



Findable, Accessible, Interoperable, Reusable

***AKA “Achieving Semantic
Interoperability in Materials Data”***

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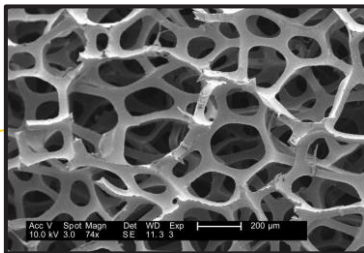
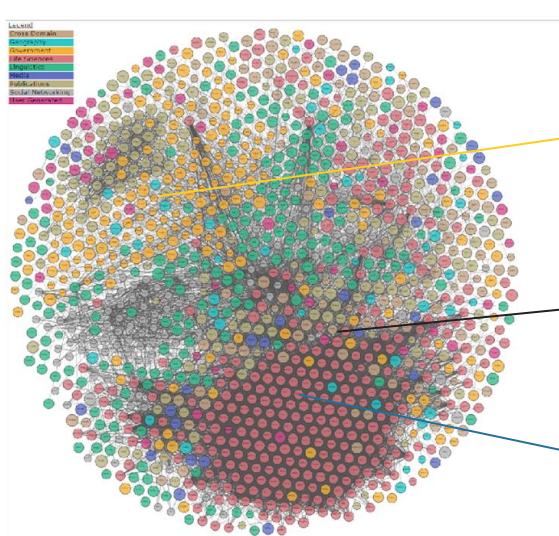
26 October, 2020

What Does Success in Our Community Look Like?

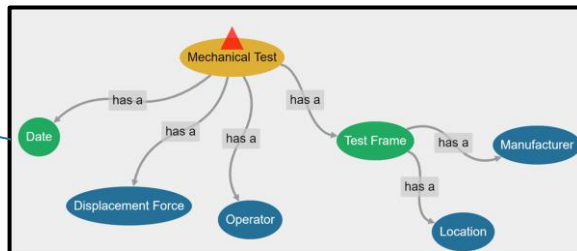


Contextualize, Validate, and Analyze

Develop human and machine readable semantic assets from *any* source



x (m)	y (m)	A (m ²)	P (m)	R (m)	R ⁴ /3	V (m/s)	z (m)	H (m)	Sf (m/m)	Mean Sf (m/m)	dx (m)	Hf (m)	H ⁴ (m)	H ⁴ -H (m)	W.S. (m)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
0	0.15	1.50	10.30	0.15	0.08	13.33	0.25	9.46	2.09						0.40
-0.5	0.16	1.59	10.32	0.15	0.08	12.61	0.25	8.51	1.74	1.91	0.50	-0.96	8.51	4.56E-09	0.41
-1	0.17	1.67	10.33	0.16	0.09	11.96	0.25	7.71	1.46	1.60	0.50	-0.80	7.71	6.46E-07	0.41
-1.5	0.18	1.76	10.35	0.17	0.09	11.39	0.24	7.03	1.24	1.35	0.50	-0.68	7.03	2.99E-08	0.42
-2.5	0.19	1.92	10.38	0.19	0.11	10.40	0.24	5.95	0.92	1.08	1.00	-1.08	5.95	-2.53E-09	0.43
-5	0.23	2.34	10.47	0.22	0.14	8.55	0.23	4.19	0.49	0.70	2.50	-1.76	4.19	-3.55E-08	0.46
-7.5	0.27	2.73	10.55	0.26	0.17	7.32	0.21	3.21	0.29	0.39	2.50	-0.97	3.21	-4.17E-08	0.49
-10	0.31	3.12	10.62	0.29	0.19	6.42	0.20	2.61	0.19	0.24	2.50	-0.60	2.61	-2.36E-09	0.51
-12.5	0.35	3.49	10.70	0.33	0.22	5.73	0.19	2.21	0.13	0.16	2.50	-0.40	2.21	-3.15E-07	0.54
-15	0.39	3.86	10.77	0.36	0.25	5.18	0.18	1.93	0.09	0.11	2.50	-0.28	1.93	-4.32E-09	0.56
-17.5	0.42	4.24	10.85	0.39	0.29	4.72	0.16	1.72	0.07	0.08	2.50	-0.21	1.72	-2.03E-07	0.59
-20	0.46	4.62	10.92	0.42	0.32	4.33	0.15	1.57	0.05	0.06	2.50	-0.15	1.57	-1.85E-09	0.61
-22.5	0.50	5.02	11.00	0.46	0.35	3.99	0.14	1.45	0.04	0.05	2.50	-0.12	1.45	-9.32E-08	0.64
-25	0.54	5.43	11.09	0.49	0.39	3.68	0.13	1.36	0.03	0.04	2.50	-0.09	1.36	-1.44E-09	0.67
-27.5	0.97						0.11								1.08



