OGC activities for UAS

ANSI UAS Standardization Collaborative Meeting

George Percivall
CTO, Chief Engineer
Open Geospatial Consortium

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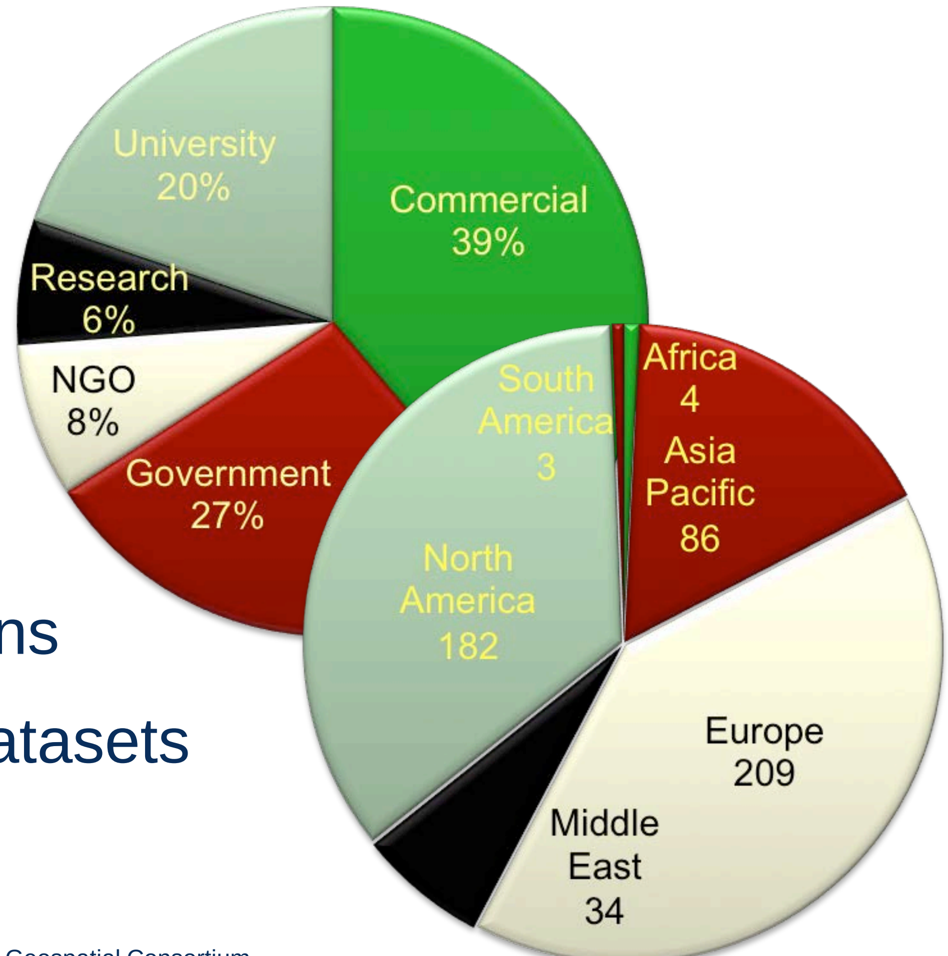
Making location count.

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



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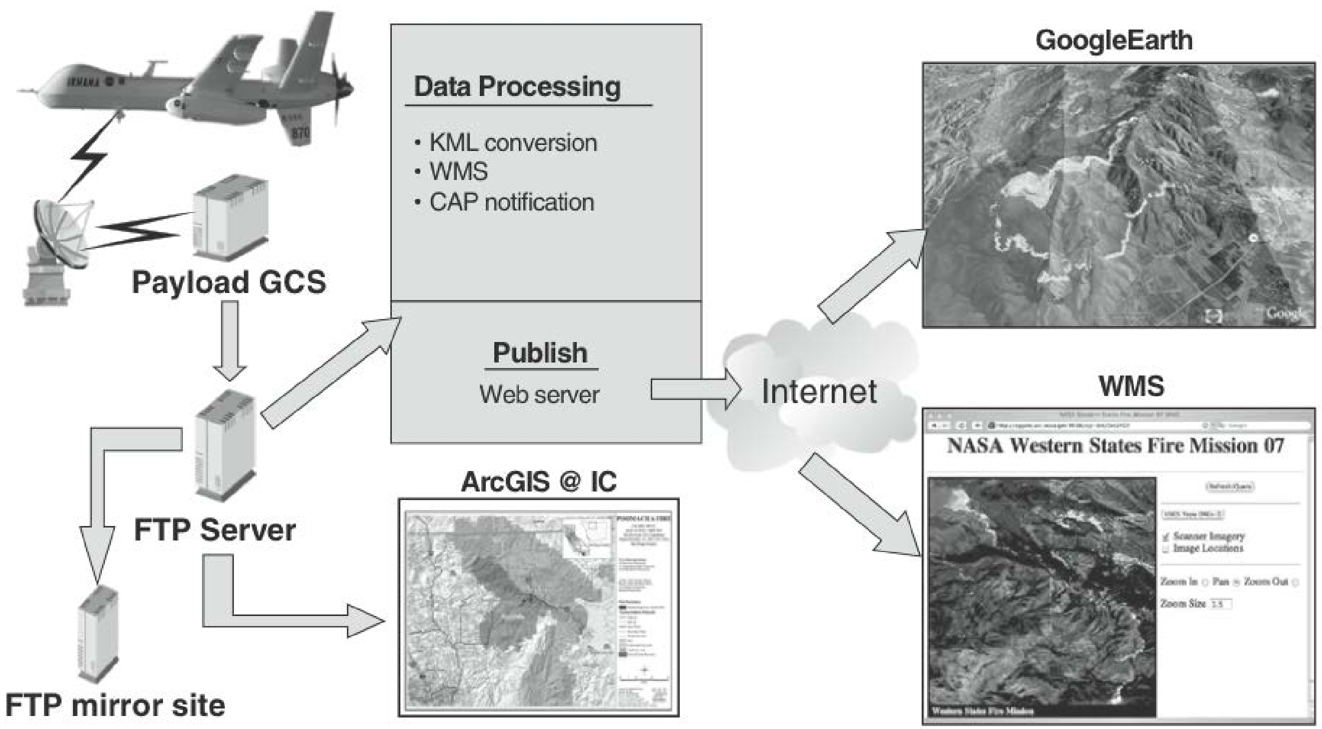
NASA and US Forest Service UAS

