



*Update on the Linked And Networked
DRoneS project:*
DEVELOPMENT PHASE

Charles F Vardeman II (UND), Jane Wyngaard (UND)



UNIVERSITY OF NOTRE DAME
CENTER FOR RESEARCH COMPUTING

Overview

1. LANDRS overview and goals
2. LANDRS Ontology
3. LANDRS Toolkit Technology Stack
4. Drone Data Buddy Demonstrator
5. Planned adopters and extensions

LANDRS: Goals

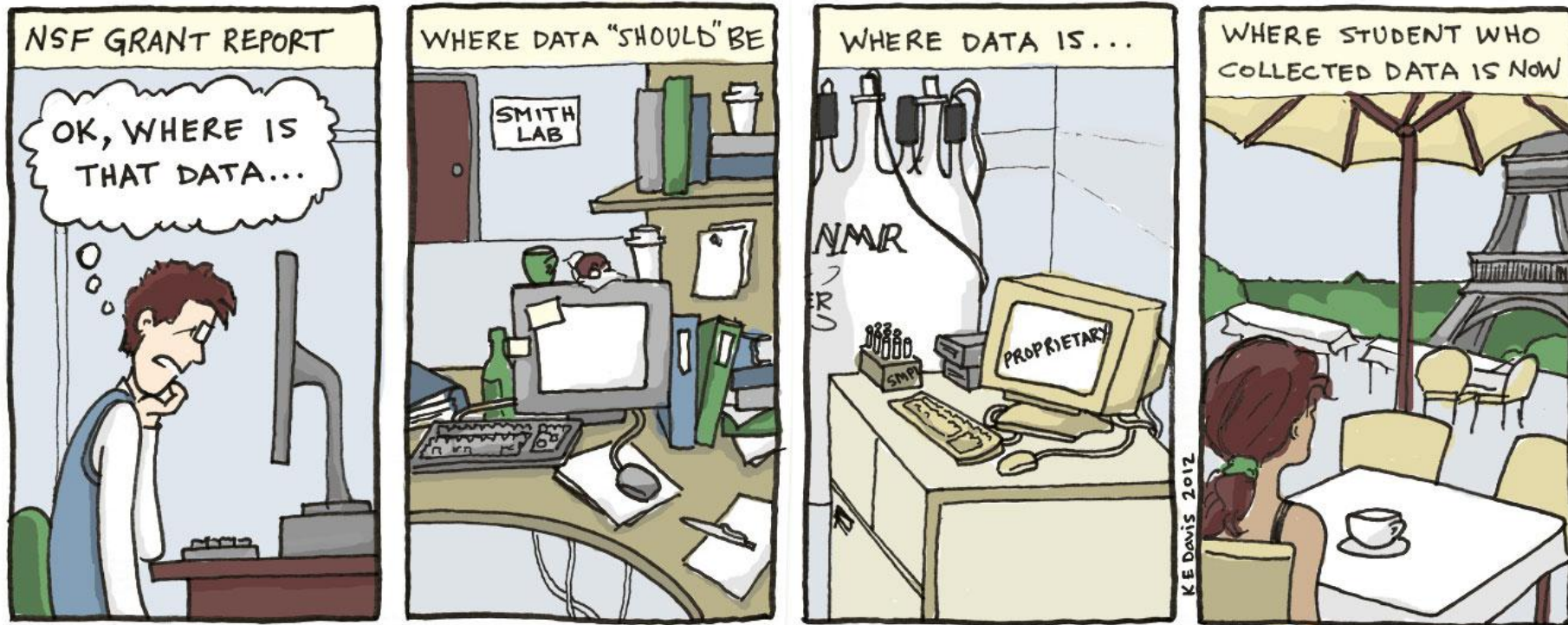
Problem: Complex and painful drone data pipeline costs significant data value

Goal: Allow users to capture the lost value by providing standards based APIs for building drone data wrangling tools.