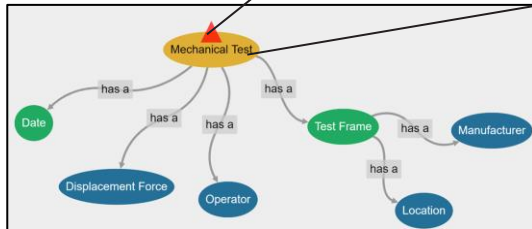
<https://lod-cloud.net>

Agile Automation Armed with Digital Knowledge

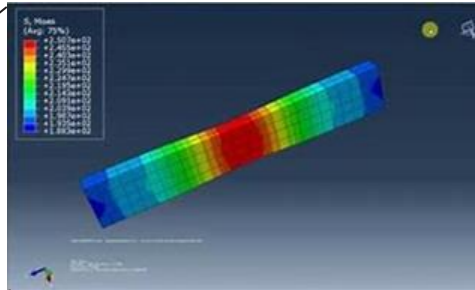


Integrate Modeling and Analytics to Exploit Data

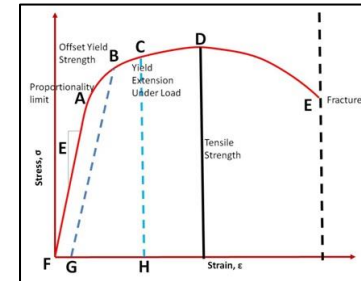
Knowledge graphs fuel predictive analytics and physical modeling



Semantic Map of Context



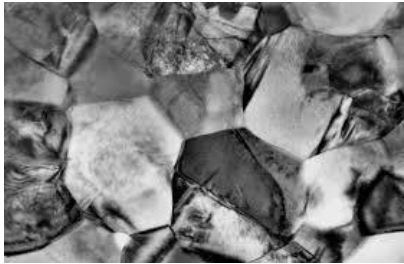
Simulated Data



Extracted Experimental Data

Scenarios:

- “Find all samples made using the material Ti-6Al-4V.”
- “Show me build data that has an acquisition rate of 40 Hz.”
- “Identify Figures of Merit relating the printed parts’ mechanical performance to its thermal history.”
- Many *Basic* use cases - material X, sample Y, parameter Z....



time	n.risk	n.event	survival	std.err	lower 95% CI	upper 95% CI
5	23	2	0.913	0.0588	0.8049	1
8	21	2	0.8261	0.079	0.6848	0.996
9	19	1	0.7826	0.086	0.631	0.971
12	18	1	0.7391	0.0916	0.5798	0.942
13	17	1	0.6957	0.0959	0.5309	0.912
18	14	1	0.646	0.1011	0.4753	0.878
23	13	2	0.5466	0.1073	0.3721	0.803
27	11	1	0.4969	0.1084	0.324	0.762
30	9	1	0.4417	0.1095	0.2717	0.718
31	8	1	0.3865	0.1089	0.2225	0.671
33	7	1	0.3313	0.1064	0.1765	0.622
34	6	1	0.2761	0.102	0.1338	0.569
43	5	1	0.2208	0.0954	0.0947	0.515
45	4	1	0.1656	0.086	0.0598	0.458
48	2	1	0.0828	0.0727	0.0148	0.462

These use cases are not easy to find answers for! Why?

Failure points

Poor design practices in software
and data



Result: Little or no
interoperability



Too much focus on single
research objectives



Result: Lack of supporting data
and context



Overcomplicated, knee-jerk
responses



Result: No progress towards FAIR

Findable, Accessible, Interoperable, Reusable...

Case Study

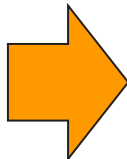
The Facts

- Ti-64 AM data payload
- SQL-based solution
- 10 TB size
- Formal data plan



The Results

- 3000 hrs of added data effort
- \$250,000 of added tech
- 10% of the data are FAIR

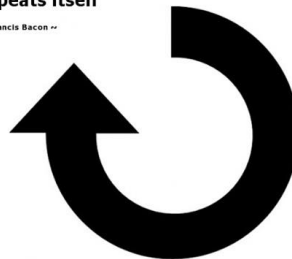


Lessons Learned (sort of)

- Ad hoc data model
- Out-of-date technology
- Insufficient accountability

Everything in the world
repeats itself

-- Francis Bacon --



Breaking the Cycle

Model

Also known as a schema. Defines and relates key properties.