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



Source: Ambrosia, G., Sullivan, D., Buechel, S., GSA Special Paper 482 , 2011

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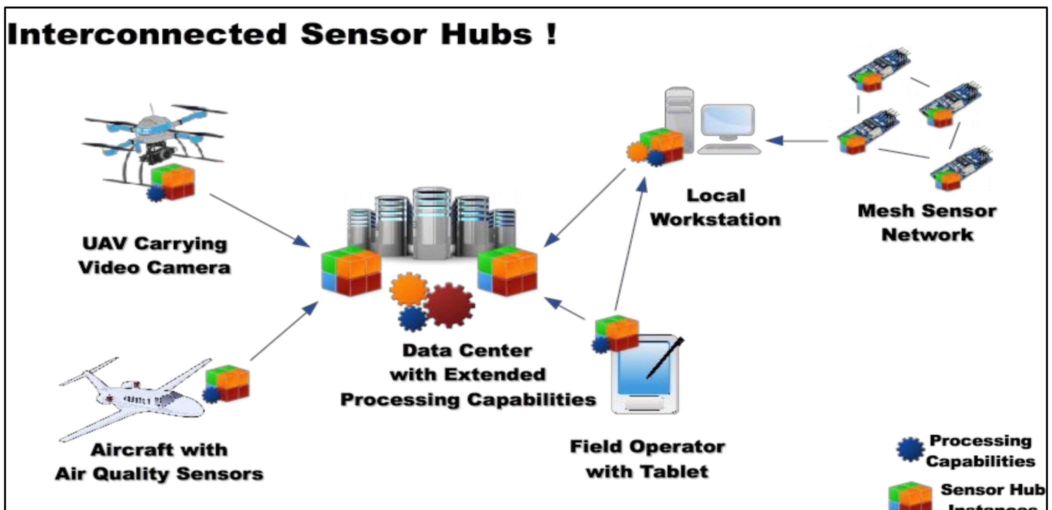
DHS - Incident Management Information Sharing (IMIS) IoT Pilot

Drone Operator Display



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

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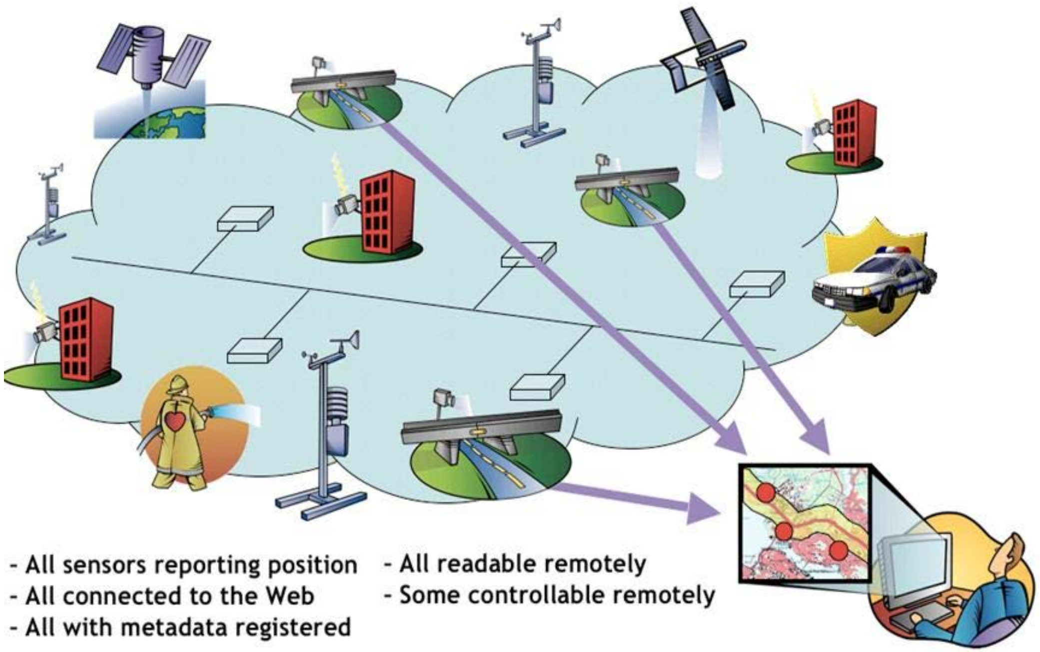
https://www.dhs.gov/publication/incident-management-information-sharing-imis-internet-things-iot-extension-engineering

