OGC activities for UAS

ANSI UAS Standardization Collaborative Meeting

George Percivall
CTO, Chief Engineer
Open Geospatial Consortium
The Open Geospatial Consortium

Not-for-profit, international voluntary consensus standards organization; leading open innovation for geospatial data

- Founded in 1994
- 525+ member organizations
- 100 innovation initiatives
- 48 Open Standards
- 230 OGC certified products
- Thousands of implementations
- Enabling access to 100K+ datasets
NASA and US Forest Service UAS

- Ikhana UAV with multispectral sensor
- Fire intelligence to management teams
- Web access to geospatial processing via open standards

OGC Standards Used in IMIS IoT Pilot

- Sensor Observation Service
- Sensor Planning Service
- SensorThings
- Web Processing Service
- Catalog
- OWS Context
- Web Feature Service
- Web Map Service

Live demonstrations in multiple sites in 2016

OGC Sensor Web Enablement Standards

SWE Standards for Discovery and Tasking Sensors; Access and Process Observations

- Sensor Model Language (SensorML)
- Observations & Measurements (O&M)
- Sensor Planning Service (SPS)
- Sensor Observation Service (SOS)
- Catalogue Service
- Sensor Alert Service (SAS)
- PUCK
OGC WAMI Specification

• Wide Area Motion Imagery
  – An OGC Best Practice

• Motion Imagery
  – Video where each image in
    the video is spatio-temporally
    related to the next image

• Two required services
  – Collection Service (CS):
    What do I have?
  – Image Service (IS):
    Delivers an images and
    metadata across time

Also referred to as
Persistent Wide Area Surveillance
Challenges motivate the use of standards

• Diversity of alternatives in UAVs show a lack of standardization at all levels: sensors, platforms, processing

• To advance, UASs need to increase use of existing standards and in some cases new standards will need to be developed.

• Standards for geographic observations are quite mature and UASs benefit from using them
Challenges with UAS technology

• Image distortion with inexpensive digital cameras
• Sensors have low or no metadata which hinders use of sensor data
• Limited accuracy of the exterior information: position, orientation
• Need for smooth, fast workflow: processing raw data into classified imagery
• Requirements for accountability increase requirements on provenance in data processing
Using SensorML to manage UAS complexity

• Manage proliferation of sensors on UAV platforms
  – Mission planning: after the most appropriate UAV is determined, it is time to choose which kind of sensor will be accompany to the UAV.

• Using SensorML to manage specifications
  – Platforms: helicopter, quadcopter, blimp and airplane
  – Sensors: micro analog, HD camera, lowlight and thermal camera
  – In a database to support processing, e.g., MATLAB, BPEL

Source: C. Avci, Halmstad University
## OGC UAV Study Areas

<table>
<thead>
<tr>
<th>Study Areas</th>
<th>Challenge</th>
<th>OGC Positioning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data management</td>
<td>high volume data of variable accuracy</td>
<td>Big Data, Data Quality, WCS-T, SWE/SensorThings</td>
</tr>
<tr>
<td>Data discovery</td>
<td>no metadata</td>
<td>Metadata, Data Quality, CSW</td>
</tr>
<tr>
<td>Data quality assurance</td>
<td>mixed sources of mixed accuracy</td>
<td>SensorML, Imagery Metadata Link to ASPRS/ISPRS, ASTM</td>
</tr>
<tr>
<td>Data dissemination</td>
<td>Streaming of oblique imagery and point clouds</td>
<td>WAMI, SOS, WCS, JPIP Point Clouds, HDF, NetCDF, GML/JP2</td>
</tr>
<tr>
<td>Mission planning</td>
<td>exchange of flight planning data</td>
<td>SPS, GML/AIXM, KML, Aviation DWG</td>
</tr>
<tr>
<td>Oblique sensors</td>
<td>quality, indexing, geopositioning</td>
<td>Data Quality, SWE/SensorThings</td>
</tr>
</tbody>
</table>
OGC Unmanned Systems (UxS) DWG

• OGC Domain Working Group (DWG)
• Initially conceived to focus on Unmanned Aerial Systems (UAS), but scope has been broadened to all types of platforms
  – That being said, the focus will be on autonomous or remotely piloted platforms which acquire data

• UAS use cases include:
  – Exchange of flight plans
  – Metadata for hobbyist sensors
  – Lightweight protocols for sensor management
  – and others….

• DWG may identify standards development

Copyright © 2017 Open Geospatial Consortium
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>ISO TC 211</td>
<td>Geographic Information, Coordinate Reference Systems, Metadata</td>
<td>Cooperative Agreement and Joint Advisory Group</td>
</tr>
<tr>
<td>ISO TC 20/SC 16</td>
<td>Unmanned aircraft systems</td>
<td>Developing liaison</td>
</tr>
<tr>
<td>IHO</td>
<td>Maritime Navigation</td>
<td>Existing Liaison, will begin considering UxS</td>
</tr>
<tr>
<td>ASTM</td>
<td>LIDAR and unmanned aircraft systems</td>
<td>Workshop &amp; white paper planned</td>
</tr>
<tr>
<td>RTCA/EUROCAE</td>
<td>AIXM</td>
<td></td>
</tr>
<tr>
<td>ASPRS</td>
<td>LAS for LIDAR</td>
<td>LAS near to being OGC Community standard</td>
</tr>
</tbody>
</table>
OGC Standards
  – Freely available
  – www.opengeospatial.org/standards
  – compliant implementations list

OGC Innovation
  – www.opengeospatial.org/ogc/programs/ip

George Percivall
  gpercivall at opengeospatial.org
  @percivall
• Open standards provide alternatives to “stove-pipe” vertical integration of data collection, database management, analysis, portrayal and user interface.