Capture

Pick a comfortable format that complies with the model

Store

Don't allow the database to break the model

Validate

Can the data be exchanged and consumed according to FAIR?

Exchange

Transport data frequently

What is a data model?

A representation of the object of interest - AM build, powder pedigree, etc.

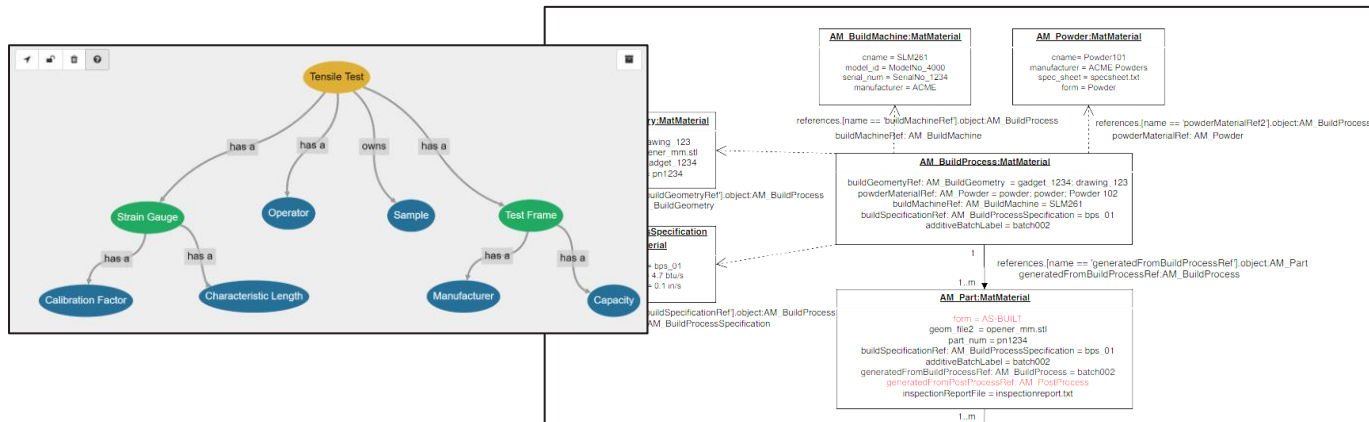
Standards are a good place to start!



Leonardo da Vinci
Polymath

Leonardo di ser Piero da Vinci, known as Leonardo da Vinci, was an Italian polymath of the Renaissance whose areas of interest included invention, drawing, painting, sculpture, architecture, science, music, mathematics, engineering, literature, anatomy, geology, astronomy, botany, paleontology, and cartography. [Wikipedia](#)

Born: April 15, 1452, Anchiano, Italy
Died: May 2, 1519, Château du Clos Lucé, Amboise, France
On view: [Ambrosian Library](#), [Louvre Museum](#), [MORE](#)
Periods: [High Renaissance](#), [Early renaissance](#), [Renaissance](#), [Italian Renaissance](#), [Florentine painting](#)
Known for: [Art \(painting, drawing, sculpting\)](#), [science](#), [engineering](#), [architecture](#), [anatomy](#)
Education: [Andrea del Verrocchio](#)



The model should relate to the research objective(s)

What is an interface?

A means of accessing data or functions within a program

REST = best (don't settle for less!)

Example:

```
objectType='AM_Powder' <- There's the object from the data model
```

```
expr="[name=='*']" <- We want all names
```

```
data={'type':objectType, 'expr':expr, 'f':['cname']} <- We want the "cname" for all names
```

```
reply=session.post(url+'query', data) <- Nothing fancy
```

Demonstration - HyperThought & MaterialCenter

Goal: Show how good design patterns make FAIR easy

Participants: AFRL, MSC/Hexagon, GE

Approach:

1. Develop lightweight connection between HT and MC (it took 37 minutes!)
2. Move data payload *without* a formal data model (couple of days of work in data munging)
3. Receive 3rd party analysis of data fitness
4. **Move data payload *with* a formal data model (CDD)**
5. Monitor and analyze performance/effectiveness
6. Gather independent audit of data quality
7. Press the approach within the community

Collaborators: ARL, NIST, ASTM, EWI, and others...