OGC Sensor Web Enablement Standards

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



- All sensors reporting position
- All connected to the Web
- All with metadata registered
- All readable remotely
- Some controllable remotely

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

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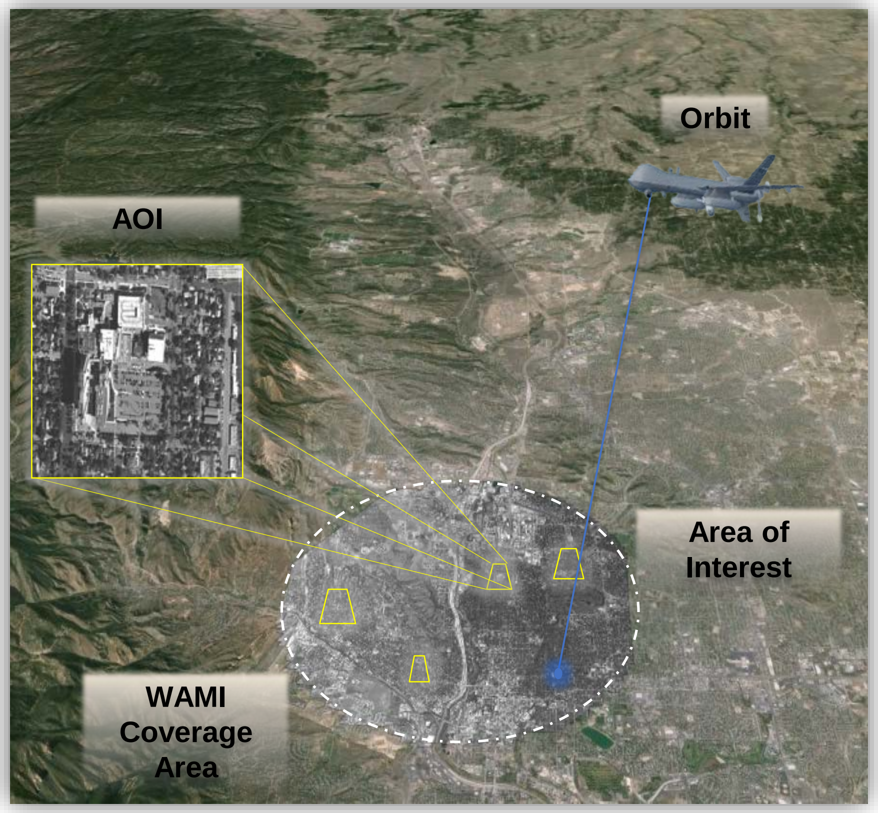
OGC WAMI Specification

- 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

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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

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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

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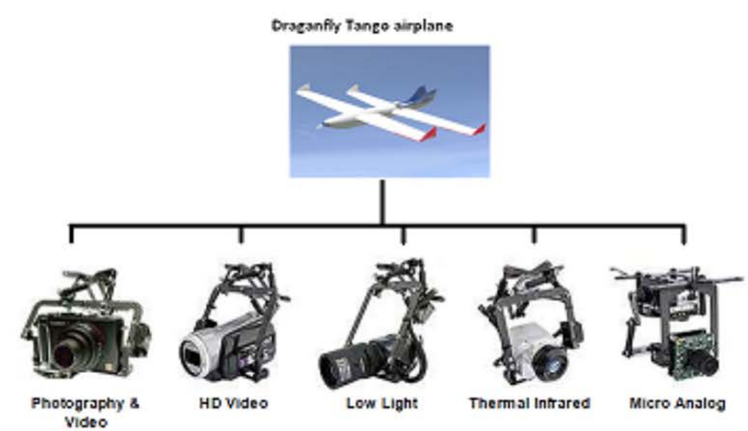
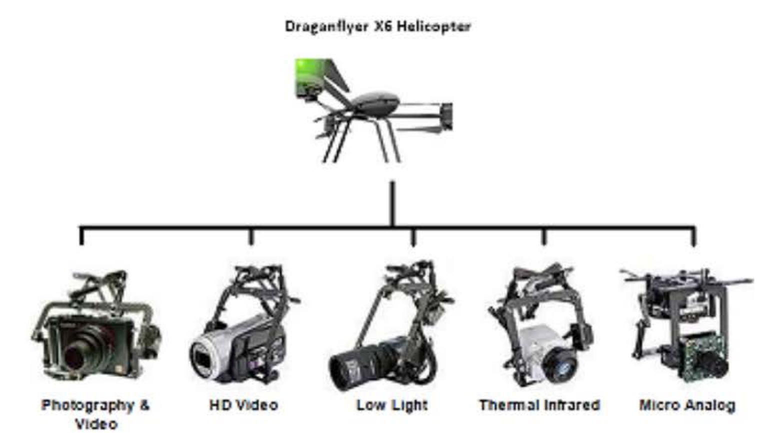
Using SensorML to manage UAS complexity

