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Semantic Technology for Intelligence, Defense, and Security 2010: Collected Imagery Ontology Semantics for Airborne Video

Engineered for life

Overview of the Ontology Study & Model

- Vast amounts of collection information from persistent surveillance system will be stored in relational databases, including imagery, support and format metadata, process data, performance or quality information and exploited products.
- Ontologies can be used to better communicate the meaning and context of this data in a consistent manner. Initially, ontology terms are only used to represent a limited number of fields in a database. An ontology, in this context, essentially functions as a controlled vocabulary and few formal relations are used between database fields. A full representation of PS collection content, using a principled approach to ontology, encoded using a formal language such as OWL provides significant additional benefits.
- Benefits include data consistency checks, the ability to formulate highly expressive queries, and the potential for seamless interoperability with other data resources (e.g. SIGINT databases). The efforts of this program study are to make such a representation available for the IMINT and VideoIMINT Database for Persistent Surveillance collections.

Ontology Study Deliverables

1. IMINT Ontology (videoIMINT considerations) in OWL
2. Infrastructure for Motion Imagery feature extraction
3. Motion Imagery support metadata extraction demo
4. Integrated 1, 2, 3 demonstration
5. Sensor/UAV tasking approach (using Ontology)
6. Final Report

Preliminary IMINT Ontology Class Structures

- Platform Sensor and Sensor Operation } *Task* = Upper Domains
  - Platforms
  - Sensors
  - Operational Parameters
  - Calibration and Quality Metrics

  } *Task* = Define Properties
- Collection and Collection Performance
  - Collection Variables
  - Collection Operational Parameters
  - Sensor Performance Metrics
- Mission and Targets
  - Mission Description
  - Detection and Characterization Requirements
- Imagery and Exploitation Products
  - IMINT Data Hierarchy
  - Product Descriptions
  - Product Utility
  - Data Assurance Metrics
- Integrated Ontology
  - Relationship and Rule Algorithms

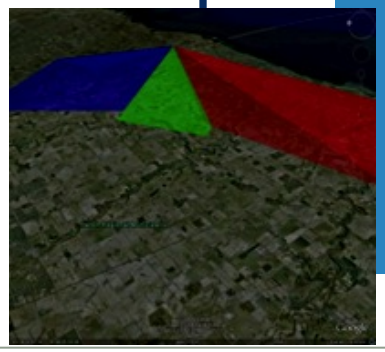
Platform Sensor Ops Ontology

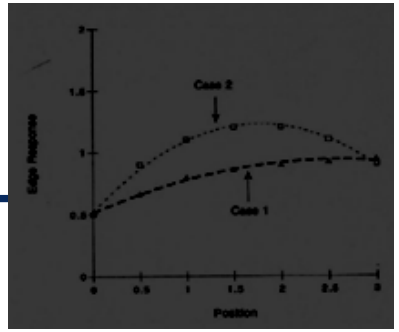
Assets …

- Aircraft
  - Type
  - Tail No.
    - With a sensor *s2*
    - Has parameters
      - Array density
      - Optical FL
    - Has calibration history
      - Accuracy, Precision
      - Detection response
    - **@ time = t*n*…** With sensor *sn*

