Autonomous Closed-loop Tasking, Acquisition, Processing, and Evaluation for Situational Awareness Feedback

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Overview of Features

• Closed loop satellite autonomy closes the gap between the users and the assets
• Base layer is distributed architecture based on GMSEC bus so each asset still under independent control
• Situational awareness provided by middleware layer through common application programmer interface to GMSEC components developed at GSFC
• User setup their own tasking requests, receive views into immediate past acquisitions in their area of interest, and into future feasibilities for acquisition across all assets
• Automated notifications via pub/sub feeds returned to users containing published links to image footprints, algorithm results, and full data sets
• Theme-based algorithms available for on-demand and processing
Example Ground System Architecture (NASA EO-1) for Autonomous Closed-loop Tasking, Acquisition, Processing, and Evaluation for Situational Awareness Feedback
Distributed Architecture on GMSEC Bus

• Middleware services provide rest-ful API (not SOAP-WSDL interface)
• Nothing is centralized so no single point of failure
• Based on free-ware or open-source tools under the hood so minimal license fees
• Client workflows are orchestrated in javascript or Python using browser on user platform
• Servers run on Linux
Single Sign-On to All Middleware Services

- Security for access to services should be single sign-on handled by a distributed network of security servers that allow users to sign on once, then as they access other services in the network, those services verify with the security servers that the user is allowed to access and perform certain functions.

- This should apply not only to human interactions with the system, but with delegated authority to have machine-to-machine automated interactions on the users behalf.

Welcome To the NASA GSFC SensorWeb OpenID Server (BETA 1)

Now supporting Verisign Identity Protection (VIP) Services for two-factor authentication

Please get your own credentials ASAP for a more secure access to the system

Building Securely The GEOSS Federation One Node At a Time...

Please Login or New Account
Target Identification and Submittal

- Users setup their own target requests using either coordinate entry, map box, or geonames (similar to an archive search tool)
- Users view their target requests as footprint locations on a map tool
- In-view dates and acquisition times for the target requests are automatically generated as feasibilities for all satellite assets going out at least 5 days
- Total column cloud predictions for each target in-view time and footprint location automatically supplied and updated every 3 hours going forward about 3 days
- Users are made aware of asset engineering activities that could block their request submittal from being executed
- Users view competing requests from other users to be able to judge likelihood of acquisition in support of task submittal decision making
- Near-term target requests are submitted to the scheduling system of each asset and the status of each request is maintained and visible to the users (status = submitted, scheduled, uplinked, acquired, downlinked, posted)
- Setup of a user target request automatically generates a subscription to receive notifications of data receipt for all images acquired in that target request area
- (See next page for example display)
# Sample User Target Setup

## Scenario/Campaign Entries

<table>
<thead>
<tr>
<th>Name</th>
<th>Content</th>
<th>Theme</th>
<th>User</th>
<th>Scenario Requests</th>
<th>Created At</th>
<th>Updated At</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>South America Science 2016</td>
<td>South America Science 2016</td>
<td>air</td>
<td>sfye</td>
<td>King Sejong Station site, La Cigüena Santa Fe, Sinop Mato Grosso,...</td>
<td>01/26/2016 02:48 PM</td>
<td>01/26/2016 02:48 PM</td>
<td>0.0</td>
</tr>
<tr>
<td>Kwando River Blockage</td>
<td>Kwando River Blockage Namibia/Angola border</td>
<td>flooding</td>
<td>sfye</td>
<td>Kwando River Blockage</td>
<td>01/19/2016 01:52 PM</td>
<td>01/19/2016 01:52 PM</td>
<td>0.0</td>
</tr>
<tr>
<td>Argentina Floods 20161015</td>
<td>Charter Activation for Argentina Floods 20161015</td>
<td>flooding</td>
<td>sfye</td>
<td>Formosa Argentina 20161015 Charter, Asuncion Argentina 20161015 Charter</td>
<td>01/06/2016 07:07 PM</td>
<td>01/06/2016 07:07 PM</td>
<td>0.0</td>
</tr>
</tbody>
</table>

