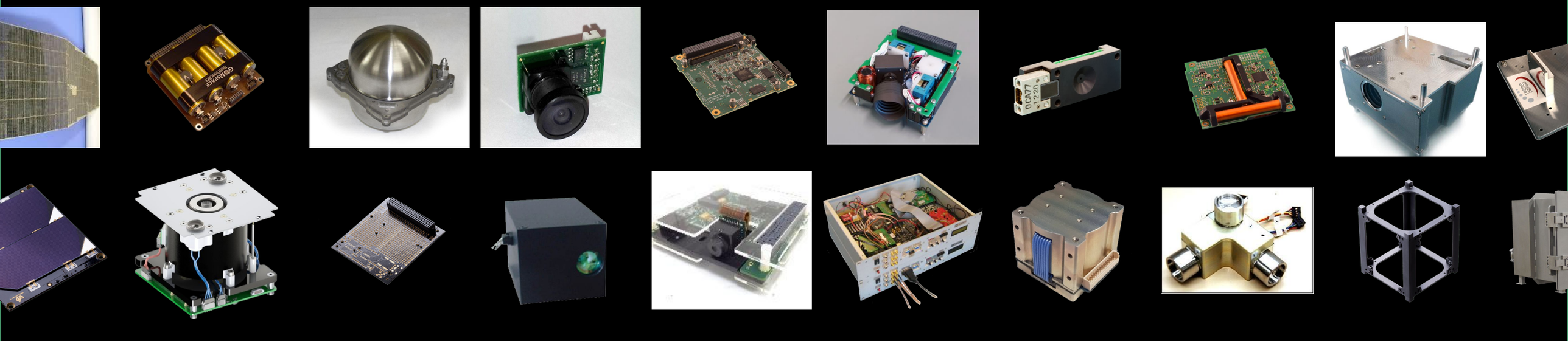
Development of a universal ontology for the global space supply chain



<u>24th June, 2019</u>

Space System Ontology - Brainstorming Workshop

ESA/ESTEC, Noordwijk

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Space engineers face hard questions ...

What is the standby power of Aerojet's MR-103G thruster?

How do the RW-0.03 and RWA-05 reaction wheels compare?

How many satellites have been delivered to orbit in the last quarter?

Which on-board computer is recommended for my payload suite?

Are satellites getting bigger or smaller?

How reliable is my supply chain and where are the key risks?

Who produces Cubesat batteries with flight heritage?

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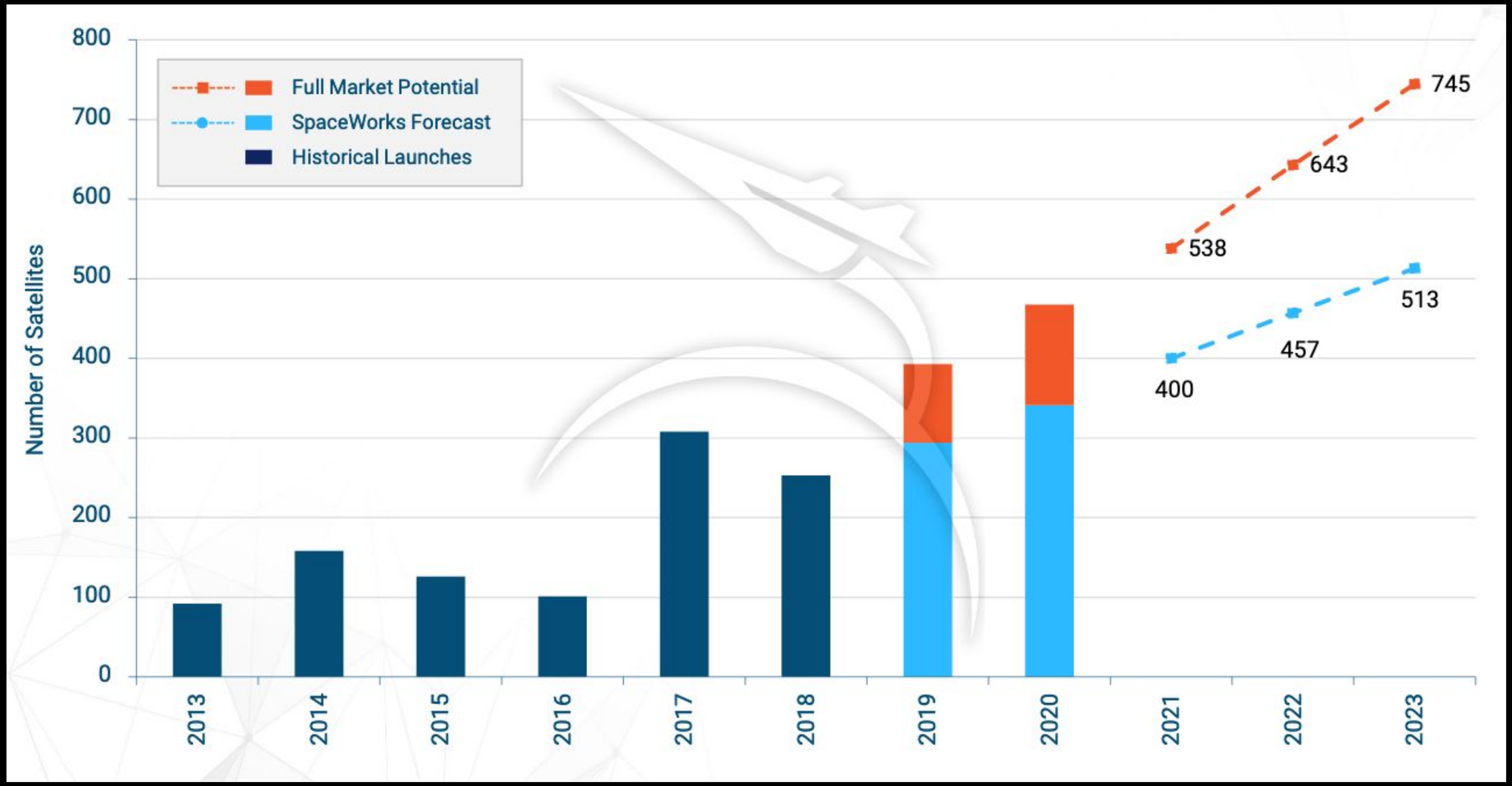
Industry growth is making this much harder