- 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

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OGC UAV Study Areas

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

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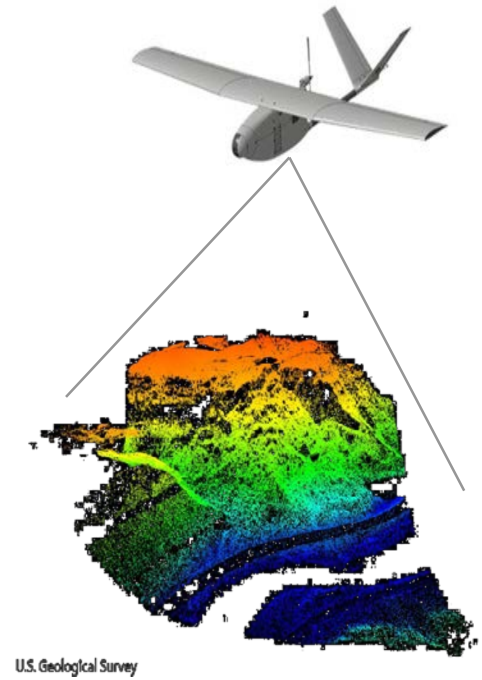
OGC Unmanned Systems (UxS) DWG

- 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



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OGC SDO Collaborations relevant to UxS

ISO TC 211	Geographic Information, Coordinate Reference Systems, Metadata	Cooperative Agreement and Joint Advisory Group
ISO TC 20/SC 16	Unmanned aircraft systems	Developing liaison
IHO	Maritime Navigation	Existing Liaison, will begin considering UxS
ASTM	LIDAR and unmanned aircraft systems	Workshop & white paper planned
RTCA/EUROCAE	AIXM	
ASPRS	LAS for LIDAR	LAS near to being OGC Community standard

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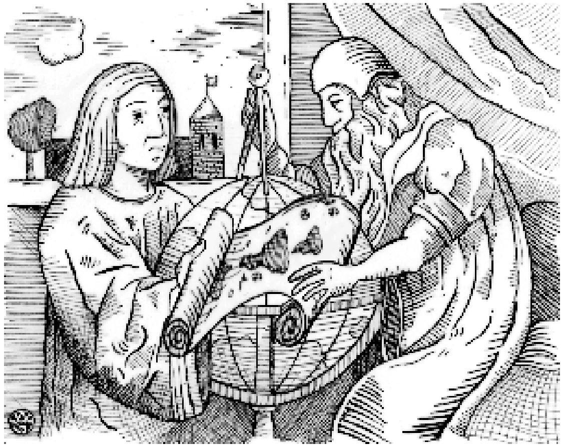
For Details on OGC …



OGC Standards

- Freely available
- www.opengeospatial.org/standards
- compliant implementations list