The Guts

```
1 import requests
2 import json
3
4 session = requests.Session()
5 session.params={'format':'JSON'}
6 url= "someURL"
7
8 user='foo'
9 password='bar'
10 data ={'passwd':password, 'user':user}
11
12 session.post(url+'login',params=data)
13
14 objectType='AM_Part'
15 expr="[name=='*Test-Part-2*']"
16 data={'type':objectType, 'expr':expr}
17 reply=session.post(url+'query', data)
18
19 result=json.loads(reply.text)
20 print(result)
```

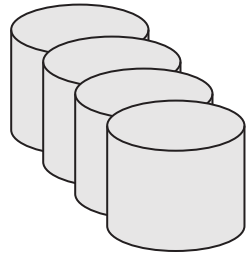
Gives us...

37 minute pedigree...

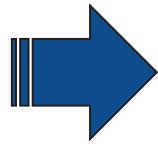
```
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'list': False}, {'name': 'editRevisionNumber', 'label': 'Revision',
'type': 'Long', 'list': False}, {'name':
'generatedFromBuildProcessRef',
'label': 'Build Process', 'type': 'DbObject',
'list': False}, {'name': 'generatedFromPostProcessRef',
'label': 'Post Build Process', 'type': 'DbObject', 'list': False}]},
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{'oid': '', 'text': ''}, 'generatedFromPostProcessRef':
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'AM_Part', 'version': '1.9'}
```

This is a massive breakthrough!

Common Additive Manufacturing Database Experiment (CAMDEN)



4 AM datasets

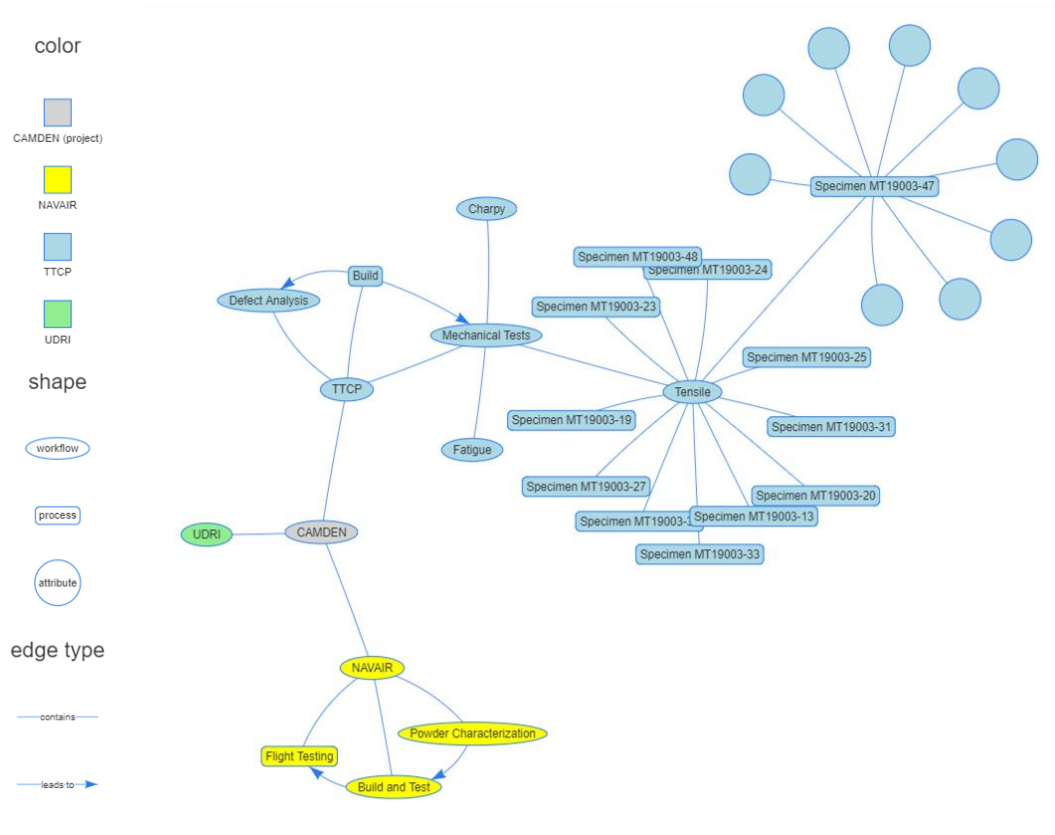


Hyperthought™



How does CAMDEN affect me?

A new and improved way to visualize materials data



Community Needs

ID data sharing needs - who **really** wants to share data?

Open object/data models, schemas, and releasable data

Funding/advocacy for accessible cloud infrastructure and data analysis projects

Advocacy for standards usage with industry and federal components

Boost staffing in comp/data science across the board

Questions??

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