(SpaceWorks, 2018)

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Open supply chain is necessary for commercialization

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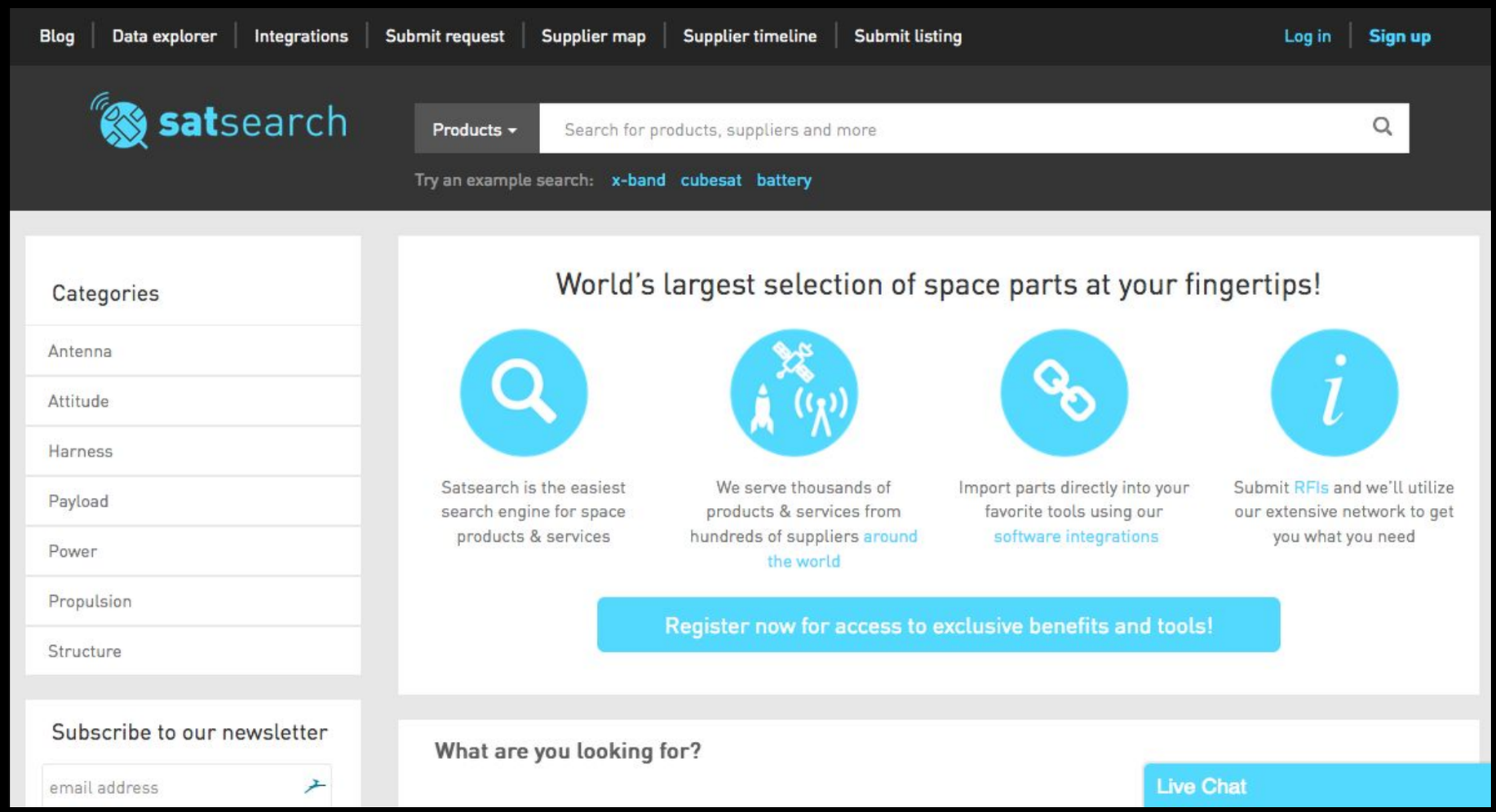
A ***B2B marketplace***
that indexes the global space supply chain