• Pick and choose components that work well together because of open standards – “plug and play”

• Efficient processing and dissemination of the data achieved using software and systems that implement open standards

• Gain full benefit of the explosion of UAV platforms and sensors that will be interchangeable based on open standards
Collect the same stuff...

e.g., traditional aerial photography by drones

http://beechcraft.txt
av.com/

http://blog.parrot.com/2014/04/11/8324/?lang=parrot-usa
... but have different constraints

Payload weight and power supply constraints lead to...

• Smaller payloads
• Smaller lenses
• Lower resolution of sensor
• Less precise camera model
• More likely error to propagate to derivative products
Sensor Comparisons

@ 4100 m altitude
Pixel resolution = 30 cm

@ 1100 m altitude
Pixel resolution = 30 cm
UAS frameworks similar to previous geographic observing system frameworks

UAS Production Process (USGS)

Acquire Data → Process Data → Manage Data → Disseminate Data

Framework for research on UAVs (Ma)

UAVs

Data acquisition
- Flight planning
- Autonomous flight
- Flight trajectory

Data processing
- Photography
- Image matching and mosaicking
- Classification

Applications
- Environment and agriculture
- Terrain extraction
- 3D visualization
- Monitoring of hazards

Copyright © 2017 Open Geospatial Consortium
Framework for UAS using OGC SWE

• UAV challenges
  – sensors publish data in unpredictable manner.
  – proprietary access to data

• Need to integrated data stream web publishing

• Framework to simplify integration in an interoperable way using OGC SWE standards

Source: Rieke, M., Foerster, T., Broering, A. 14th AGILE International Conference
Framework to combine UAS with other sensors

- Precision farming: variety of vendor-specific sensor systems, control units and processing software
- SWE-based infrastructure: control, access, transmission and storage of sensor data for web services
- Field trial proved applicability of the infrastructure.

SWE infrastructure for precision farming (Source: Geipel)
Data quality

- Traditional photogrammetric parameters may not be available for UAV imagery
- What image properties are available must be described in a common way
- End-users must understand the relative quality of collected information
- Such understanding must be described in common terminology
Relevant studies and best practices

• OGC Incident Management Information Sharing Internet of Things Pilot Project (IMIS IoT Pilot)
  • http://www.opengeospatial.org/blog/2209

• OGC Web Services – Phase 3 Testbed
  • http://www.opengeospatial.org/projects/initiatives/ows-3

• OGC Sensor Web Enablement: Overview And High Level Architecture
  • http://docs.opengeospatial.org/wp/07-165r1/
OGC: Community challenges

- Mission planning – there is no single format for exchange of mission planning data that can be transferred to different equipment,
- Operations – how does the device communicate its position and orientation, how does it “Get home,” what sensors help guide the device, how is the mission reported?
- Data acquisition – how does data get tagged with metadata; what formats are supported; is data transmitted during collection?
- Data exchange – imagery may be stored just a few common formats (JPEG, GeoTIFF, various raw formats, etc.), but given the fact that many observations might be highly oblique, what requirements need to be inserted into metadata standards?
- Data processing – Mosaicking/compilation of data from multiple acquisition paths with the resulting resolution and precision considerations. Handling of temporal artifacts (temperature, sunlight, haze, etc.) to provide data consistency across subsequent revisits.
- Archival data formats - Interoperable formats that allow for easy replay of missions and re-purposing of data for additional uses.
Mission planning

- Collection area
- Collection path (“mowing the lawn” vs. others)
- No fly zones (NFZs)
- What to do in case of loss of control

- What is the minimum amount of info to standardize to still allow proprietary use of that information? Just the collection area and NFZs?
“Global Information Sharing.

To facilitate global information sharing and interoperability, data exchange models are being developed based on Open Geospatial Consortium standards.

The FAA and Eurocontrol are jointly developing the Weather Information Exchange Model (WXXM) and the Aeronautical Information Exchange Model (AIXM).