OGC Innovation

- www.opengeospatial.org/ogc/programs/ip

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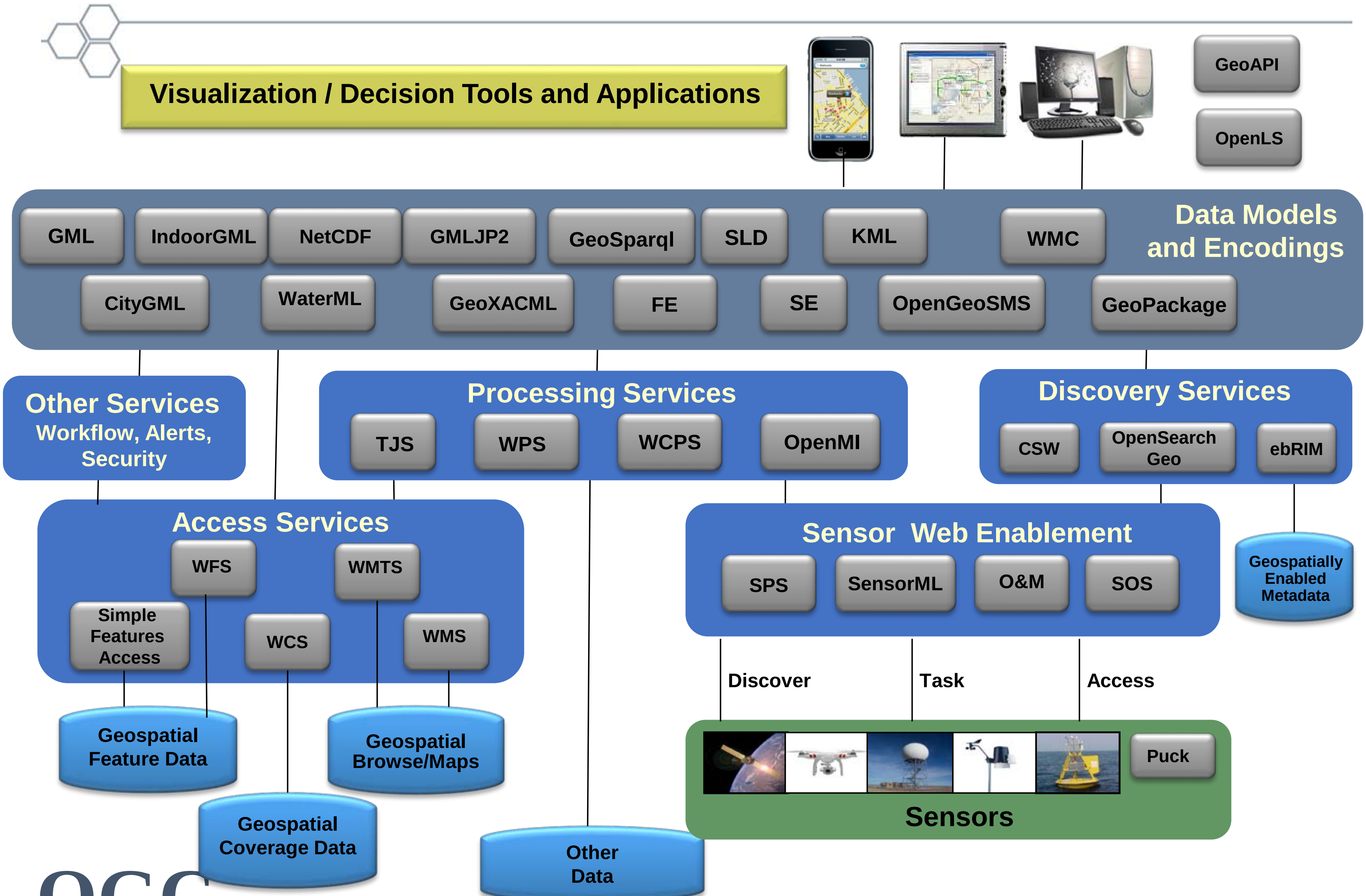
OGC Services Architecture



Common Approach for UAV Data Geoprocessing

- 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

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Collect the same stuff…

e.g., traditional aerial photography by drones

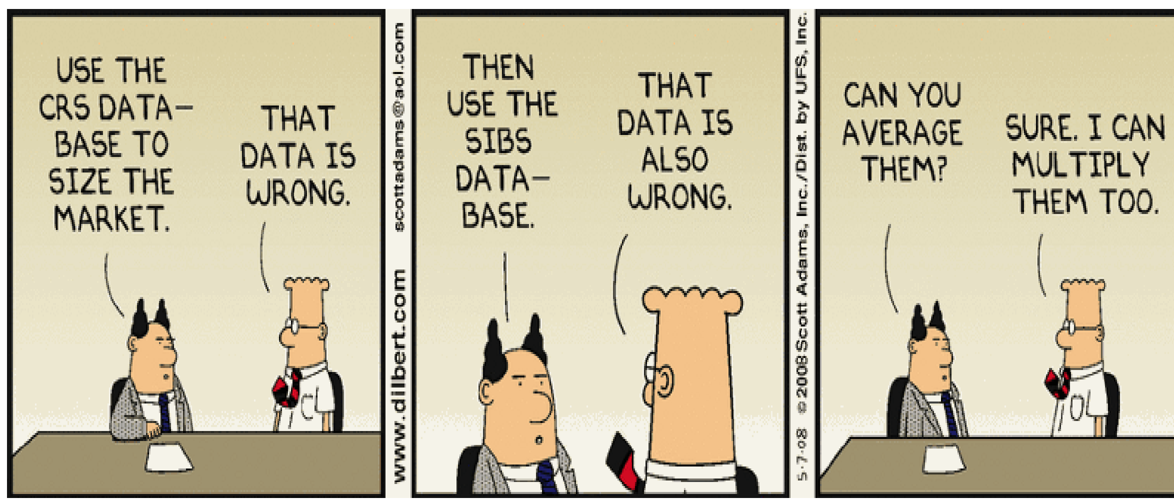
http://beechcraft.txtav.com/

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**



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Payload comparison

Source: Vexcel Imaging

Source: http://aerial-cam-drones.com/camera-drones-consumers-solutions-for-taking-aerial-shots-at-a-price/