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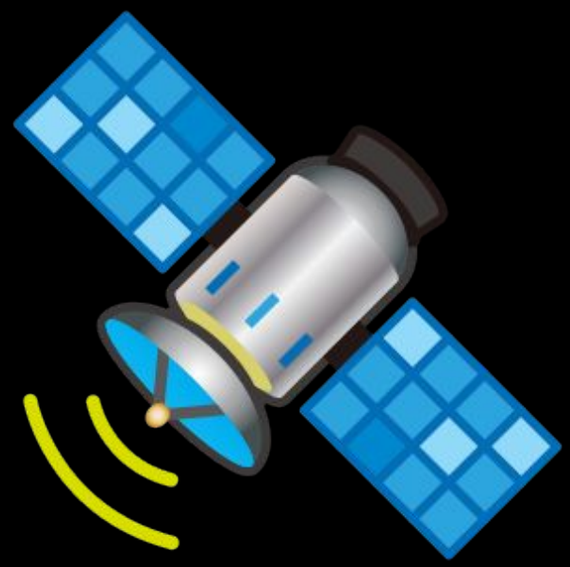
Our platform is growing

> 1,100 suppliers



> 5,200
products & services

>1,500 users/month

€10M+ qualified lead volume in 2019

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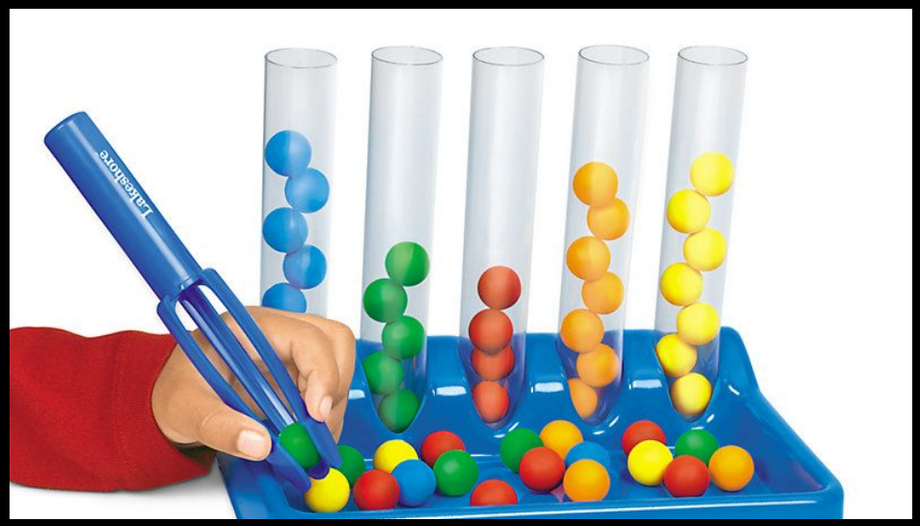
Our users want to ...

Search



Sort

Filter

Compare

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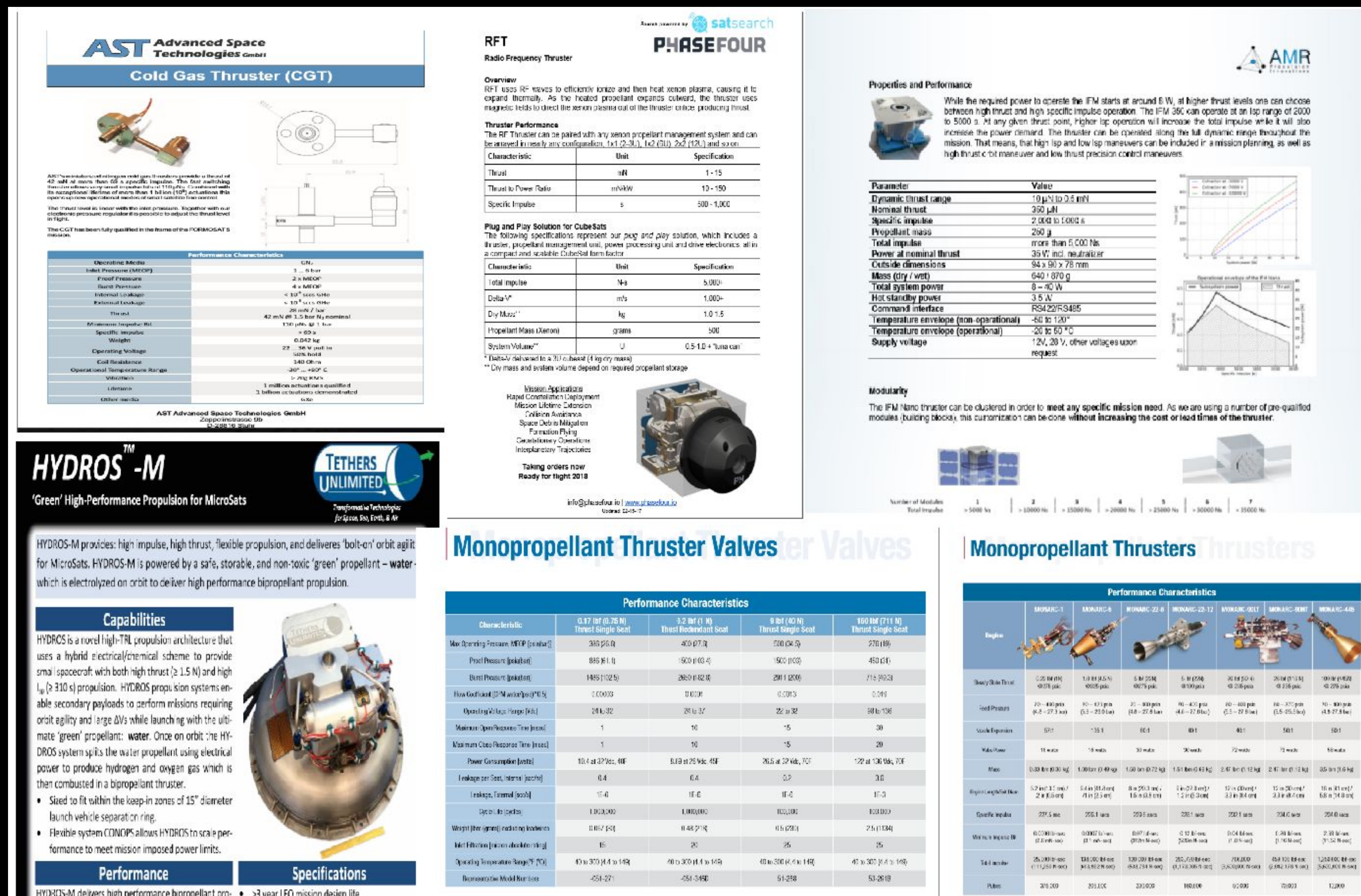
Information is locked in "messy" documents