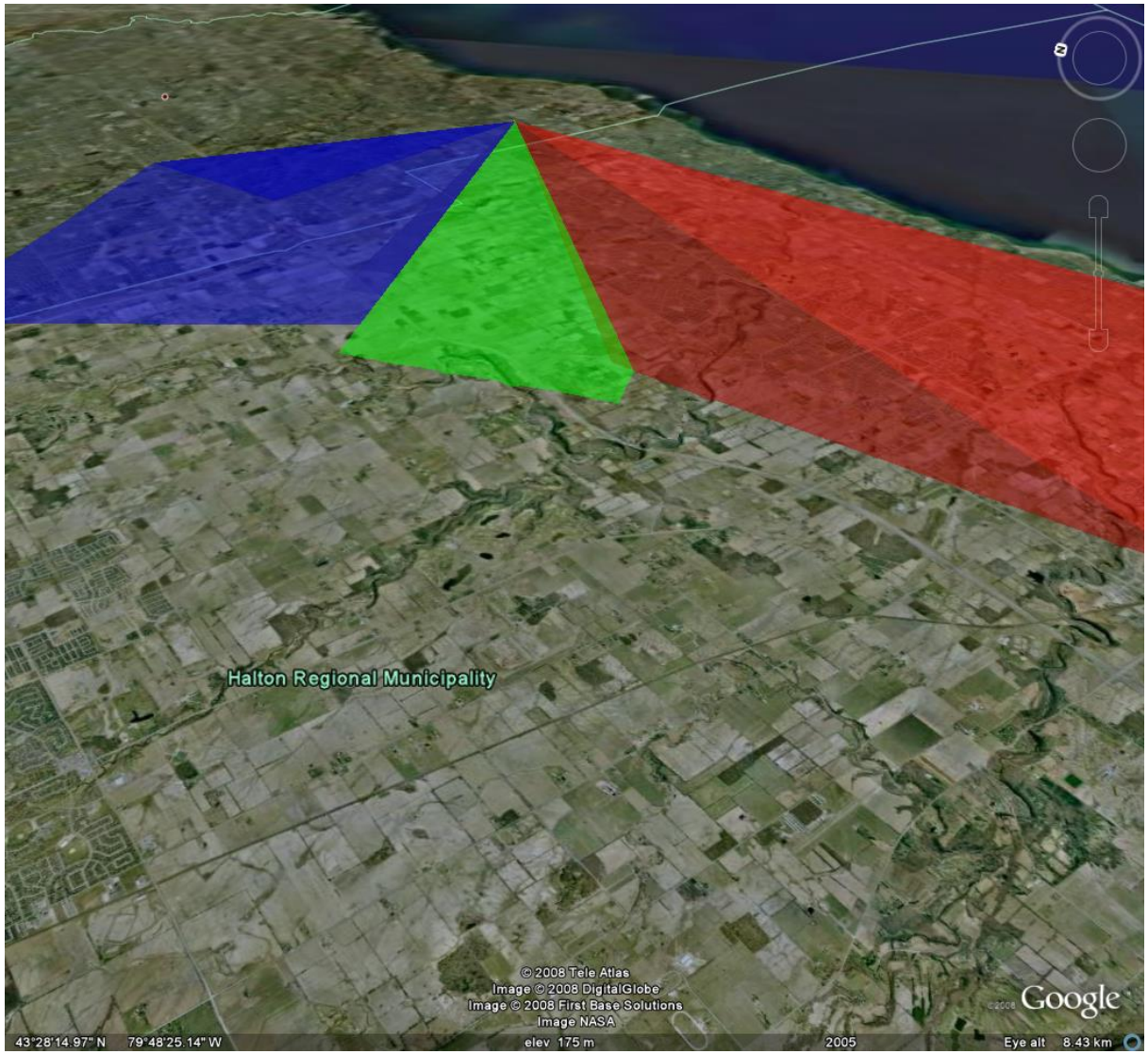
Ops Domains

- Platforms
- Sensors
- Operational Parameters
- Calibration and Quality Metrics





Sensor Coverage Projection - Assurance



Ontology should provide a means to…

- Utilize information from sensor metadata
- Visualize sensor coverage in Google Earth
- Provide metrics for Mission Assurance

Dynamic Collection Ontology

Single Platform, 6-Pack of Cameras

Multiple Platforms, Single cameras

- Dynamic Oblique Footprints:
  - Red s_1
  - Green s_2
  - Orange s_3
  - Brown s_4
  - Yellow s-5
  - Magenta s_6

@ time = t_0…

Circle of Persistence

time = t_0…

time = t_1…

time = t_2…

time = t_n…

- Collection…
- Sensor Performance
  - Type **sensor *s_2***
    - *s2* has view
      - GSD
      - IFOV
      - LOS
    - With sensor *sn*

Collection Domains

- Collection Variables
- Collection Operational Parameters
- Sensor Performance Metrics

GSD

… Calculate

IFOV | Asymmetric Considerations | Altitude | Scanning | Line of Sight | Radius of Earth