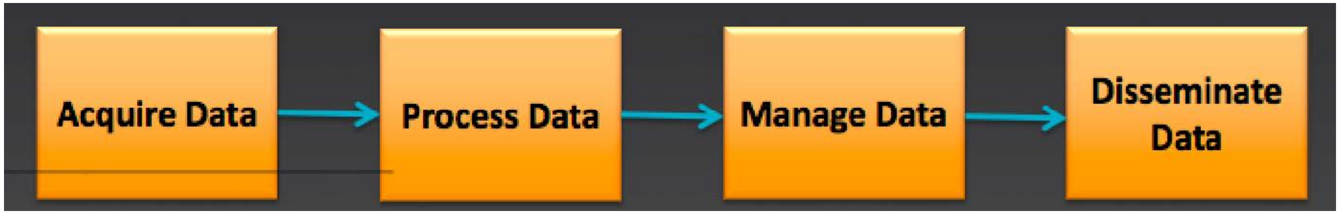
Sensor Comparisons

@ 4100 m altitude
Pixel resolution = 30 cm

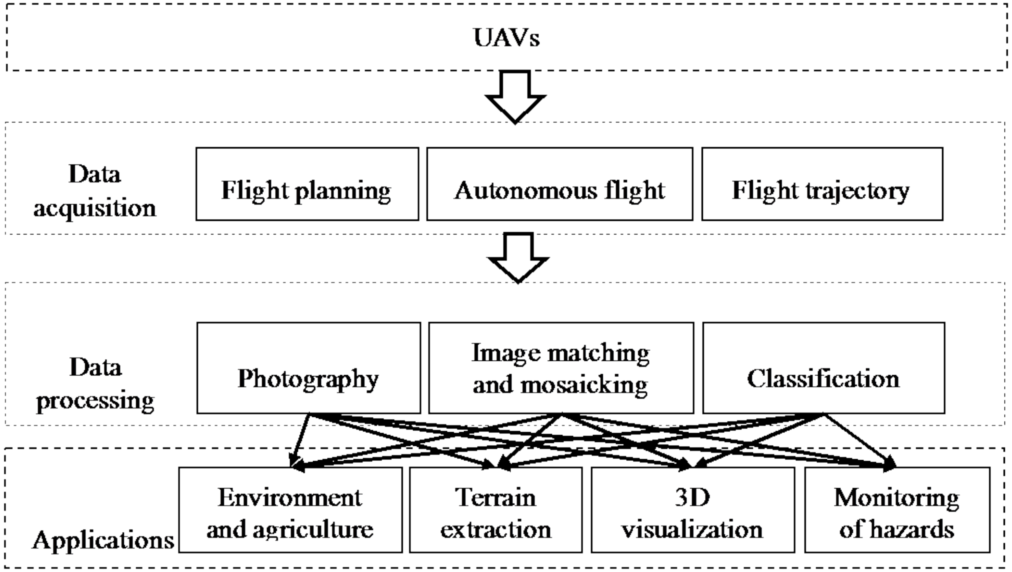
@ 1100 m altitude
Pixel resolution = 30 cm

UAS frameworks similar to previous geographic observing system frameworks

UAS Production Process (USGS)



Framework for research on UAVs (Ma)



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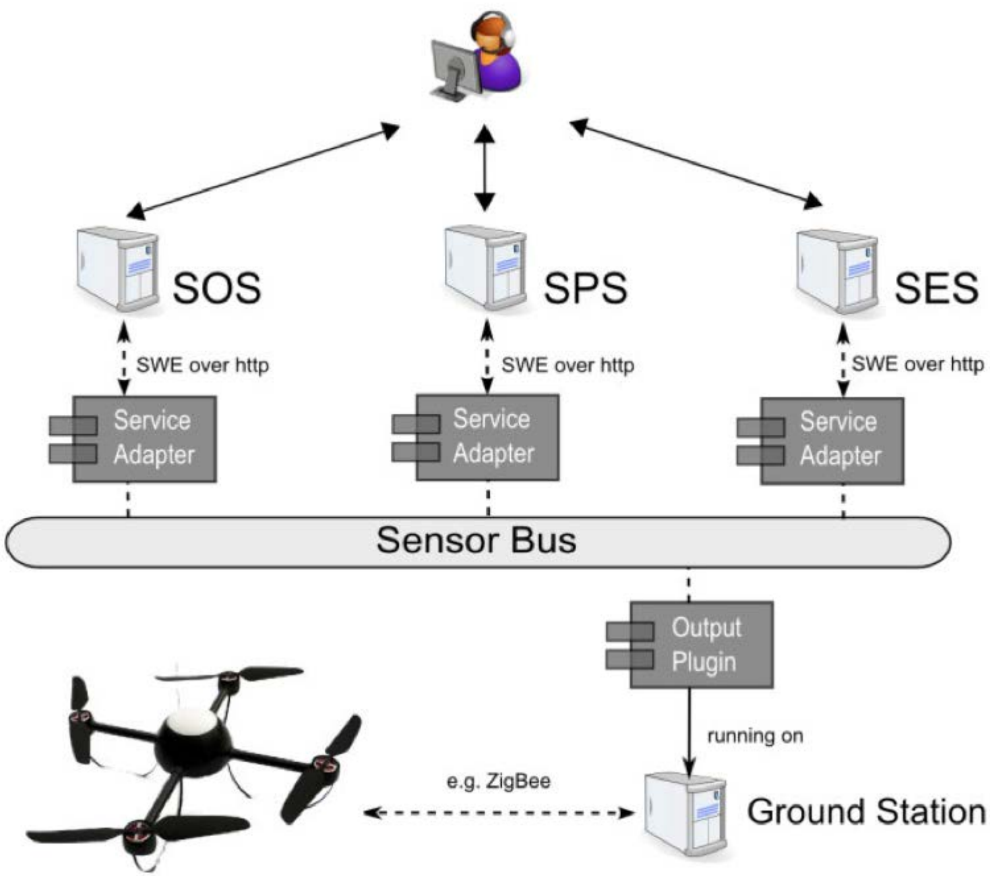
Framework for UAS using OGC SWE