Unlocking this knowledge is essential to deep searching, filtering, sorting, comparing of products & services

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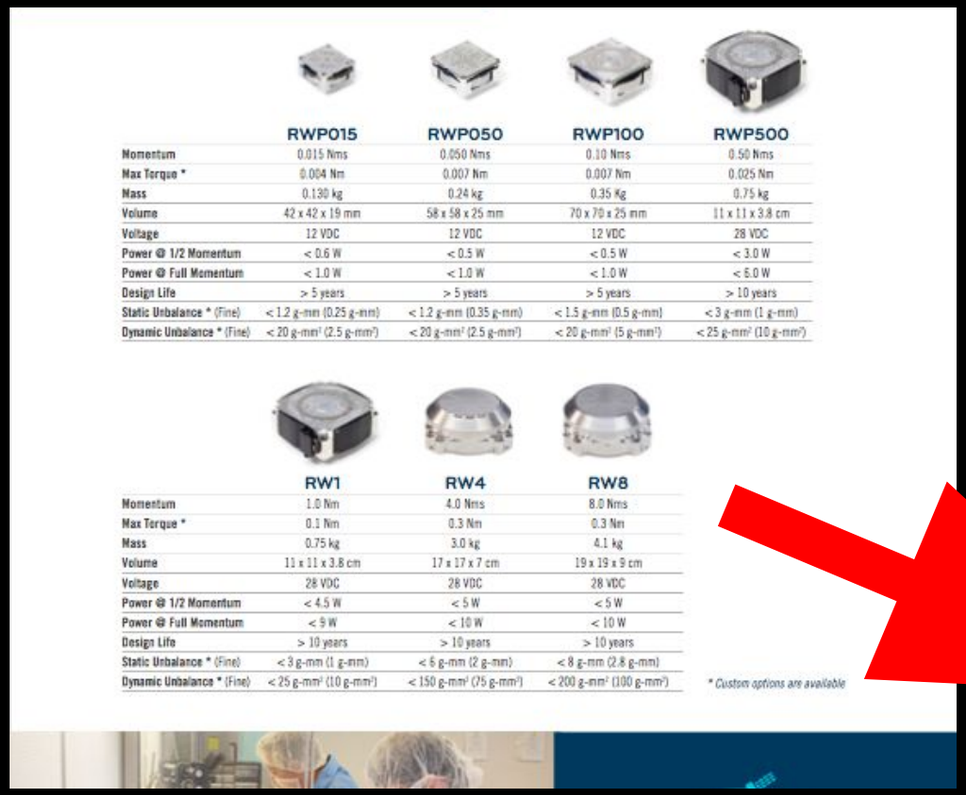
Solution: Structured docs from source data



	RWP015	RWP050	RWP100	RWP500
Momentum	0.015 Nms	0.050 Nms	0.10 Nms	0.50 Nms
Max Torque *	0.004 Nm	0.007 Nm	0.007 Nm	0.025 Nm
Mass	0.130 kg	0.24 kg	0.35 Kg	0.75 kg
Volume	42 x 42 x 19 mm	58 x 58 x 25 mm	70 x 70 x 25 mm	11 x 11 x 3.8 cm
Voltage	12 VDC	12 VDC	12 VDC	28 VDC
Power @ 1/2 Momentum	< 0.6 W	< 0.5 W	< 0.5 W	< 3.0 W
Power @ Full Momentum	< 1.0 W	< 1.0 W	< 1.0 W	< 6.0 W
Design Life	> 5 years	> 5 years	> 5 years	> 10 years
Static Unbalance * (Fine)	< 1.2 g-mm (0.25 g-mm)	< 1.2 g-mm (0.35 g-mm)	< 1.5 g-mm (0.5 g-mm)	< 3 g-mm (1 g-mm)
Dynamic Unbalance * (Fine)	< 20 g-mm² (2.5 g-mm²)	< 20 g-mm² (2.5 g-mm²)	< 20 g-mm² (5 g-mm²)	< 25 g-mm² (10 g-mm²)

	RW1	RW4	RW8
Momentum	1.0 Nm	4.0 Nms	8.0 Nms
Max Torque *	0.1 Nm	0.3 Nm	0.3 Nm
Mass	0.75 kg	3.0 kg	4.1 kg
Volume	11 x 11 x 3.8 cm	17 x 17 x 7 cm	19 x 19 x 9 cm
Voltage	28 VDC	28 VDC	28 VDC
Power @ 1/2 Momentum	< 4.5 W	< 5 W	< 5 W
Power @ Full Momentum	< 9 W	< 10 W	< 10 W
Design Life	> 10 years	> 10 years	> 10 years
Static Unbalance * (Fine)	< 3 g-mm (1 g-mm)	< 6 g-mm (2 g-mm)	< 8 g-mm (2.8 g-mm)
Dynamic Unbalance * (Fine)	< 25 g-mm² (10 g-mm²)	< 150 g-mm² (75 g-mm²)	< 200 g-mm² (100 g-mm²)