Mission & Target Ontology

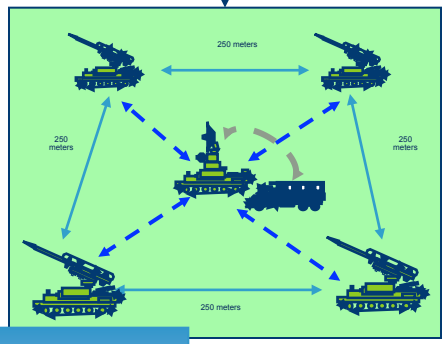
Mission Domains

- Mission Description
- Detection and Characterization

Mission / Target

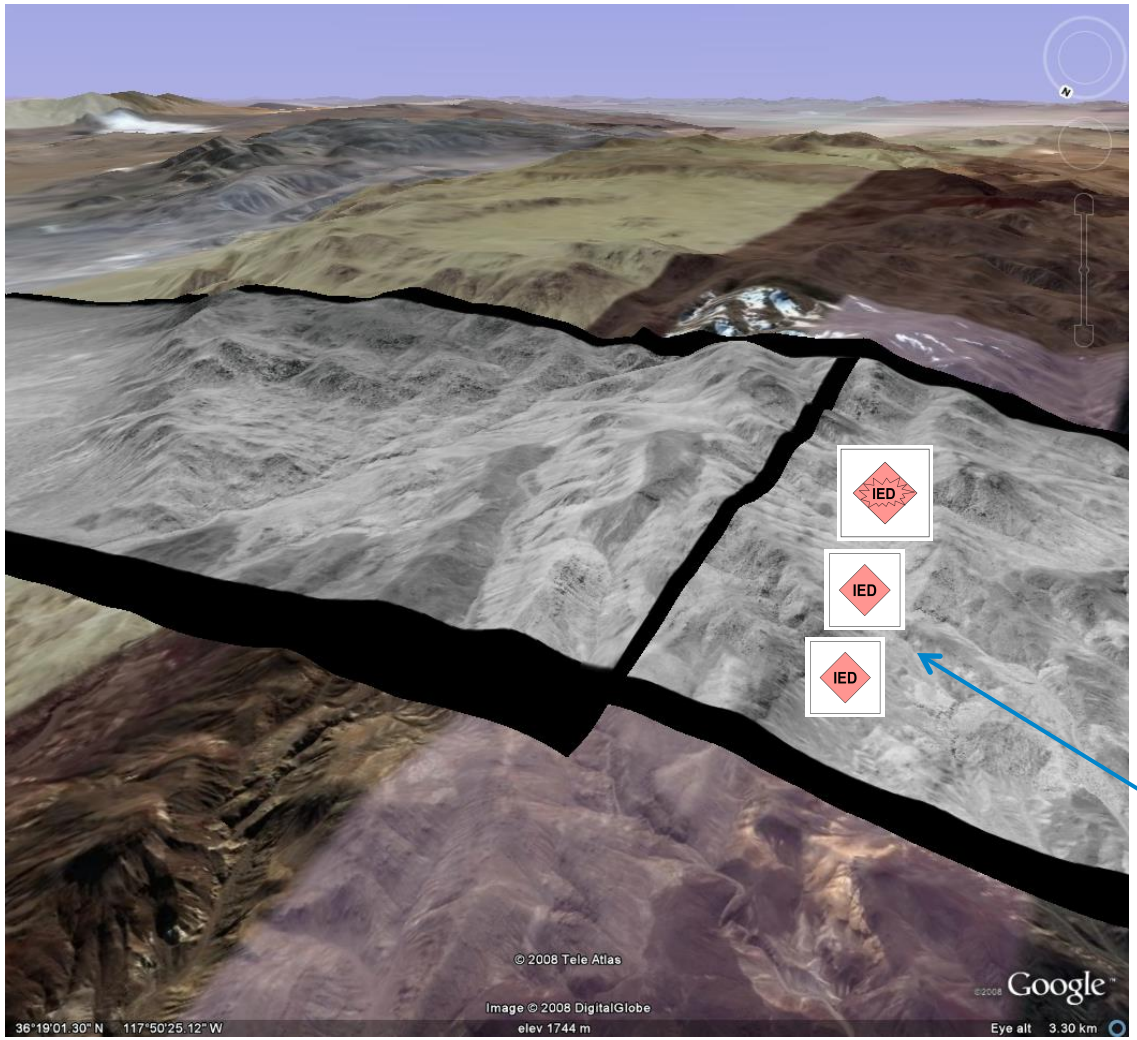
is_a Type

- Convoy support
- Track
  - Vehicle
  - Person
  - Ship
  - Aircraft
  - :
- Aid Defense Suppression
  - Manpad
  - IADS
  - :
- Sensor Rqmts (optimize)
- ROI (extent)
- Materiel
- Context



Integrated Air Defense System

Imagery Projection with Analysts Notation



Ontology should provide a means to…

- Visualize sensor collection
- Utilizing imagery data and sensor metadata for registration

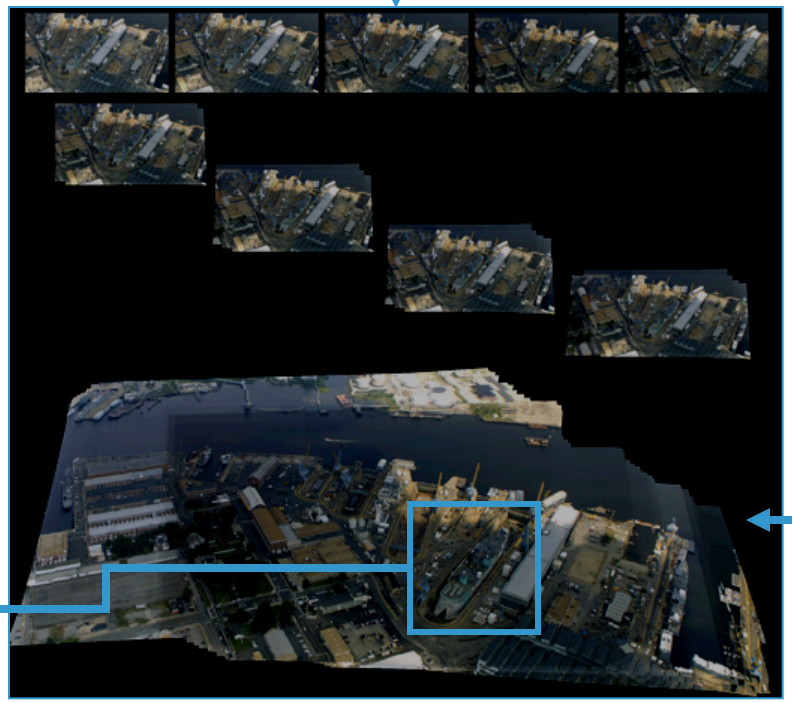
Point to image for metadata, icon tagging…