## Scenario/Campaign Tasking Requests for Argentina Floods 20161015

<table>
<thead>
<tr>
<th>Id</th>
<th>Name</th>
<th>Content</th>
<th>Geolocation</th>
<th>Daytime Time</th>
<th>Center</th>
<th>Duration</th>
<th>Scenario Feasibilities</th>
<th>Scenario Requests Tasks</th>
<th>Created At</th>
<th>Updated At</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>5307</td>
<td>Asuncion Argentina 20161015 Charter</td>
<td>Asuncion Argentina 20161015 Charter</td>
<td>-25.3, -57.78</td>
<td>day time</td>
<td>Hyperion</td>
<td>12s</td>
<td></td>
<td>-</td>
<td>12/30/2015 01:09 AM</td>
<td>12/30/2015 02:15 PM</td>
<td>0.0</td>
</tr>
<tr>
<td>5406</td>
<td>Formosa Argentina 20161015 Charter</td>
<td>Formosa Argentina 20161015 Charter</td>
<td>-26.158, -58.365</td>
<td>day time</td>
<td>Hyperion</td>
<td>12s</td>
<td></td>
<td>-</td>
<td>12/30/2015 01:09 AM</td>
<td>12/30/2015 02:15 PM</td>
<td>0.0</td>
</tr>
</tbody>
</table>

| Mississippi River 20151229                | Mississippi River 20151229                   | flooding     | sfye          | Cape Girardeau MO 20151229, Vicksburg MS 20151229, St. Louis 20151229,...         | 12/28/2015 03:19 PM | 12/28/2015 03:19 PM | 0.0    |
| Garland Texas 20151227                    | Garland Texas 20151227                      | flooding     | sfye          | Garland Texas 20151227                                                              | 12/24/2015 07:28 PM | 12/24/2015 07:28 PM | 0.0    |
| Holly Springs MS 20151223                 | Holly Springs MS 20151223                   | flooding     | sfye          | Holly Springs/Ashton MS 20151223, Booneville MS 201512/23                         | 12/21/2015 09:26 PM | 12/21/2015 09:26 PM | 0.0    |
| Shenzen China Landslide 20151221         | Shenzen China Landslide 20151221           | landslide    | sfye          | Shenzen China Landslide 20151221                                                 | 12/14/2015 02:07 PM | 12/14/2015 02:07 PM | 0.0    |
| Philippines Typhoon Melor                 | Philippines Typhoon Melor 20151214          | flooding     | sfye          | Philippines Typhoon Melor 20151214, Philippines Typhoon Melor Naga, Philippines Typhoon Melor Manila | 12/10/2015 08:13 PM | 12/11/2015 08:04 PM | 0.0    |
| Nevado del Ruiz, Colombia                 | Nevado del Ruiz activity                    | volcano      | eanderson     | Nevado del Ruiz activity                                                            | 12/10/2015 08:13 PM | 12/11/2015 08:04 PM | 0.0    |
Awareness for Timing of Delivery

- Users know in advance on a constantly updated basis exactly when to expect data from the next day's acquisitions from all satellites.
- Image delivery availability and quality assessment used as input to the planning/scheduling for the following day's collections.
  - For example, Landsat-8 data is acquired and assessed in time to affect decision about tasking for next EO-1 in-view target-by-target.
Rapid Assessment of Recent Images

- User is provided rapid assessment immediately after new images have been taken to visualize the image quality/cloud cover
  - Geolocated scene overlays of recently acquired data are published and notifications automatically fed to users in a compact file format that is appropriately named (asset ID, date, time, center-point coordinates, relevant geonames)

- Users are sent the image overlays and combine them with planned future footprints without having to search for them
  - Each asset posts image data in a centralized system, but users have particular information delivered to their consumer client on a distributed basis from regional product publishers

- The users can track which targets have been acquired vs. which ones aren't yet including not only the user’s own target requests, but all images in the users’ area of interest regardless of who submitted them
  - If an image was just taken of an area that fulfills the needs of some other user that was about to submit it for scheduling, then that user doesn’t have to submit their request
Recent Acquisition Notification Process

Acquisition notifications are sorted with links to products.