* Custom options are available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    "measurementUnit": "N m s",
    "minimumValue": "",
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    "productConfiguration": "base",
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    "value": "0.015"
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    "measurementUnit": "N m",
    "minimumValue": "",
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    "productConfiguration": "base",
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    "uuid": "dfba18ef-e9c0-43bd-abe4-c45ada956ede",
    "value": "0.004"
},
```


A common, universal language describing space systems is necessary

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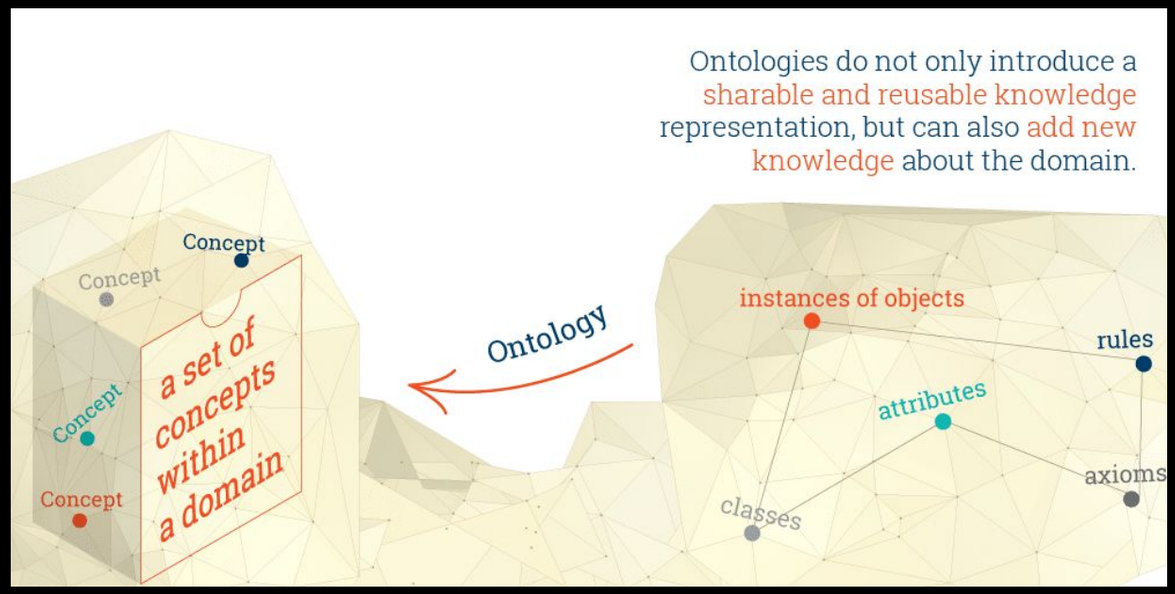
What do we understand as an ontology?

“a set of representational primitives with which to model a domain of knowledge or discourse”

(Gruber, 2009)

Fundamental ingredients

- Classes (or sets)
- Attributes (or properties)
- Relationships (or relations among class members)



(ontotext, 2019)

A universal ontology for the space industry can help reduce cost, lead time, and failures

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What problems do we observe?

- Inconsistent nomenclature
- Inconsistent use of units
- Varied use of precise values and (open/closed) ranges
- “Random” symbols: ~, ±
- Complex values, e.g., interdependencies
- Inconsistent notation for uncertainty
- Graphical data
- Data incompleteness
- ...

<u>Result</u>

We’re all talking different “dialects”

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Developing a universal space systems ontology

1. Top-down
   a. “Design by committee”
   b. Requires stakeholders to be active in discussions

2. Bottom-up
   a. “Design by data”
   b. Requires stakeholders to actively provide source data

<u>Ideal solution</u>

Hybrid top-down and bottom-up approach

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A software pipeline to generate an ontology

Source unstructured documents

01

Data processing

02

Data structuring

03

Data storage & tooling

04

A learning system would enable rapid development of a flexible, comprehensive, and reliable ontology

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We serve structured data through our API

Filter... x

Product

Get full product details
List product attribute classes
List product categories
List products

Supplier

Get full supplier details
List suppliers

Satsearch API

1.0.0

Satsearch API app

Product

Product - Get full product details

1.0.0

GET

