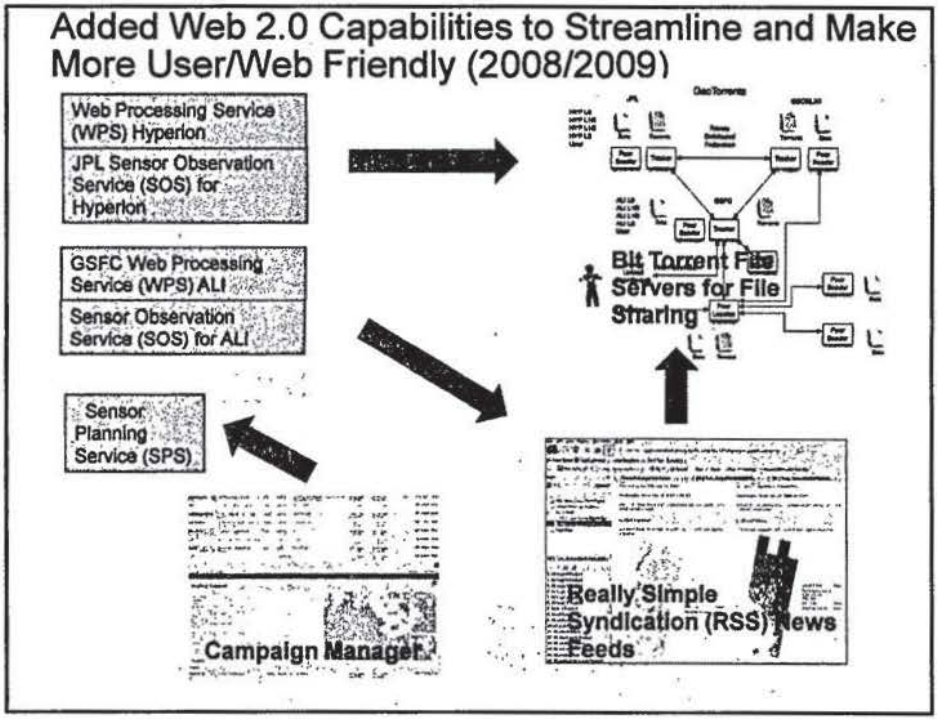
EO-1 Original Operations Flow to Task Sensors & Access Science (2000 – 2003)



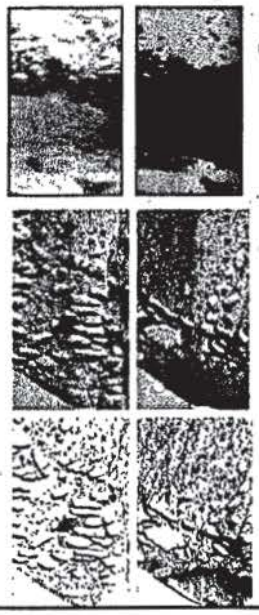
Revised Operations Flow To Task Sensors and Access Science Data Using Onboard Autonomy (2003 – 2007)




Added OGC Compliant Web Service Interfaces for Users 2008
USGS
Level 0 data
Level 0 data
Level 0 Processing at GSFC
JPL Web Processing Service (WPS) Hyperion
JPL Sensor Observation Service (SOS) for Hyperion
L2 products
L1R, L1G
GSFC Web Processing Service (WPS) ALI
GSFC Sensor Observation Service (SOS) for ALI
L2 products
L1R, L1G
Level 0 data
White Sands Scheduling group
contact times
ASPEN Ground Planner with Web Interface
Sensor Planning Service (SPS)
raw science data via X-band
station in-views times
overflights times
Flight Dynamics Support Sys
semi-automated selected weekly schedule
targets, engineering requests from all users
ASIST Telemetry & Command Sys
tracking data
goals
telemetry
Onboard EO-1
goals
science data
Science Processing
cmds
Alaska, Norway, Wallops Ground Stations
Goals, tim
CASPER Onboard Planner
activities
SCL-Meta-command controller
science data products
Evolution of EO-1 to Enable SensorWeb


Added Web 2.0 Capabilities to Streamline and Make More User/Web Friendly (2008/2009)
Web Processing Service (WPS) Hyperion
JPL Sensor Observation Service (SOS) for Hyperion
GSFC Web Processing Service (WPS) ALI
Sensor Observation Service (SOS) for ALI
Sensor Planning Service (SPS)
Bit Torrent File Servers for File Sharing
Really Simple Syndication (RSS) News Feeds
Campaign Manager

Examples of Onboard Processing with Possible Autonomous Triggers



Cloud classifier

Thermal classifier for volcanoes and fires

Sulfur classifier added July 2007

Snow, water, ice, land (SWIL) classifier

As of July 20, 2007:

Total images taken for life of EO-1 mission = approx 35,000

STATUS of ASE initiated images

	Mission	Last Week	Yesterday	Upcoming
Images Taken	11821	79	2	46
Sensorweb	1637	0	0	0
Science Scenarios Executed	1251	2	0	1
Position Triggers	230	0	0	
Ground Contacts	11222	64	10	43
X-Band	3570	28	1	13
S-Band	7352	55	9	30
Planner Goals	94030	556	33	201