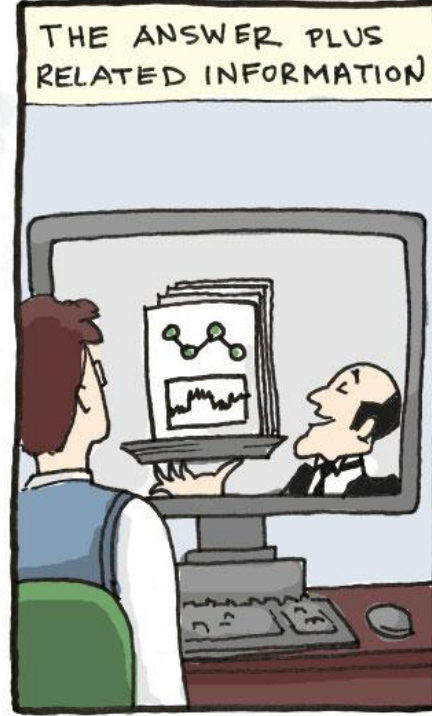


Linked-data
**API for
Networked
DRoneS**

Our current world

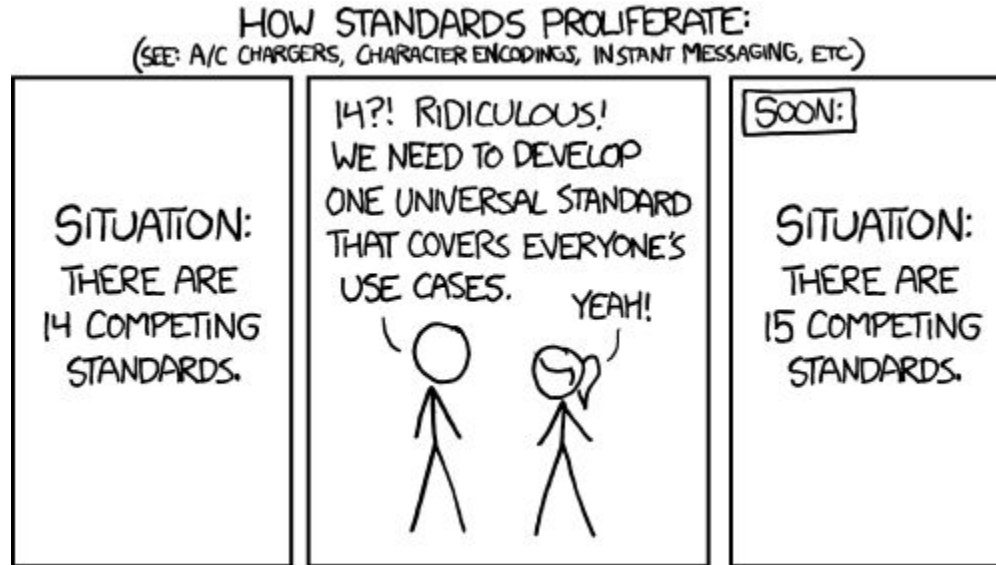


If we can enable smart agents with smart data



K.E. Davis 2012

The Issue



<https://xkcd.com/927/>

Building on Existing Standards



Spatial Data on the Web Best Practices

W3C Editor's Draft 18 February 2020

Semantic Sensor Network Ontology

W3C Recommendation 19 October 2017 (Link errors corrected 08 December 2017)



Extensions to the OWL-Time Ontology temporal aggregates

W3C Editor's Draft 18 February 2020

Hydra Core Vocabulary

A Vocabulary for Hypermedia-Driven Web APIs

Building on Existing Standards

Environment Ontology

Keywords:

Search terms

Class: atmospheric carbon dioxide

Term IRI: http://purl.obolibrary.org/obo/ENVO_01000451

Definition: Atmospheric carbon dioxide is an environmental material composed of carbon dioxide in its gaseous form present in an atmosphere.

Annotations

- http://www.geneontology.org/formats/oboInOwl#created_by: ORCID:0000-0002-4366-3088
- <http://www.w3.org/2000/01/rdf-schema#comment>: This could also be considered a part of an environmental material like air.
- [in_subset](#): [envoPolar](#)

SWEET Ontologies

 on channel #sweetontology

Introduction

Official repository for Semantic Web for Earth and Environmental Terminology (SWEET) Ontologies.