AIXM will be utilized in worldwide ground exchange of AI”

https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_00-63A.pdf
## Data Exchange Reference Model

<table>
<thead>
<tr>
<th>DATA Format</th>
<th>AIXM</th>
<th>FIXM</th>
<th>WXXM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information Product</td>
<td>NAS Standard Templates</td>
<td>Individual Flight Objects</td>
<td>NAS Standard Weather</td>
</tr>
<tr>
<td>Cal / Val</td>
<td>Geospatially Corrected with Occasional Updates</td>
<td>Geospatially Corrected with Dynamical Updates</td>
<td>Geospatially Corrected with Dynamical Updates</td>
</tr>
<tr>
<td>Authentication</td>
<td>FAA</td>
<td>Operator – to NESG (pub.) FAA – to NESG (pub.)</td>
<td>Operator – to NESG (pub.) FAA – to NESG (pub.)</td>
</tr>
<tr>
<td>Primary Source</td>
<td>FAA</td>
<td>Operators</td>
<td>NWS, FAA, and Operators</td>
</tr>
</tbody>
</table>

Source: Robert Klein, FAA, ATIEC August 2014
Aviation Data Models use OGC Standards

Aeronautical Information Exchange Model (AIXM)

Weather Information Exchange Model (WXXM)

Flight Information Exchange Model (FIXM)
Operations

how does the device communicate its position and orientation, how does it “Get home,” what sensors help guide the device, how is the mission reported?

Source: www.qualtre.com
Data acquisition

How does data get tagged with metadata; what formats are supported; is data transmitted during collection?

**Satellite camera RPC data**

- **LINE_OFF**: +015834.00 pixels
- **SAMP_OFF**: +013464.00 pixels
- **LAT_OFF**: -42.86070000 degrees
- **LONG_OFF**: +147.25880000 degrees
- **HEIGHT_OFF**: +0300.000 meters
- **LINE_SCALE**: +015834.00 pixels
- **SAMP_SCALE**: +013464.00 pixels
- **LAT_SCALE**: +00.07150000 degrees
- **LONG_SCALE**: +000.08280000 degrees
- **HEIGHT_SCALE**: +0970.000 meters

**LINE_NUM_COEFF_1**: -5.396368863150944E-04
**LINE_NUM_COEFF_2**: +2.627711654471593E-03
**LINE_NUM_COEFF_3**: -1.002878365030092E+00
**LINE_NUM_COEFF_4**: -3.403033110765838E-02
**LINE_NUM_COEFF_5**: +5.236585985386163E-03
**LINE_NUM_COEFF_6**: +2.100573285690368E-03
**LINE_NUM_COEFF_7**: +3.116646954215110E-03
**LINE_NUM_COEFF_8**: +4.062679628915546E-04
**LINE_NUM_COEFF_9**: -5.500898738846068E-03
**LINE_NUM_COEFF_10**: +5.262025538628248E-05
**LINE_NUM_COEFF_11**: +2.595873285690368E-03
**LINE_NUM_COEFF_12**: -2.236321986531990E-06
**LINE_NUM_COEFF_13**: +2.028224523347030E-05
**LINE_NUM_COEFF_14**: -5.240094084170959E-06
**LINE_NUM_COEFF_15**: +2.169130236379565E-05
**LINE_NUM_COEFF_16**: -2.360025540323606E-05
**LINE_NUM_COEFF_17**: +1.567039324774875E-06

**Consumer camera EXIF data**

- **Exif.Image.Orientation Short**: 1 top, left
- **Exif.Image.Xresolution Rational**: 1 180
- **Exif.Image.Yresolution Rational**: 1 180
- **Exif.Image.ResolutionUnit Short**: 1 inch
- **Exif.Photo.FocalLength Rational**: 1 21.3 mm
- **Exif.Photo.PixelXDimension Short**: 1 2272
- **Exif.Photo.PixelYDimension Short**: 1 1704
- **Exif.Iop.RelatedImageWidth Short**: 1 2272
- **Exif.Iop.RelatedImageLength Short**: 1 1704
- **Exif.Photo.FocalPlaneXResolution Rational**: 1 8114.29
- **Exif.Photo.FocalPlaneYResolution Rational**: 1 8114.29
- **Exif.Photo.FocalPlaneResolutionUnit Short**: 1 inch
imagery may be stored just a few common formats (JPEG, GeoTIFF, various raw formats, etc.), but given the fact that many observations might be highly oblique, what requirements need to be inserted into metadata standards?

Example:
Structure From Motion

Source: USGS
Data processing

- Mosaicking/compilation of data from multiple acquisition paths with the resulting resolution and precision considerations. Handling of temporal artifacts (temperature, sunlight, haze, etc.) to provide data consistency across subsequent revisits
Archival data formats

• Interoperable formats that allow for easy replay of missions and re-purposing of data for additional uses
Common Approach to Geoprocessing of UAV Data across Application Domains

G. S. Percivall, M. Reichardt, and T. Taylor
Open Geospatial Consortium, Wayland MA, USA

Abstract:
UAVs are a disruptive technology bringing new geographic data and information to many application domains. UASs are similar to other geographic imagery systems so existing frameworks are applicable. But the diversity of UAVs as platforms along with the diversity of available sensors are presenting challenges in the processing and creation of geospatial products. Efficient processing and dissemination of the data is achieved using software and systems that implement open standards. The challenges identified point to the need for use of existing standards and extending standards. Results from the use of the OGC Sensor Web Enablement set of standards are presented. Next steps in the progress of UAVs and UASs may follow the path of open data, open source and open standards.

Keywords: Geoprocessing, Open Standards, OGC, UAV, UAS