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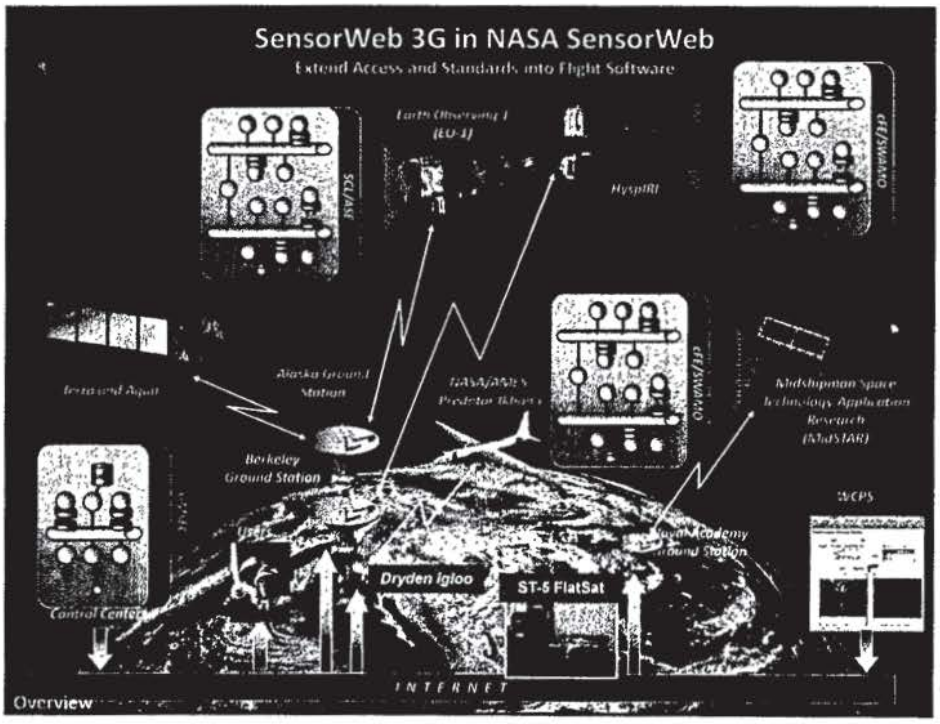
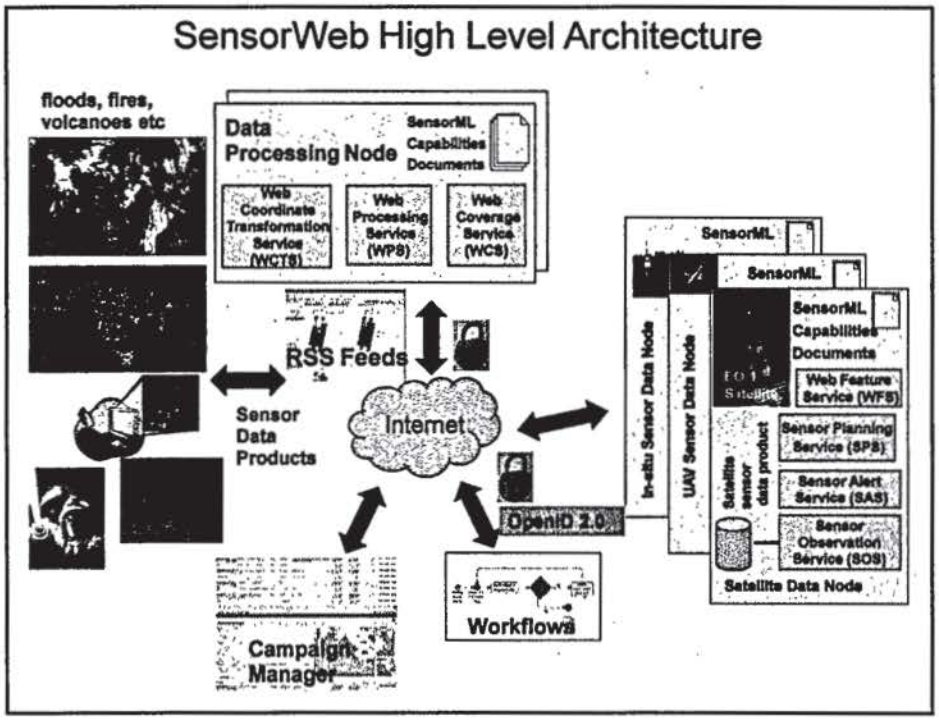
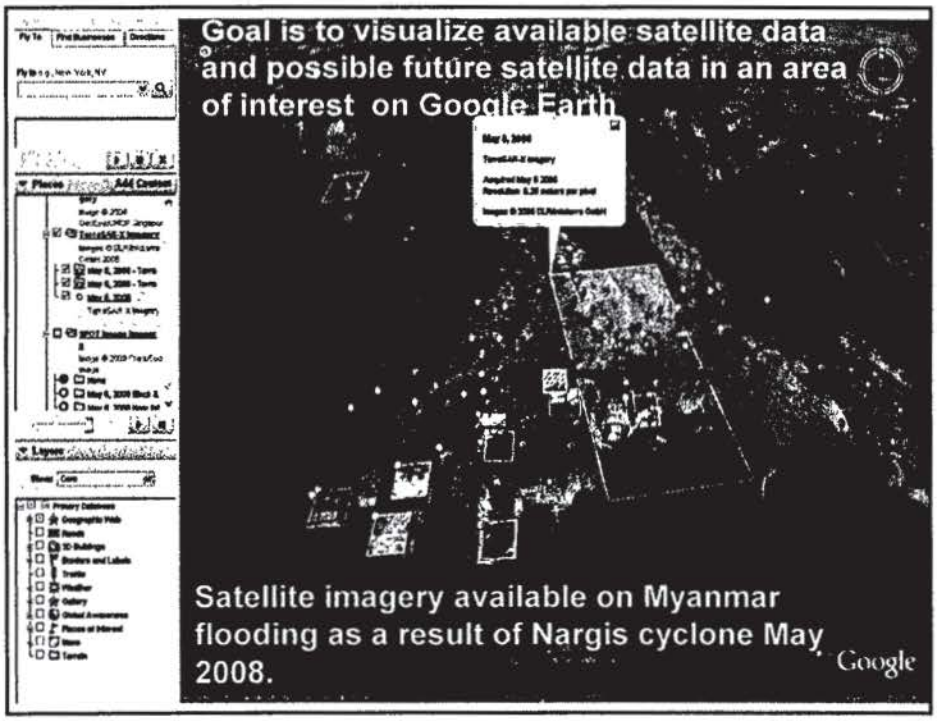
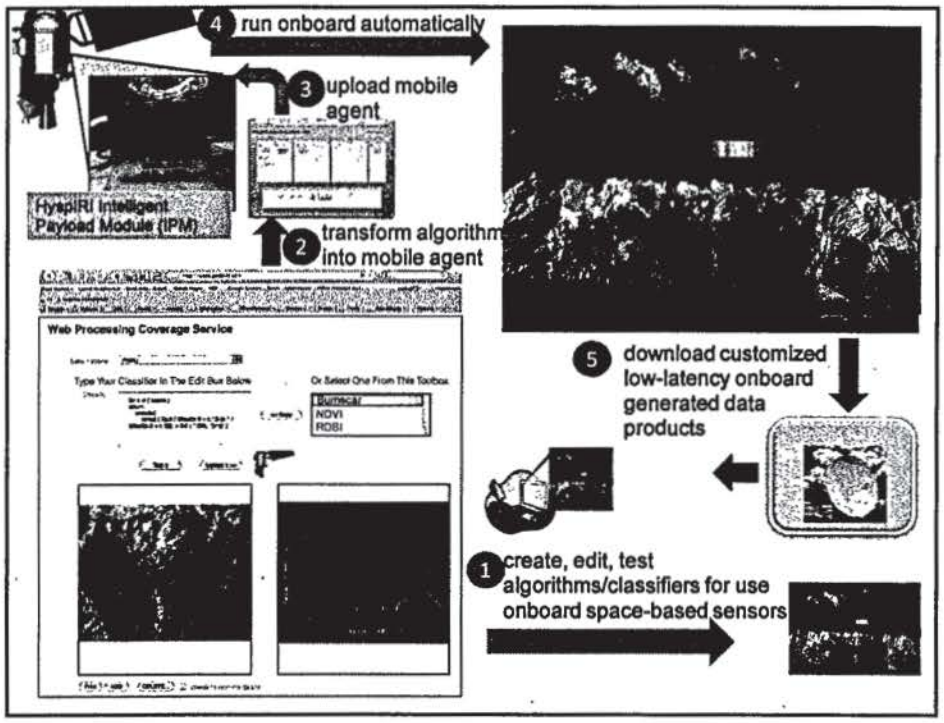



SensorWeb High Level Architecture
floods, fires, volcanoes etc
Data Processing Node
SensorML Capabilities Documents
Web Coordinate Transformation Service (WCTS)
Web Processing Service (WPS)
Web Coverage Service (WCS)
RSS Feeds
Sensor Data Products
Internet
OpenID 2.0
Workflows
Campaign Manager
SensorML
SensorML
SensorML Capabilities Documents
Web Feature Service (WFS)
Sensor Planning Service (SPS)
Sensor Alert Service (SAS)
Sensor Observation Service (SOS)
Satellite Data Node
In-situ Sensor Data Node
UAV Sensor Data Node
Satellite sensor data product


Goal is to visualize available satellite data and possible future satellite data in an area of interest on Google Earth
Satellite imagery available on Myanmar flooding as a result of Nargis cyclone May 2008.
Google


4 run onboard automatically
3 upload mobile agent
HyspIRI Intelligent Payload Module (IPM)
2 transform algorithm into mobile agent
Web Processing Coverage Service
5 download customized low-latency onboard generated data products
1 create, edit, test algorithms/classifiers for use onboard space-based sensors