- 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

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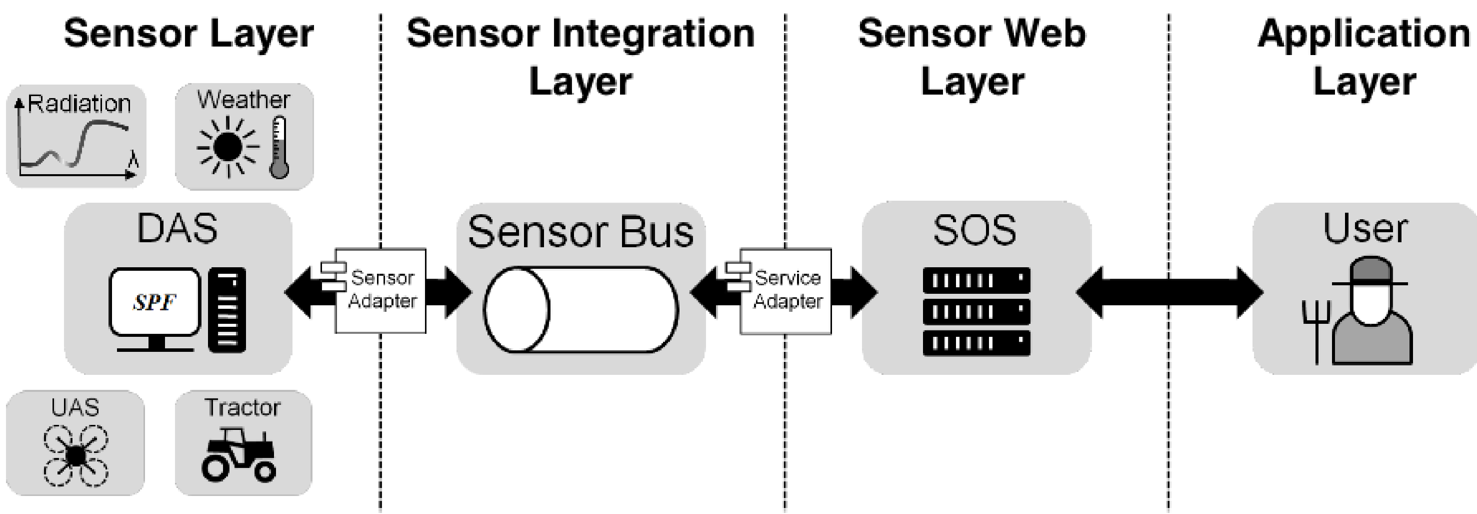
Framework to combine UAS with other sensors

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



SWE infrastructure for precision farming (Source: Geipel)

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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/

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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.

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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?

FAA Advisory Circular AC 00-63A - AIXM

- *“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 Comparison Reference

Data Exchange Reference Model			
DATA Format	AIXM	FIXM	WXXM
Information Product	NAS Standard Templates	Individual Flight Objects	NAS Standard Weather
Cal / Val	Geospatially Corrected with Occasional Updates	Geospatially Corrected with Dynamical Updates	Geospatially Corrected with Dynamical Updates
Authentication	FAA	Operator – to NESG (pub.) FAA - to NESG (pub.)	Operator - to NESG (pub.) FAA - to NESG (pub.)
Data & Information Description	1. Airport / Surface Templates 2. OCS, ICA, etc. 3. Flow Constrained Area 4. Standard Terminal Arrival Route (STAR) 5. Standard Instrument Departure (SID) 6. RNP Approaches, J-Routes, 7. Q-Routes, etc. 8. Temporary Flight Restriction (TFR) 9. Special Use Airspace (SUA) 10. eNOTAMs 11. Traffic Management Initiatives (TMIs) 12. Air Traffic / Traffic Flow Management	1. Flight Plan(s) 2. Approved RNAV Routing 3. RTAs 4. Flight History 5. Flight Object 6. Trajectory Option Set (TOS) 7. FF-ICE (Flight & Flow Information for a Collaborative Environment	1. METARs 2. SIGMETs and Convective SIGMETs 3. TAFs 4. Winds and Temps Aloft 5. AIRMETs 6. Real-time Surface Winds / Wind Field Profiles 7. PIREPs
Primary Source	FAA	Operators	NWS, FAA, and Operators