```
https://api.satsearch.co/v1/products/:uuid
```

Header

Field	Type	Description
Authorization	String	Replace `:token` with supplied Auth Token Allowed values: `"Bearer :token"`
X-APP-ID	String	Replace `:app-id` with supplied secret app id Allowed values: `":app-id"`

Parameter

api.satsearch.co

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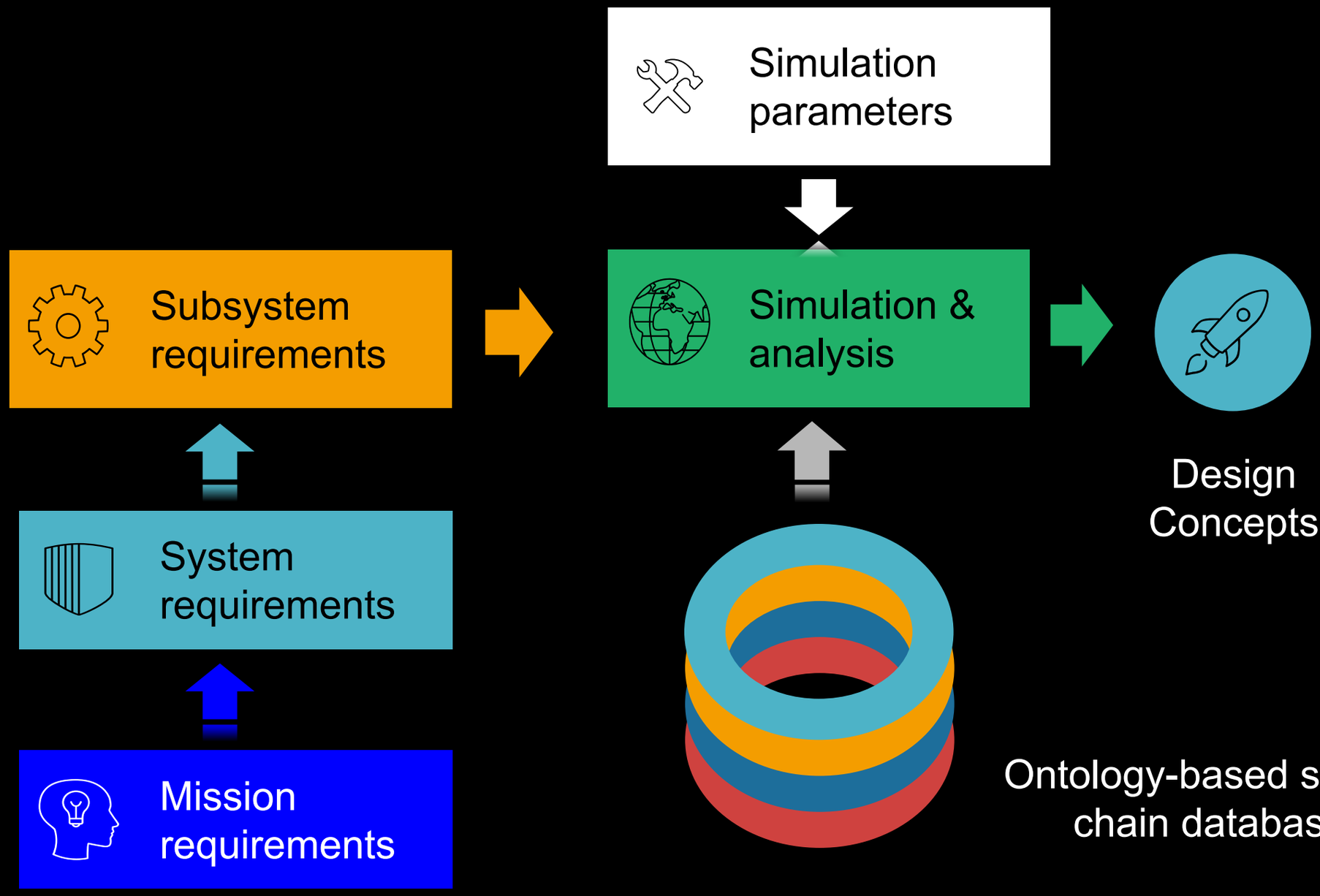
Application: Integrated Mission Design



Connecting an ontology-based supply chain database to mission design process enables intelligent automation