Product and Exploitation Ontology

Product Domains

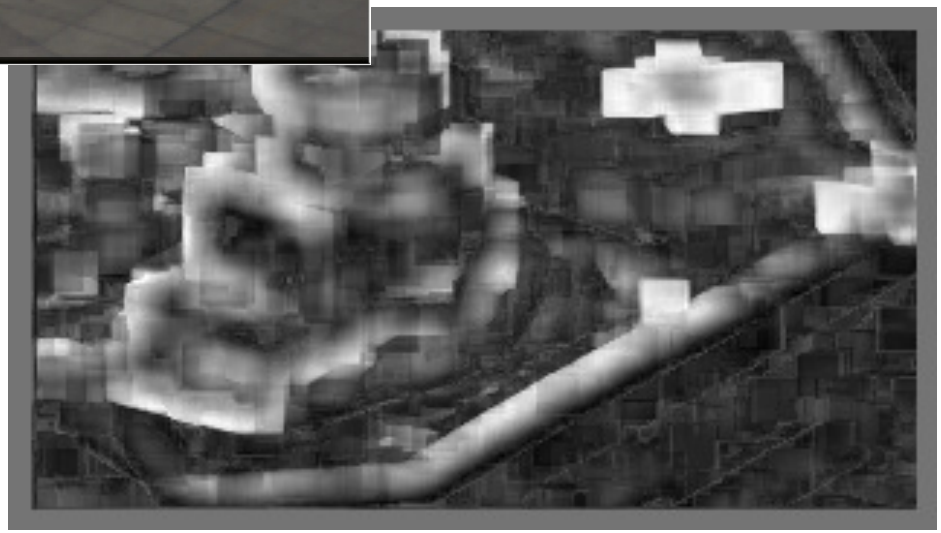
- IMINT Data Hierarchy
- Product Descriptions
- Product Utility
- Data Assurance Metrics
- Feature Extraction

IMINT product
is_a Type
- Video
- Frame Sequence
  - Still
  - MV 2Hz
  - MV 30 Hz
  - MV …:
- Format
  - MJPEG
  - H264
  - MJPEG2K
- Mosaic
  - J2K



IMINT product feature
is_a Type
- Terrestrial feature
- Vegetation
- Urban
- Mountain
- Desert
- Vehicle
  - Mil
  - Civ
- Aircraft
  - Mil
  - Civ
- Ship
  - Mil
  - Ship

