

# ONTOLOGY DRIVEN WEB-APP DEVELOPMENT USING JSON-LD

A Presentation to the NASA Datanauts

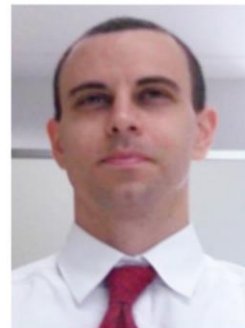
By Daniel A. O'Neil

```
{
  "@context": {
    "name": "http://schema.org/name",
    "homepage": {"@id": "http://schema.org/url", "@type": "@id"},
    "image": {"@id": "http://schema.org/image", "@type": "@id"}
  },
  "name": "Daniel A. O'Neil",
  "homepage": "https://www.linkedin.com/in/simtologist",
  "image": "https://media.licdn.com/media/p/3/000/0c4/113/3932a00.jpg"
}
```

September 2016

# Terminology and Resources

- **Ontology** - Defines terminology and semantic relationships among concepts
- **Web Ontology Language (OWL)** – a World Wide Web Consortium (W3C) specification for expressing ontologies.  
<https://www.w3.org/TR/owl-features/>
- **JavaScript Object Notation Linked Data (JSON-LD)** – a W3C specification for a serialization and messaging format  
<https://www.w3.org/TR/json-ld/>
- **Protégé** – is an ontology editor developed by the Stanford Center for Biomedical Informatics Research <http://protege.stanford.edu/>
- **Space Situational Awareness Ontology (SSAO)**
  - Developed by Robert Rovetto
  - Expressed in OWL
  - Explained in “Preliminaries of a Space Situational Awareness Ontology”



**Rovetto, Robert J.**

Ontologist  
University of Maryland, Department of Philosophy (2007 alum)  
University at Buffalo, SUNY, Department of Philosophy (2011 alum)

**CODER**  
CENTER FOR ORBITAL DEBRIS  
EDUCATION AND RESEARCH

Research topic: **Space Ontology**, Formal Ontology

<https://arxiv.org/ftp/arxiv/papers/1606/1606.01924.pdf>

<http://www.coder.umd.edu/node/285>

Onto-egg\_Description (language: en) [space-stational-awareness-ontology/](http://www.semanticweb.org/rovetta/ontologies/2014/01/space-stational-awareness-ontology/) (<http://www.semanticweb.org/rovetta/ontologies/2014/01/space-stational-awareness-ontology/>) (<http://www.semanticweb.org/rovetta/ontologies/2014/01/space-stational-awareness-ontology/>)

The Space Stational Awareness Ontology is intended to describe the spatial and temporal information, and that of the processes associated, related to the station and its environment.



Depicting ontological development and  
 interrelationships between various  
 domain ontologies, with one or more  
 representational frameworks of the 830

**Ontology**  
 - Astronomical Body  
 - COSPAR ID  
 - Data Format  
 - Ephemeris  
 - Geometric Entity  
 - Keplers Laws of Planetary Motion  
 - Launch Date  
 - NORAD ID

**Jungius**  
 - Longitude of the Ascending Node  
 - Eccentric Anomaly  
 - Time of Passage

- ▶ **Operational\_Status**
- ▶ **Operator**
- ▶ **Orbit**
- ▶ **Orbital\_Flowout**

References [Jungert et al.]  
"An Ontological Architecture for Orbital  
2014. Springer Berlin Heidelberg