5 stars of LD Vocabulary Use



- There is dereferencable human readable information about the used vocabulary



- The information is available as machine-readable explicit axiomatization of the vocabulary



- The vocabulary is linked to other vocabularies



- Metadata about the vocabulary is available



- The vocabulary is linked to by other vocabularies

- Forked Open Source Zazuko Ontology Manager
<https://zazuko.com/products/ontology-manager/>
- LD Community of Developers
- schema.landrs.org
(live but not yet beta)

Propose Terms for Voting

[Thing](#) > [Product](#) > [Flight Controller Board](#)

Flight Controller Board

Canonical URL: <http://schema.landrs.org/schema/FlightControllerBoard>

Quick links: [Proposals](#) [Conversation](#)

Comment on Terms

Description

A flight controller (FC) is a small circuit board of varying complexity. Its function is to direct the RPM of each motor in response to input. A command from the pilot for the multi-rotor to move forward is fed into the flight controller, which determines how to manipulate the motors accordingly.

Sub Class Of

<http://www.w3.org/2000/01/rdf-schema#subClassOf>

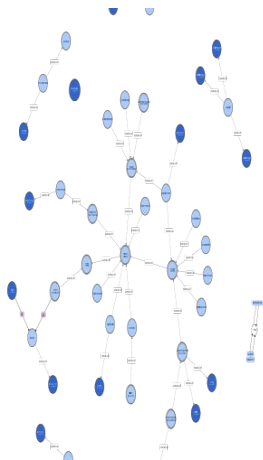
- <http://schema.landrs.org/schema/Product>
- <http://www.w3.org/ns/sosa/system>

Properties

Property	Expected Type	Description
----------	---------------	-------------

This resource does not have any properties.

<https://www.landrs.org/ontology/>



Landrs Schema

language **en**

Release 2020-02-01

Revision:

0.0.1

License:

License: <https://creativecommons.org/publicdomain/zero/1.0/>

Visualization:

Visualize with [WebVowl](#)

Cite as:

Landrs Schema, Revision: 0.0.1.

[Provenance of this page](#)

Abstract

This ontology is developed as part of the Sloan Funded LANDRS project to advance UxV data interoperability

[back to ToC](#)

1. Landrs Schema: Overview

This ontology has the following classes and properties.