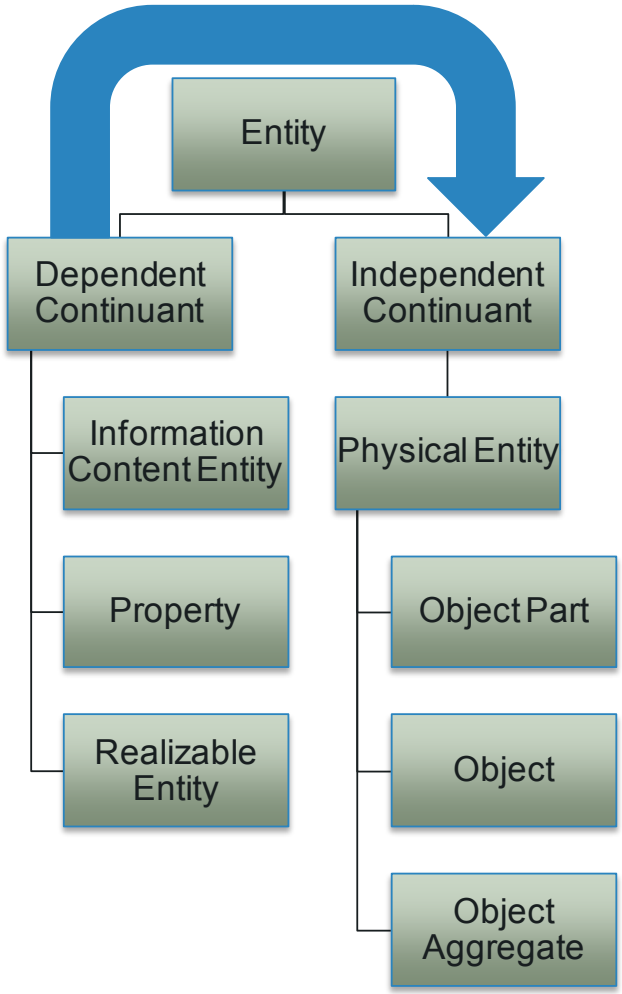
Classification & Semantic Search



Jason Corso, SUNY Buffalo

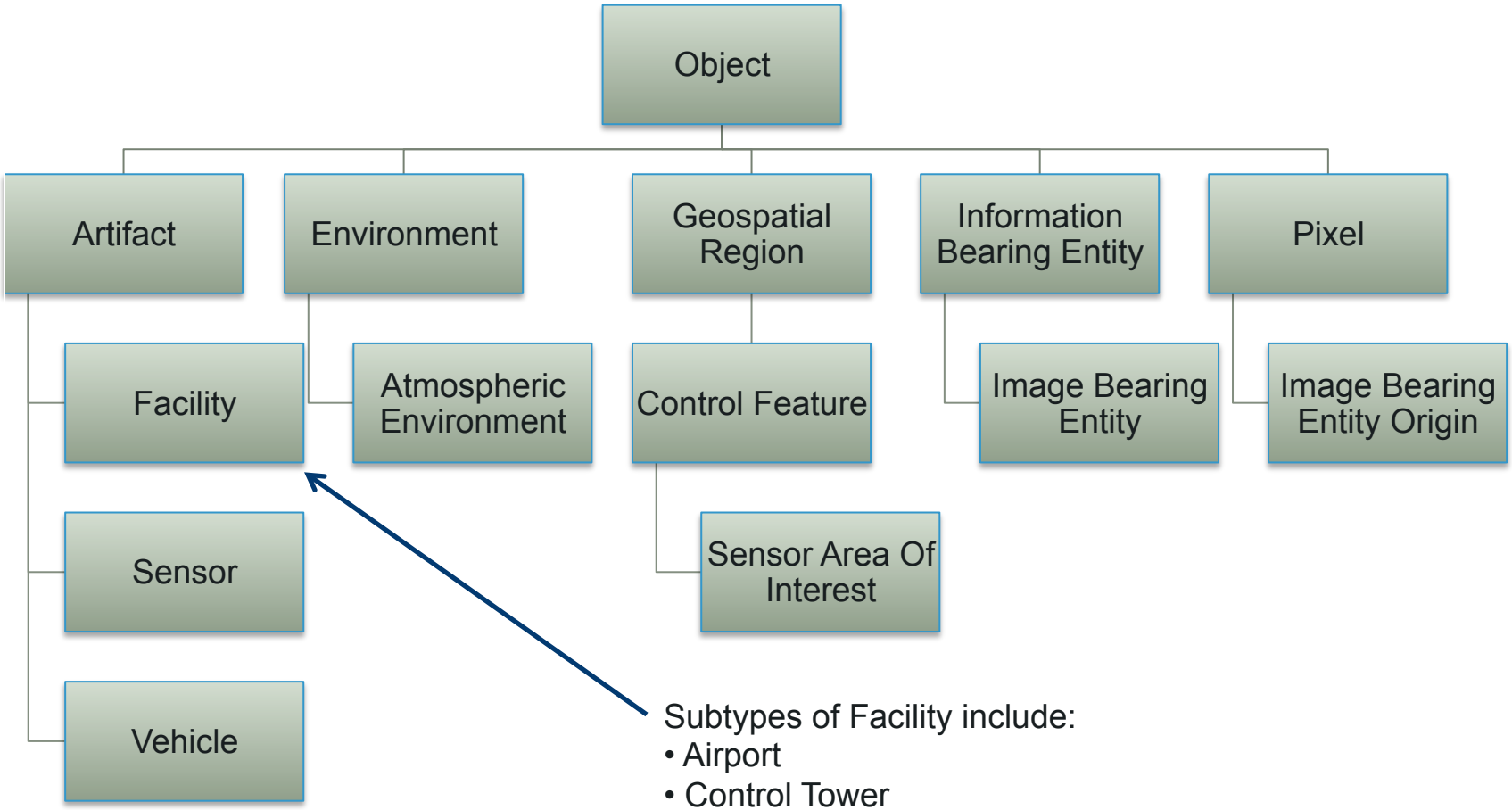
The Principal Subtypes of Entities

The ***dependent*** side of the divide defines information objects such as the output of imagery capture and the variable characteristics of objects such as altitude, speed, and direction



The ***independent*** side of the divide defines objects of the domain, their parts and the composites they sometimes form.