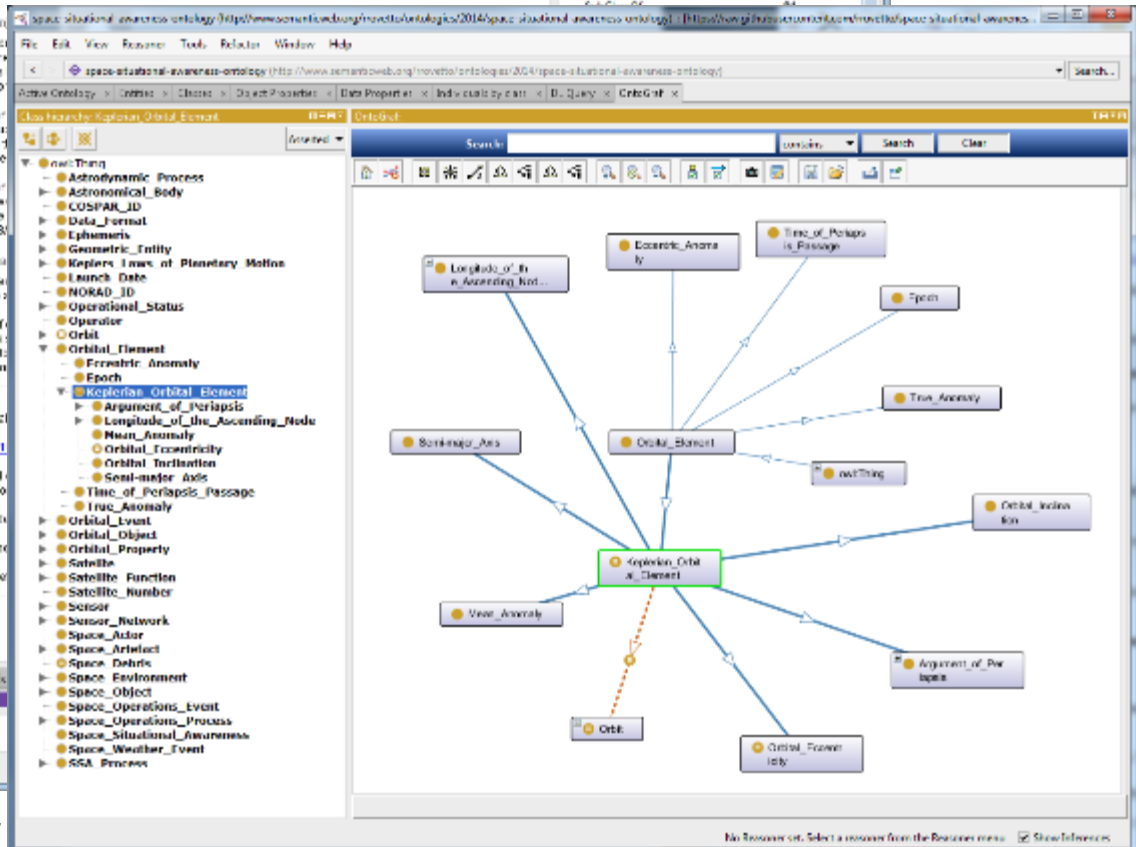
URL: <http://springer.com/watch>

- Orbital Eccentricity
- Orbital Inclination
- Semi-major Axis
- Time of Perapsis Passage

- Space Object Catalogs, T. Robert Hill
- Orbital Event
- Orbital Object
- Orbital Property
- Satellite
- Satellite Function
- Reposition Orbital Element

The screenshot shows the 'Ontology Editor' window. On the left, a tree view lists the classes: 'Space\_Environment' (selected), 'Space\_Object', 'Space\_Debris', 'Space\_Artifact', 'Space\_Active', 'Sensor\_Network', 'Sensor', 'Satellite\_number', and 'Mission'. On the right, a diagram shows the 'Space\_Environment' class (green box) with a dashed orange line connecting it to the 'Space\_Object' class (purple box). Other blue lines with arrowheads point from 'Space\_Environment' to other classes, indicating relationships.


## Protégé Screenshots of the SSAO




No Response set. Select a response from the Response menu. ☒ Show Inference

Ontology file located in Robert John Rovetto's Github repository

<https://raw.githubusercontent.com/rrovetto/space-situational-awareness-domain-ontology/master/SSAO> rrovetto.owl