Classes

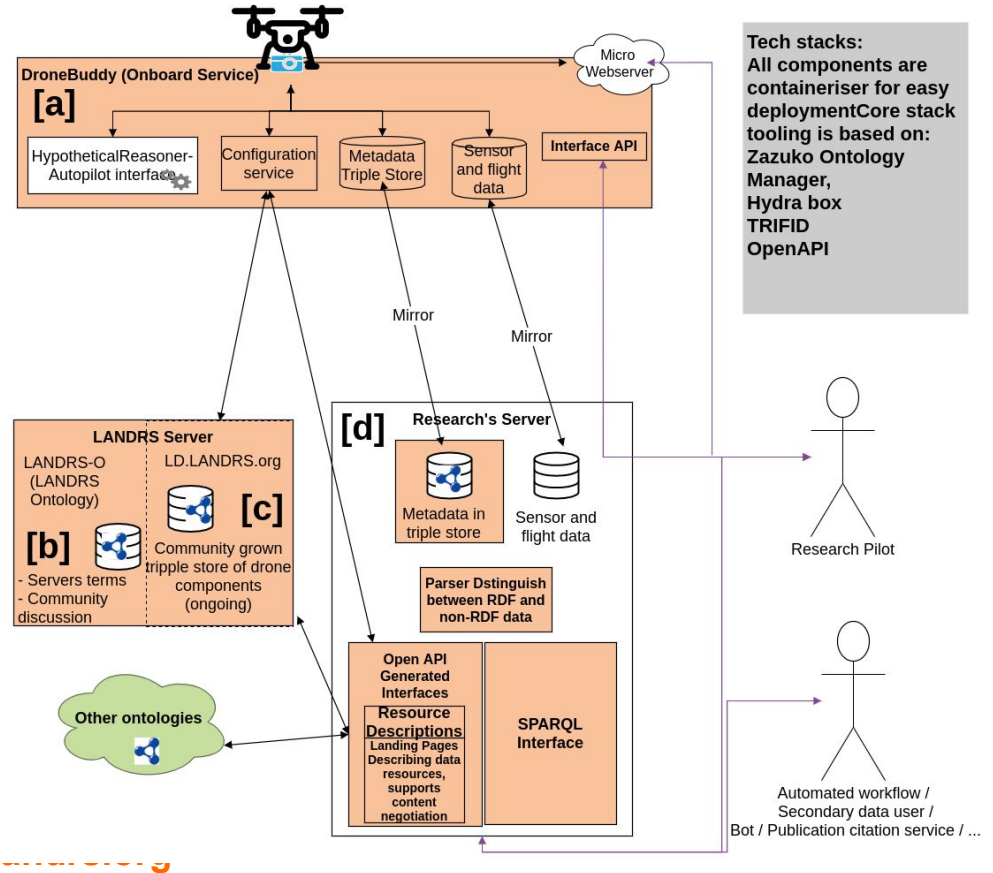
Airframe Automated Robot Autonomous Robot Autopilot Component event Event Flight Control System Flight Controller Board
Ground Control Station Mission Motorized Vehicle p o component type Payload Product Remotely Piloted Robot robot Robot
Robotic Vehicle Sensor Payload Surface Vehicle Thing Underwater Vehicle unmanned aerial vehicle
Unmanned Aerial Vehicle Unmanned Aerial Vehicle Unmanned Aircraft Component Unmanned Aircraft System Unmanned Aircraft System
Unmanned Vehicle Unmanned Vehicle Unmotorized Vehicle UxV Body Vehicle

Object Properties

component hasWhole Winston ODP Component p

Building LD Applications

Drone Data Buddy example application



LANDRS SPARQL End Point

zozukoTrifid

Query x +

https://ld.landrs.org/query

```
1 PREFIX sosa: <http://www.w3.org/ns/sosa/>
2 PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
3 PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
4 SELECT * WHERE {
5   ?sub rdf:type ?obj
6 }
7 LIMIT 10
```

https://ld.landrs.org/actuator/35-207306-844818-0/T5008

https://ld.landrs.org/actuator/35-207306-844818-0/T5008

type	Actuator
sameAs	https://www.xoarintl.com/brushless-electric-motors/titan/titan-T5000-heavy-lifting-series/
comment	XOAR Titan T5000 Brushless Electric Motor Heavy Lifting Series offers all multicopters and drones manufacturers, engineers, pilots and enthusiasts the best performance and reliable propulsion system with XOAR Precision Pair Propellers. XOAR Titan Brushless Electric Motors are specially designed with top grade materials and unique design to work with XOAR Precision Pair Propellers in order to offer the best balance in weight and performance. XOAR Titan T4000 Heavy Lifting Series includes T5008 - KV320, T5010 - KV300, T5012 - KV300, T5015 - KV285 which supports All Up Weight (AUW) for quadcopter, hexacopter, octocopter from min. 6.24 Kg, 9.36 Kg, 12.48 Kg to max. 12.4 Kg, 18.6 Kg and 24.8 Kg respectively. See below for more detailed specs and performance data.
label	XOAR Titan T5008 Brushless Electric Motor Heavy Lifting Series
isHostedBy	FlightControllerBoard

Press CTRL - <spacebar> to autocomplete

Table Response Pivot Table Google Chart Geo  

Showing 1 to 10 of 10 entries (in 0.052 seconds)

Search: Show 50 entries

sub	obj
1 http://schema.landrs.org/mission	https://data.nasa.gov/ontologies/atmonto/ATM#Flight
2 http://schema.landrs.org/Payload	http://www.w3.org/2000/01/rdf-schema#Class
3 http://ld.landrs.org/schema/Thing/drone/#s/FlightControllerBoard	http://schema.landrs.org/FlightControllerBoard
4 http://ld.landrs.org/actuator/35-207306-844818-0/T5008	http://www.w3.org/ns/sosa#Actuator