Objects –
The Kinds of Individuals of the Domain

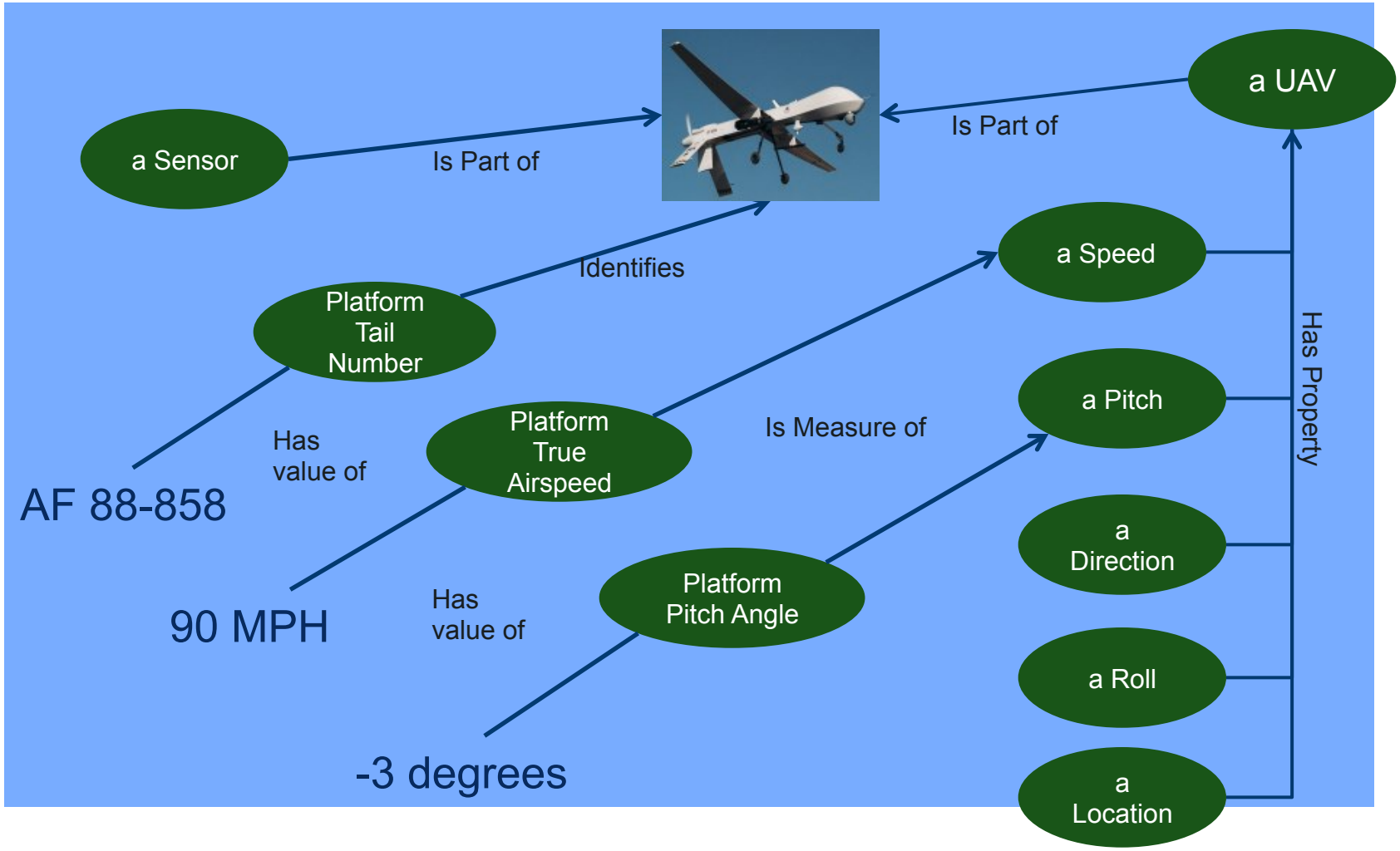


Subtypes of Facility include:
- Airport
- Control Tower
- Hangar
- Runway

Metadata Scalar Measurements

- The Subtypes of Scalar Measurement Include:
- Corner Latitude Point 1
- Corner Latitude Point 2
- Corner Latitude Point 3
- Corner Latitude Point 4
- Corner Longitude Point 1
- Corner Longitude Point 2
- Corner Longitude Point 3
- Corner Longitude Point 4
- Density Altitude
- Frame Center Elevation
- Frame Center Latitude
- Frame Center Longitude
- Ground Sample Distance
- Image Bearer Height
- Image Bearer Horizontal Coordinate
- Image Bearer Vertical Coordinate
- Image Bearer Width
- Modulation Transfer Modulation Measure
- Outside Air Temperature
- Pixel Depth Value
- Platform Heading Angle
- Platform Indicated Airspeed
- Platform Pitch Angle
- Platform Roll Angle
- Platform True Airspeed
- Sensor Horizontal Field of View
- Sensor Latitude
- Sensor Longitude
- Sensor Relative Azimuth Angle
- Sensor Relative Depression Angle
- Sensor Relative Roll Angle
- Sensor True Altitude
- Sensor Vertical Field of View
- Slant Range
- Static Pressure
- Target Width
- Unix Timestamp
- Wind Direction
- Wind Speed

Characterizing the State of Real-World Objects by Relating their Properties to Data