Upcoming collections are displayable on a map and on a timeline.
Autonomous Delivery of Recent Acquisitions to Regional Publishers for Browse Imagery and Classification/Detection Product Processing

Regional GeoSocial API Publisher/Consumer Network (HTML/HTTPS)

This is a NEW method to distribute EO-1 and other satellite data products in a compact vectorized format (small data size TopoJSON). The vision is to have a network of regional publishers automatically pre-generate specific satellite data products for a region and then make them available to all consumers in that region. The user obtains the data product by doing a Web browser query based on latitude-longitude. The publisher then provides the user a list of the available products in the region. The user clicks on the ones he/she wants to map and the vectorized data is downloaded to their computer, tablet, or smartphone for display. It is built in to share the products via Facebook/Twitter or other social media with a single click.
Cloud-based Processing and Delivery Overview

Distributed Cloud Architecture for EO-1 Data Product Distribution and Tasking Requests

Level 1R and Level 1G Processing for ALI & Hyperion
Co-registration with Landsat GLS

Matsu Cloud

Web Coverage Processing Service (WCPS)

Namibia Flood Dashboard

Regional/Consumer Node (aggregator)
(Ruby version of code)
Holds topojson version of products

Joyent Cloud

EO-1 GeoBPMS

GitHub

Geojson.io

Publisher

Amazon Workspace
Coded in Node.js

Publishers:
EO-1 from USGS
Landsat 8 from USGS
MODIS from OAS
Radarsat from CSA/MDA

Future Iphone App
Distribution Channel for Recently Acquired Products

GeoSocial API (architecture for discovery, retrieval, mapping, evaluation, and sharing)

GeoSocial Consumer with search for EO-1 and other satellite products by Lat-Long

Crowdsourced GPS picture and boat track

EO-1 L1GST Water Extent Product Mis-registered

Select L1T co-registered product with Landsat GLS – fixes registration

Products choices appear here
User Controlled On-Demand Post Processing for Detailed Evaluation

Reflectance Processing Protocols Established for ALI and Hyperion Level 2 Products

L1R Pre-processing (product spec.)

L1R Atmospheric Correction

L2 Reflectance (R) + Auxiliary

L2 R Calibration to Canopy Biophysical Products (BPs)

EO-1 RADIANCE (L1 R)
Atmospheric correction to reflectance (R, L2)
(established last 10+ years)


Algorithms for Atmospheric Correction Processing Available for On-demand User-controlled Execution

Hyperspectral Level-2 Surface Reflectance Products

For select sites or requests:
- CEOS (Cal/Val Portal), LTER
- FLUX (ORNL/DAAC)

Hyperion Level 1G USGS
- Available, online at https://matsu.openscience.datacloud.org/eo1/

Hyperion Level 1G USGS
- Complete Archive

Future

Hyperspectral Level-2 Surface Reflectance Products

FLAASH R (%)
- Accurate - geology, vegetation and land cover characterizations (near-nadir acquisitions)

ATREM R (%)
- Fast response - geology, vegetation and land cover characterizations (off-nadir acquisitions)

ACORN R (%)
- Spectral time series - cal/val, veg. physiology and canopy chemistry (assumes nadir acquisition)

For rugged terrain, geo-coded data & Digital Elevation Model (DEM)

ATCOR 3

Atmospheric CORrection (ATCOR 3)

Available for On-demand User-controlled Execution

Public User
Coordination of Satellite Acquisitions with Flight Campaigns

Example: HyspIRI Preparatory Airborne Campaign

Objectives:
- Acquire contemporaneous satellite images over flight boxes

Tactics:
- Satellite in-views by date and time for each box are visible to the flight team along with cloud predictions and other constraints during morning flight meeting
- Which flight area is to be flown today is identified in that meeting 4-5 hours prior to aerial lift-off based on cloudiness, satellite in-views, and engineering considerations
- Once flight box is identified, satellite target request for the selected box needs to be submitted, scheduled, uplinked, and executed within 4-5 hours to acquire data coincidentally with flight

Results:
- Maximum number of contemporaneous satellite and aerial images have been acquired
Thank You!

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