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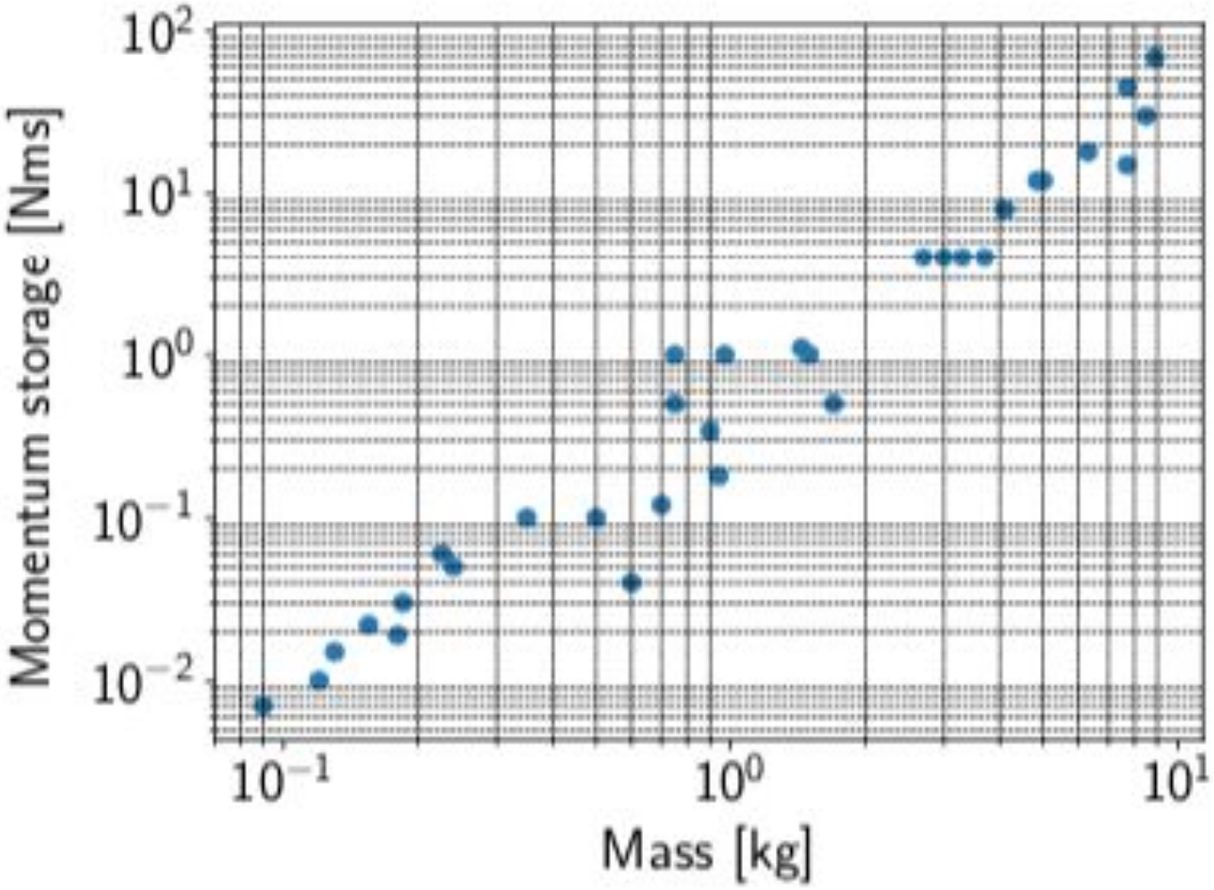
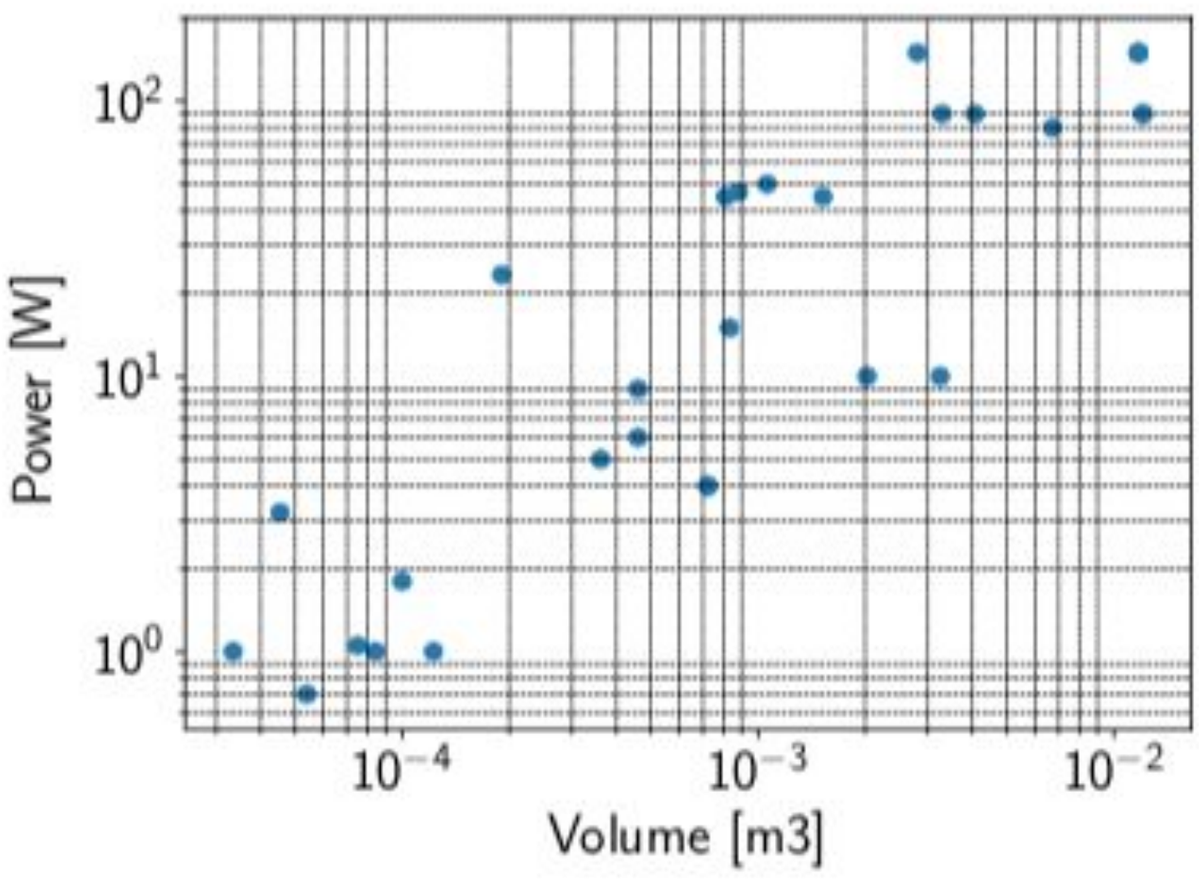
Application: Business Intelligence





(Cherukuri, 2019)

Connecting an ontology-based supply chain database to BI tooling enables deep insights into the state of the market

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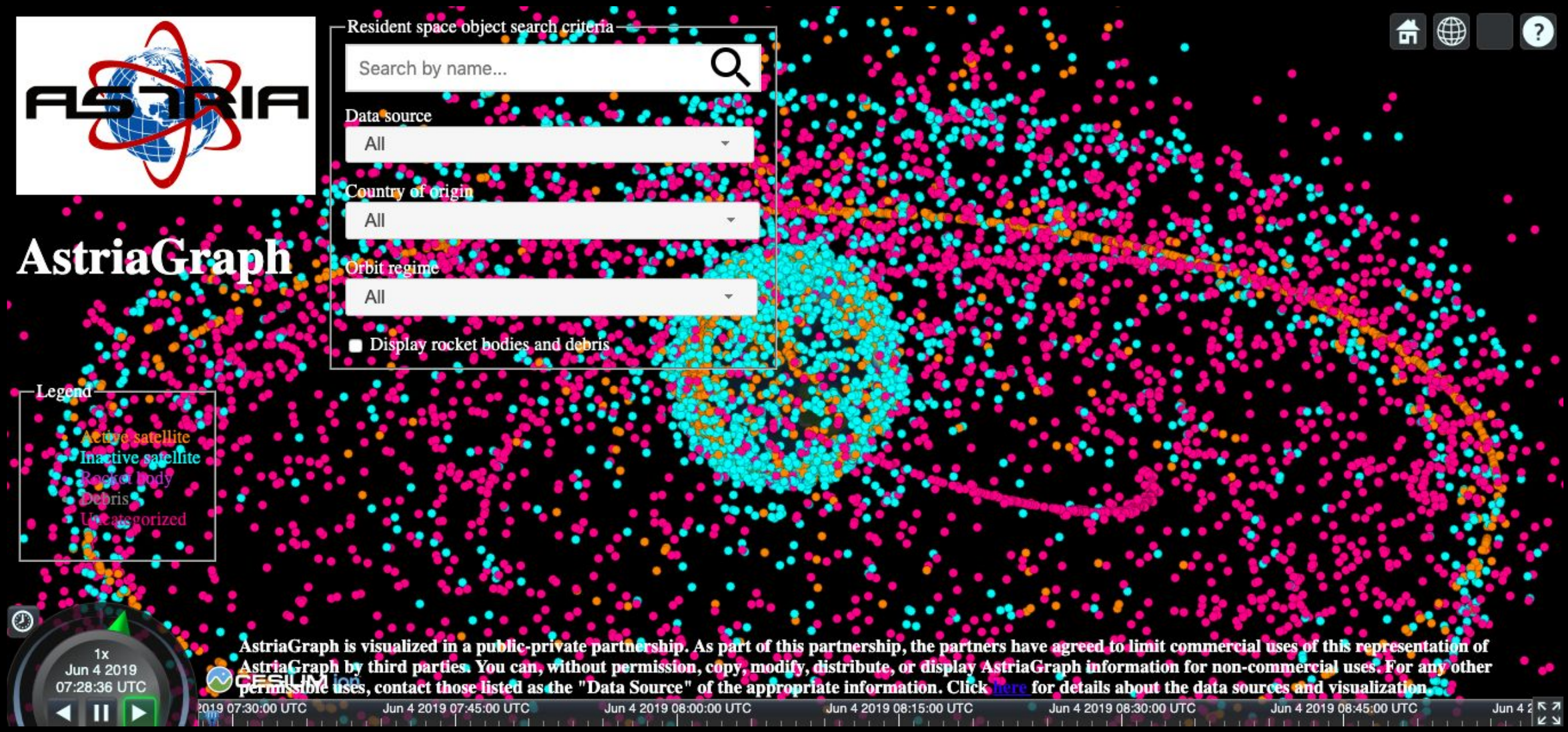
Application: Space debris risk analysis



Connecting an ontology-based supply chain database to space debris knowledge base enables deep risk insights