# Mars Fact Sheet



## Mars/Earth Comparison

### Bulk parameters

	Mars	Earth	Ratio (Mars/Earth)
Mass ( $10^{24}$ kg)	0.64171	5.9724	0.107
Volume ( $10^{10}$ km <sup>3</sup> )	16.310	108.321	0.151
Equatorial radius (km)	3396.2	6378.1	0.532
Polar radius (km)	3376.2	6356.8	0.531
Volume-weighted mean radius (km)	3389.5	6371.0	0.532
Core radius (km)	1700	3485	0.488
Ellipticity (Flattening)	0.00589	0.00335	1.76
Mean density (kg/m <sup>3</sup> )	3933	5514	0.713
Surface gravity (m/s <sup>2</sup> )	3.71	9.80	0.379
Surface acceleration (m/s <sup>2</sup> )	3.69	9.78	0.377
Escape velocity (km/s)	5.09	11.19	0.450
GM ( $\times 10^6$ km <sup>3</sup> /s <sup>2</sup> )	0.642878	0.39860	1.107
Bond albedo	0.250	0.306	0.817
Visual geometric albedo	0.170	0.367	0.463
Visual magnitude V(1,0)	-1.52	-3.86	-
Solar irradiance (W/m <sup>2</sup> )	586.2	1361.0	0.431
Black-body temperature (K)	209.8	254.0	0.828
Topographic range (km)	30	20	1.500
Moment of inertia (I/MR <sup>2</sup> )	0.386	0.3308	1.108
J <sub>2</sub> ( $\times 10^{-6}$ )	1960.45	1082.63	1.811
Number of natural satellites	2	1	-
Planetary ring system	No	No	-

### Orbital parameters

	Mars	Earth	Ratio (Mars/Earth)
Semimajor axis ( $10^6$ km)	227.92	149.60	1.524
Sidereal orbital period (days)	686.980	365.256	1.881
Tropical orbital period (days)	686.973	365.242	1.881
Perihelion ( $10^6$ km)	206.62	147.09	1.400
Aphelion ( $10^6$ km)	249.20	152.10	1.635
Synodic period (days)	779.94	-	-
Mean orbital velocity (km/s)	24.07	29.78	0.808

space situational awareness

File Edit View Resources

space-situations

Active Ontology x Entities

Class hierarchy: Helio-Centric

Graveyard\_Orbit

Highly\_Elliptical\_Orbit

Low\_Earth\_Orbit

Medium\_Earth\_Orbit

Molniya\_Orbit

Non\_Polar\_Orbit

Planet-Centric\_Orbit

Polar\_Orbit

Prograde\_Orbit

Retrograde\_Orbit

Semi\_Synchronous\_Orbit

Stellar-Centric\_Orbit

Helio-Centric\_Orbit

Sun\_Synchronous\_Orbit

Orbital\_Element

Loxocentric\_Angle

Epoch

Keplerian\_Orbit

Argument\_of\_Perigee

Argument\_of\_Uplink

Longitude

Right\_Ascension

Mean\_Anomaly

Orbital\_Eccentricity

Orbital\_Inclination

Semi\_Major\_Axis

Time\_of\_Perigee

True\_Anomaly

Orbital\_Event

Orbital\_Object

Orbital\_Property

Satellite

Satellite\_Function

Satellite\_Number

Sensor

Sensor\_Network

Instances: Mars Orbit

For: Helio-Centric Orbit

Mars\_Orbit

The screenshot displays the Protégé ontology editor interface. The top menu bar includes File, Edit, View, Reasoner, Tools, Refactor, Window, and Help. The address bar shows the ontology URL: <http://www.semanticweb.org/movetto/ontologies/2014/space-situational-awareness-ontology/>.

The left-hand pane shows the "Class hierarchy: Helio-Centric\_Orbit" with a tree view. The hierarchy includes:
 

- Graveyard\_Orbit
- Highly\_Elliptical\_Orbit
- Low\_Earth\_Orbit
- Medium\_Earth\_Orbit
- Molniya\_Orbit
- Non\_Polar\_Orbit
- Planet-Centric\_Orbit
- Polar\_Orbit
- Prograde\_Orbit
- Retrograde\_Orbit
- Semi\_Synchronous\_Orbit
- Stellar-Centric\_Orbit
- Helio-Centric\_Orbit (selected)
- Sun\_Synchronous\_Orbit
- Orbital\_Element
  - Eccentric\_Anomaly
  - Epoch
  - Keplerian\_Orbital\_Element
    - Argument\_of\_Perapsis
      - Argument\_of\_Perigee
    - Longitude\_of\_the\_Ascending\_Node
      - Right\_Ascension\_of\_the\_Ascending\_Node
    - Mean\_Anomaly
    - Orbital\_Eccentricity
    - Orbital\_Inclination
    - Semi-major\_Axis
    - Time\_of\_Perapsis\_Passage
    - True\_Anomaly
  - Orbital\_Event
  - Orbital\_Object
  - Orbital\_Property
  - Satellite
    - Satellite\_Function
    - Satellite\_Number
  - Sensor
    - Sensor\_Network