The screenshot shows the XOAR website's product page for the Titan T5000 motor. The navigation bar includes links for 'RC PROPPELLERS', 'MULTICOPTER PROPPELLERS', 'LAW PROPPELLERS', 'BRUSHLESS ELECTRIC MOTORS', 'ACCESSORIES', 'SHOP', 'BLOG', and 'CONTACT US'. The main heading is 'Titan T5000' with the subtitle 'Heavy Lifting Series for RC Multicopters and Drones'. Below the heading are buttons for 'Description', 'Specifications', and 'Where To Buy'. A large image of the motor is shown on the right side of the page.

Hydra and SHACL

Shapes Constraint Language (SHACL)

W3C Recommendation 20 July 2017



zazuko / [hydra-box](#)

Used by 18

Watch 7

Star 9

Fork 1

Code

Issues 26

Pull requests 1

Actions

Projects 0

Wiki

Security

Insights

Hydra Box - SPARQL to Linked Data APIs for Web developers

hydra

rdf

linked-data

api

hypermedia-api

hateoas

sparql

hydra-box

[Hydra](#) is a machine readable description for APIs. Hydra Box extends the API description with links to the actual code, which provides the API. Hydra Box will use such an API description to start a server which provides the API and dynamically loads the required code for it.

Hydra and SHACL

Example shapes graph

```
ex:PersonFormShape
  a sh:NodeShape ;
  sh:property [
    sh:path ex:firstName ;
    sh:name "first name" ;
    sh:description "The person's given name(s)" ;
    sh:order 0 ;
    sh:group ex:NameGroup ;
  ] ;
  sh:property [
    sh:path ex:lastName ;
    sh:name "last name" ;
    sh:description "The person's last name" ;
    sh:order 1 ;
    sh:group ex:NameGroup ;
  ] ;
  sh:property [
```