Sample Screenshot for Proof-of-Concept Demo

All data is stored and displayed based on the ontology

GV3.0 Viewer Interface

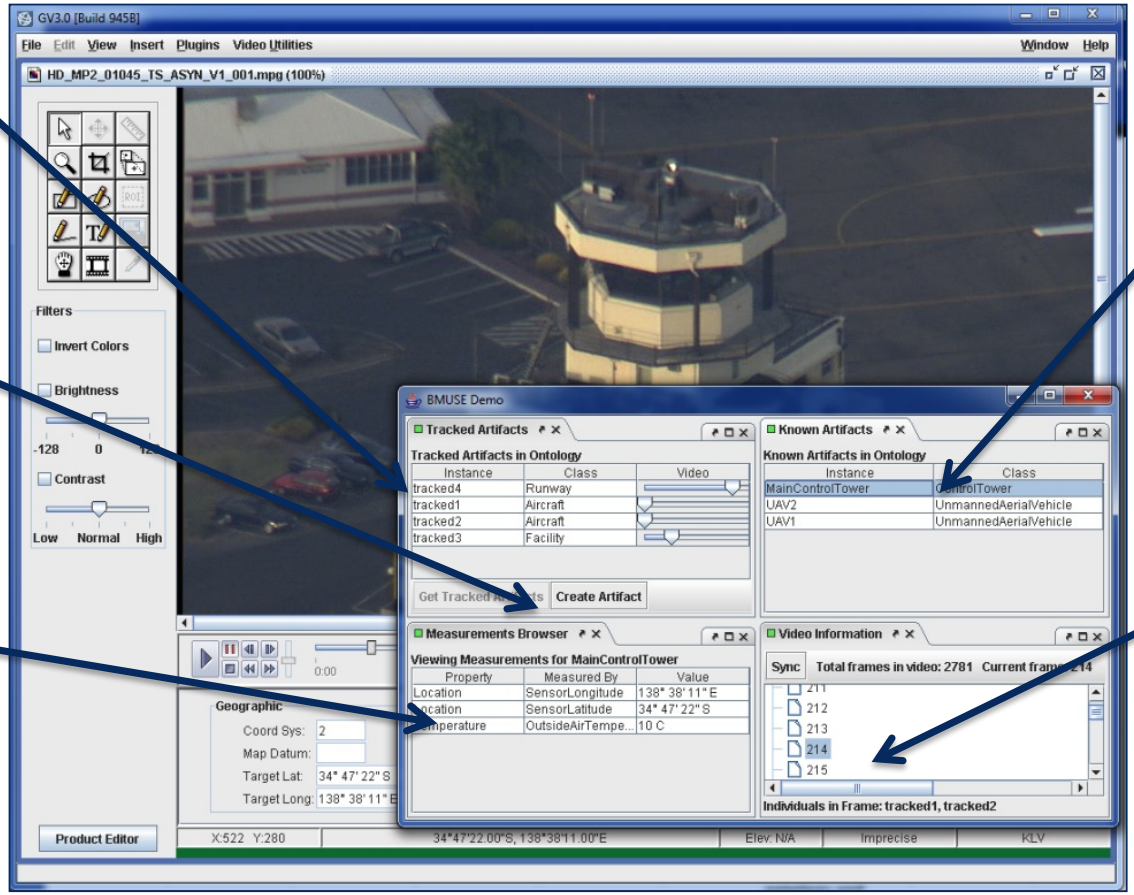
Tracked Objects in Video. Also indicates location within video