The central workspace is empty, showing the "Annotations: Mars\_Orbit" tab. The right-hand pane is divided into two sections:
 

- Description: Mars\_Orbit**: Shows the type "Helio-Centric\_Orbit".
- Property assertions: Mars\_Orbit**: Lists several data property assertions for the instance "Mars\_Orbit":
  - has\_orbital\_eccentricity: "0.09341233"^^xsd:double
  - has\_Apogee: "2.4023E8"^^xsd:double
  - has\_RAAN: "49.57054"^^xsd:double
  - has\_Perigee: "2.0662E8"^^xsd:double
  - has\_Semi-major\_Axis: "1.52366231"^^xsd:double
  - has\_Semi-major\_Axis: "2.2792E8"^^xsd:double
  - has\_orbital\_inclination: "1.85"^^xsd:double

The bottom status bar indicates "No Reasoner set. Select a reasoner from the Reasoner menu" and "Show Inferences" is checked.



# JavaScript Object Notation Linked Data (JSON-LD)

## Overview and Resources

### 3.3 Syntax Tokens

- @context – define short-hand names
- @id – uniquely identify things
- @type – specify a data type
- @value – specify a graph property value
- @graph – express relationships of things

A JSON-based Serialization  
for Linked Data



<https://www.w3.org/TR/json-ld/>



### Manu Sporny

- Is one of the authors of the JSON-LD W3C Recommendation
- Has YouTube channel for JSON-LD tutorials

<https://www.youtube.com/channel/UCnaA8lQHipp7D6nedkpdE0A>

<https://github.com/digitalbazaar/jsonld.js> Code library

*Example: Compacting an Expanded Document*

### 6.17 Expanded Document Form

Expanding a JSON-LD document applies the Internationalized Resource Identifiers (IRI) to the things, types, and values, so the @context is not necessary.

### 6.18 Compacted Document Form

Compacting a JSON-LD document applies the developer supplied context to shorten the IRIs to terms. This format is simpler because it is expressed in application specific terms and it is easier to read.

### 6.19 Flattened Document Form

Flattening a JSON-LD document collects all properties of a node into a single JSON object and labels all blank nodes with blank node identifiers, e.g., "@id": "\_:b0".

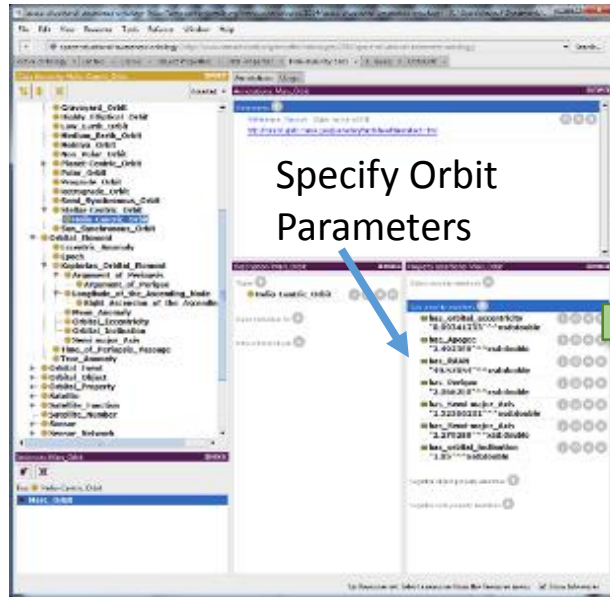
A Flattened document “may drastically simplify” processing code.

```
var doc = {
  "http://schema.org/name": "Manu Sporny",
  "http://schema.org/url": {"@id": "http://manu.sporny.org/"},
  "http://schema.org/image": {"@id":
    "http://manu.sporny.org/images/manu.png"}
};

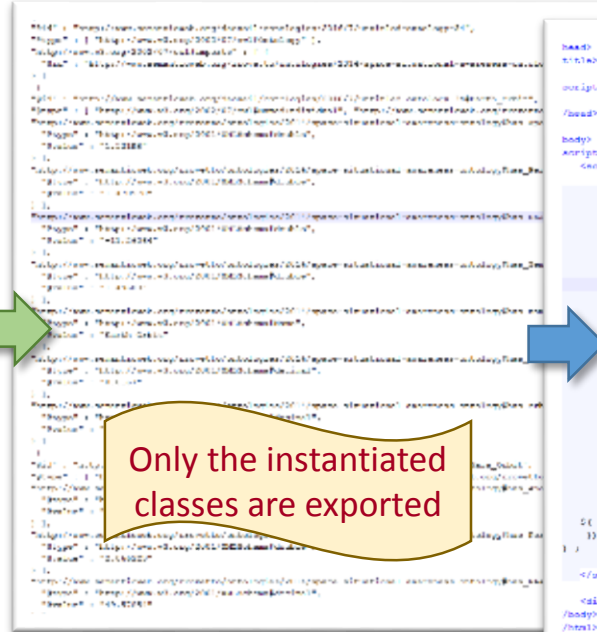
var context = {
  "name": "http://schema.org/name",
  "homepage": {"@id": "http://schema.org/url", "@type": "@id"},
  "image": {"@id": "http://schema.org/image", "@type": "@id"}
};

// compact a document according to a particular context
// see: http://json-ld.org/spec/latest/json-ld/#compacted-
// document-form
jsonld.compact(doc, context, function(err, compacted) {
  console.log(JSON.stringify(compacted, null, 2));
  /* Output:
  {
    "@context": {...},
    "name": "Manu Sporny",
    "homepage": "http://manu.sporny.org/",
    "image": "http://manu.sporny.org/images/manu.png"
  }
  */
});
```