Source: Robert Klein, FAA, ATIEC August 2014

Aviation Data Models use OGC Standards

Aeronautical Information Exchange Model (AIXM)

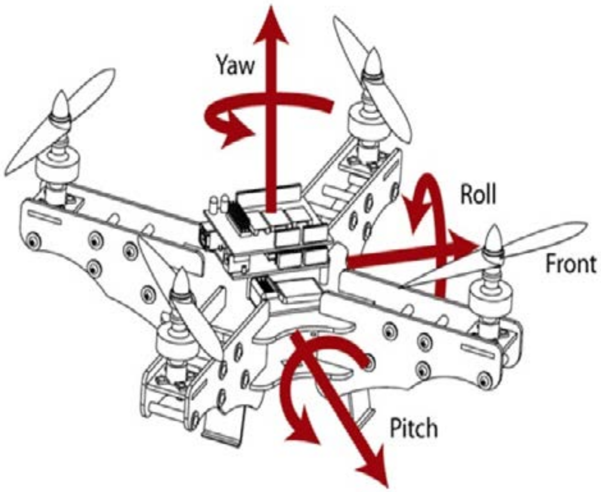
Weather Information Exchange Model (WXXM)

Flight Information Exchange Model (FIXM)

```
<aixm:RunwayElement gml:id="9R-27L RE0">
    <gml:identifier>9R-27L RE0</gml:identifier>
    <aixm:timeSlice>
        <aixm:RunwayElementTimeSlice gml:id="9R-27L TS0">
            <gml:validTime>
                <gml:TimePeriod gml:id="9R-27L TSP0">
                    <gml:beginPosition>
                        2008-03-23T14:00:00
                    </gml:beginPosition>
                    <gml:endPosition
                        indeterminatePosition="unknown"/>
                </gml:TimePeriod>
            </gml:validTime>
            <aixm:interpretation>
                BASELINE
            </aixm:interpretation>
```

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: +2.595870786562705E-06
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
```

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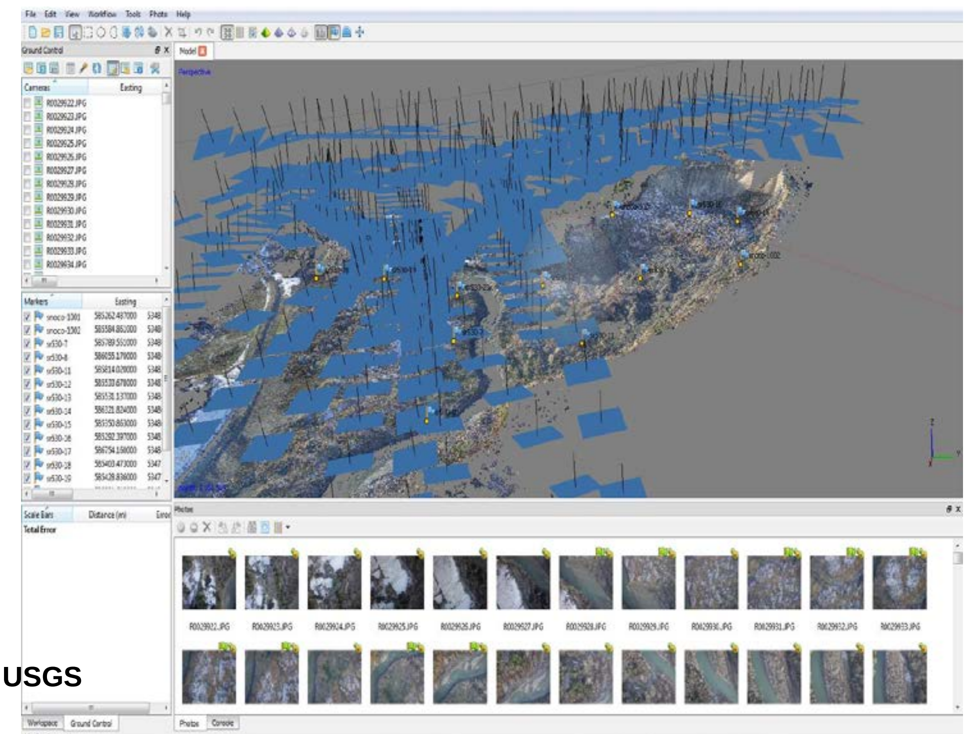
Data exchange

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?

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

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Archival data formats

- Interoperable formats that allow for easy replay of missions and re-purposing of data for additional uses

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Common Approach to Geoprocessing of UAV Data across Application Domains

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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

Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci., XL-1/W4, 275-279, 2015

http://www.int-arch-photogramm-remote-sens-spatial-inf-sci.net/XL-1-W4/275/2015/