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The biggest challenges for the future

- Gathering comprehensive, reliable, up-to-date source data
- Building robust tooling to enable increasibly automatic generation of electronic datasheets
- Developing strong (economic) incentives to accelerate rate of stakeholder adoption globally
- Enabling interoperability through open interfaces to avoid fragmentation & duplication

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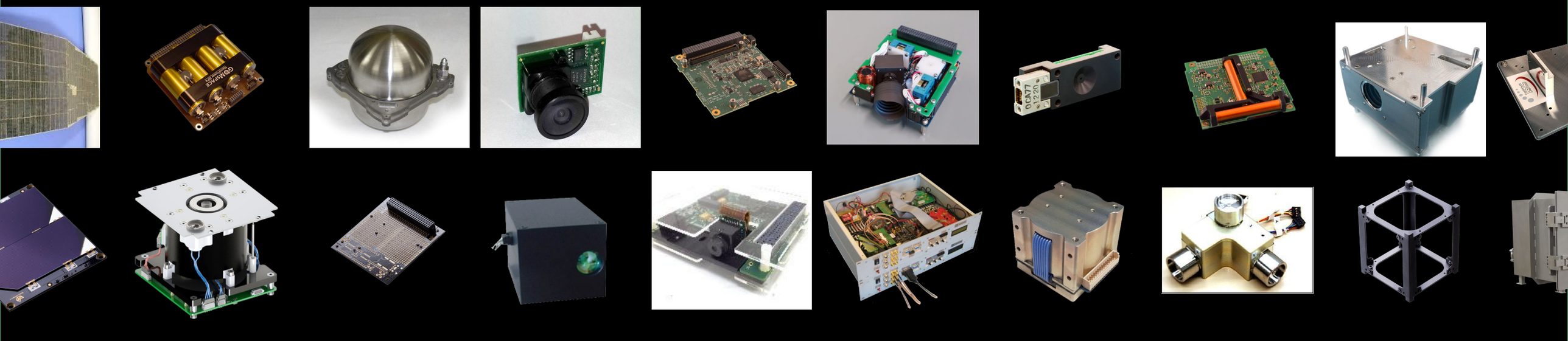

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