Name

first name: John

last name: Doe

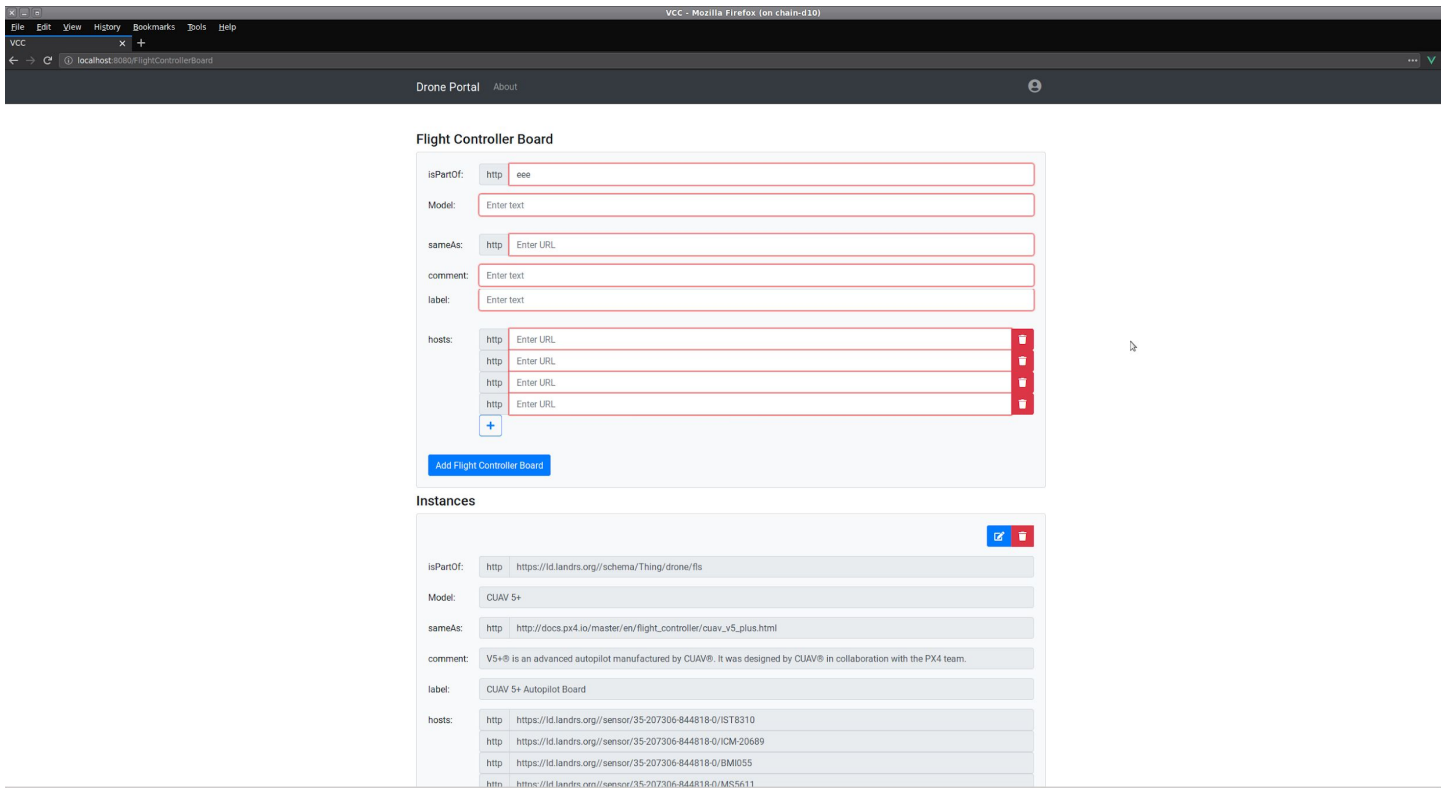
Address

street address: 123 Silverado Ave

locality: Cupertino

zip code: 54321

LANDRS Hydra and SHACL



The screenshot shows a web browser window titled "VCC - Mozilla Firefox (on chain-d10)". The address bar shows "localhost:5580/FlightControllerBoard". The page header includes "Drone Portal" and "About".

Flight Controller Board

isPartOf:

Model:

sameAs:

comment:

label:

hosts:

[Add Flight Controller Board](#)

Instances

isPartOf:

Model:

sameAs:

comment:

label:

hosts:

Incorporating OGC API

OGC API - Features - Part 1: Core

Table 1. Overview of resources, applicable HTTP methods and links to the document sections

Resource	Path	HTTP method	Document reference
Landing page	/	GET	7.2 API landing page
Conformance declaration	/conformance	GET	7.4 Declaration of conformance classes
Feature collections	/collections	GET	7.13 Feature collections
Feature collection	/collections/{collectionId}	GET	7.14 Feature collection
Features	/collections/{collectionId}/items	GET	7.15 Features
Feature	/collections/{collectionId}/items/{featureId}	GET	7.16 Feature

- Containerised Microservices
 - Apache Jena Fuseski GeoSPARQL
 - Trifid
 - Hydrabox
 - Server Web Application Client (Forms)
 - Drone Application Client

- Containerised Microservices
 - LANDRS Web API
 - Hydrabox
 - RDFjs Filesystem Store
 - Ontologies
 - LANDRS Node Component API
 - Mavlink
 - ROS
 - Dynamic mission routing

rdf-store-fs

npm v1.0.0 build passing coverage 100%

Filesystem based RDF Store that follows the [RDF/JS: Stream interfaces](#) specification.

Best Practices Exercises

1. USGS
2. LTER
3. RDA



Planned Extensions

- Image Annotation
 - <https://www.w3.org/ns/oa>
- Jupyter-lab Metadata Service:
 - <https://github.com/jupyterlab/jupyterlab-metadata-service>
- DIDs and Verifiable Credentials
 - <https://w3c.github.io/did-core/>
 - <https://w3c.github.io/vc-data-model/>
- 5G

Get involved

- General info: landrs@nd.edu
- [Slack Channel](#)
- Interested in a paid internship?
 - Pitch to us via [Google form](#)
- Submit an issue/propose something on [Github](#)