# 1. Space Situational Awareness Ontology (SSAO) Imported into Protégé



# 2. Output from Protégé JSON-LD Expanded format



# 3. JavaScript using jsonld.js code library for converting expanded to compact format



# Ontology Driven Web-App Development Process

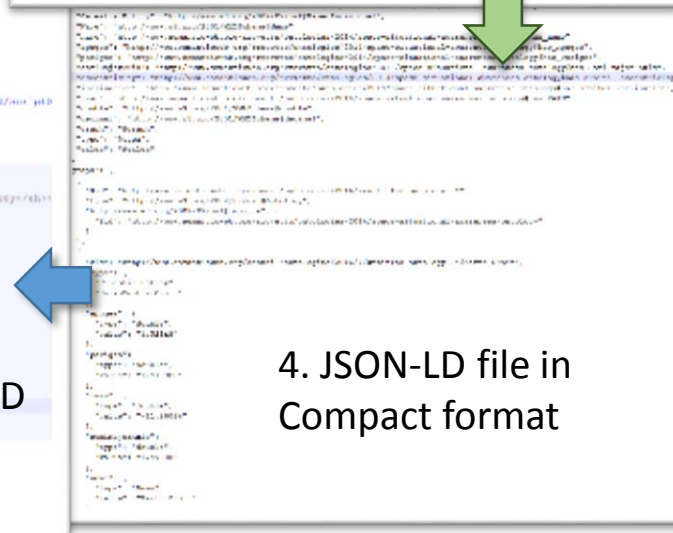
Name	Apogee	Perigee	Eccentricity	Inclination	SemiMajor Axis	RAAN
Earth_Orbit	1.521E8	1.4709E8	0.0167	0.000	1.496E8	-11.26064
Mars_orbit	2.4923E9	2.0662E9	0.0935	1.85	2.2792E9	49.57854
Mercury_Orbit	6.982E7	4.6E7	0.2056	7.0	5.791E7	48.33167
Venus_Orbit	6.98E7	4.6E7	0.007	3.4	1.0821E8	76.68069

RAAN = Right Ascension of Ascending Node

Rendered Web-Page

# 5. JavaScript reads the compact JSON-LD File and builds an HTML table

# 4. JSON-LD file in Compact format



# Conclusions

- Build upon existing ontologies developed by researchers in the domain
  - Protégé can import multiple ontologies
  - Additional custom classes can be added
  - Exported ontology only has the instantiated classes; so, there are no unused classes to cluster the data file
- The JSON-LD format builds upon JavaScript Object Notation (JSON) and provides terminology references
  - Protégé 5 exports an ontology in JSON-LD expanded format
  - The jsonld.js code library provides an example for converting the expanded format to the compact format
- The jQuery \$.getJSON() command can read the compact version of JSON-LD
  - The Context section translates the expanded format of JSON-LD @variables to the JSON “variable” format
  - A JSON-LD compact file can serve as a complexly structured data-base for web-apps