Create a new object in the video

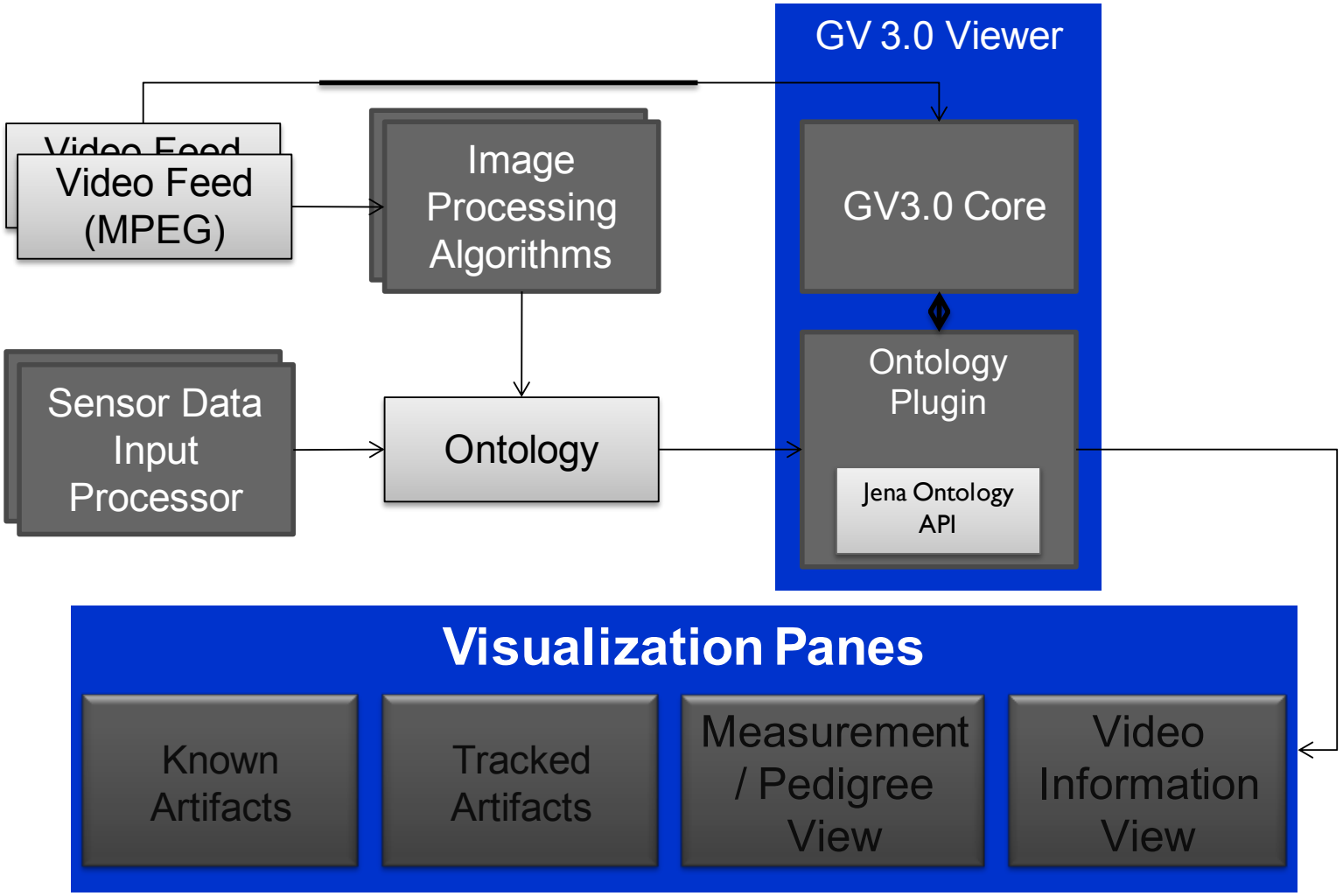
Sensor measurements of selected object

Known objects in video or mission

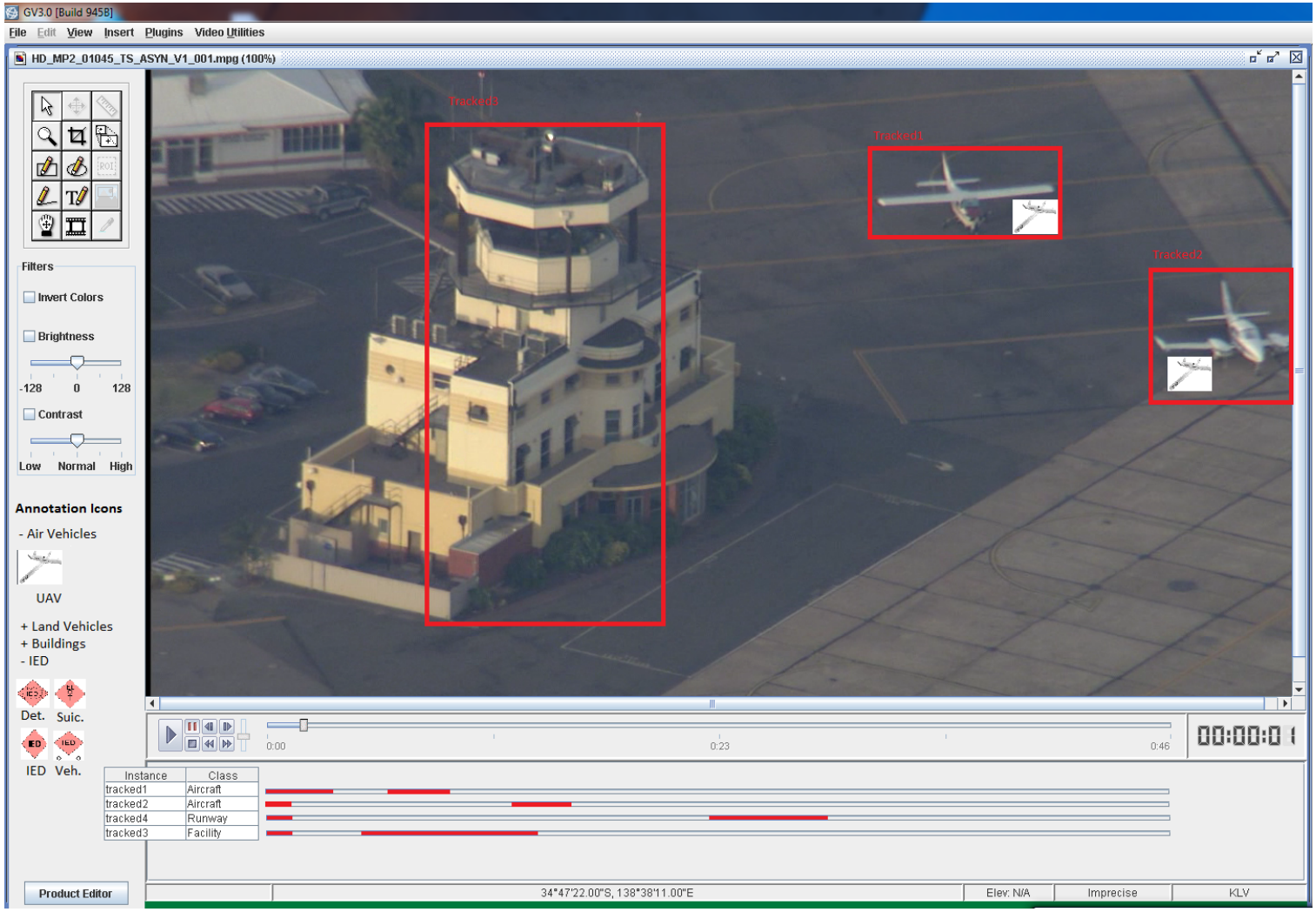
Video information



General Architecture of Utilizing Ontology



Level 1 Interface Mock Up



Summary

- The volumes and temporal nature of persistent surveillance collection information include imagery, support and format metadata, process data, performance or quality information, and exploited products.
- Ontologies can be used to better communicate the meaning and context of this data in a consistent manner.
- A full representation of PS collection content, using a principled approach to ontology domains and properties, encoded using a formal language such as OWL provides significant benefits.
- Benefits include the ability to formulate highly expressive queries, data consistency checks,, and the potential for seamless interoperability with other data resources.
- The long term efforts of this program will make such a representation available for the IMINT and VideoIMINT Database for Persistent Surveillance collections.