

Beyond Siloed Information

Missing Practices for Semantic Interoperability

February 2026

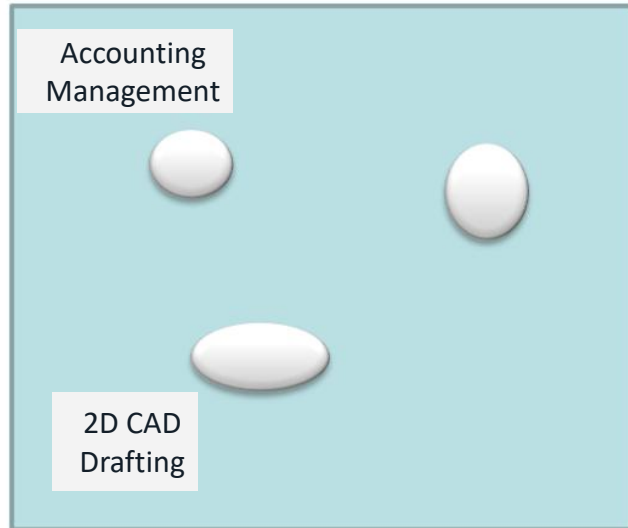
Jonathan Eyre – Senior Technical Fellow in Interoperability

Outline

- 1) Data siloes – why are we where we are?
- 2) Today's missing practices: pipelines and information methodologies.
- 3) Exploration of data structures and how they affect communication.

Part 1: Data Siloes

Evolution of Information Systems (Islands of Automation)

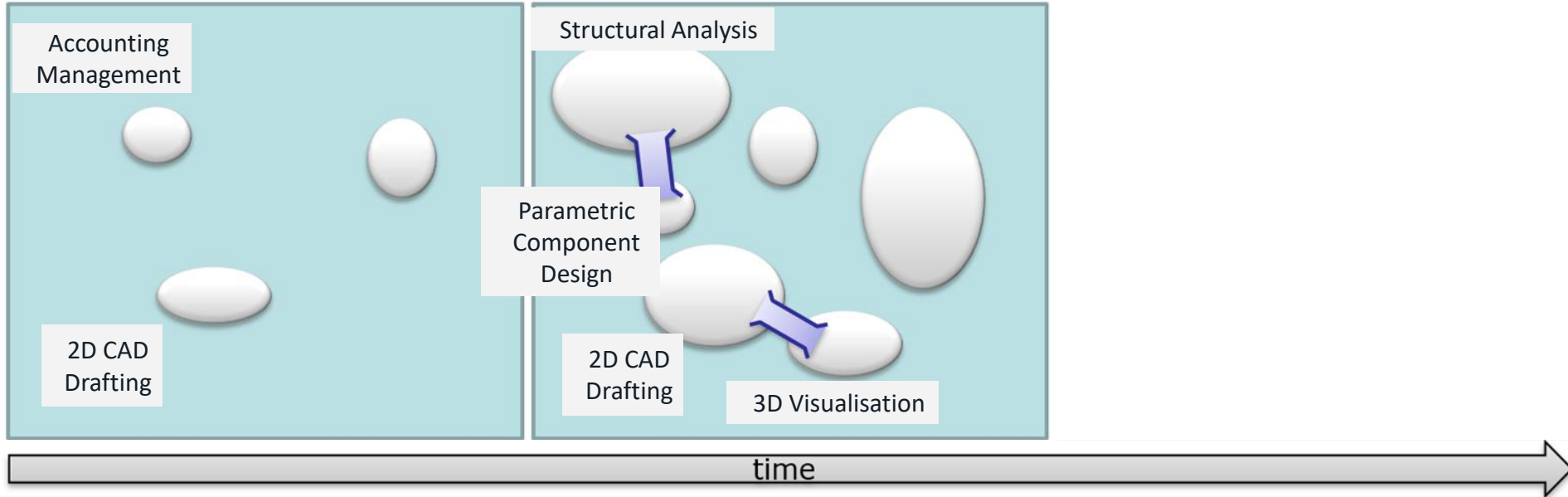


time

Systems started
independently

[Interoperability, Digitalisation, Innovation, Form](#)
March 2025 *Chris Partridge*

Evolution of Information Systems (Islands of Automation)

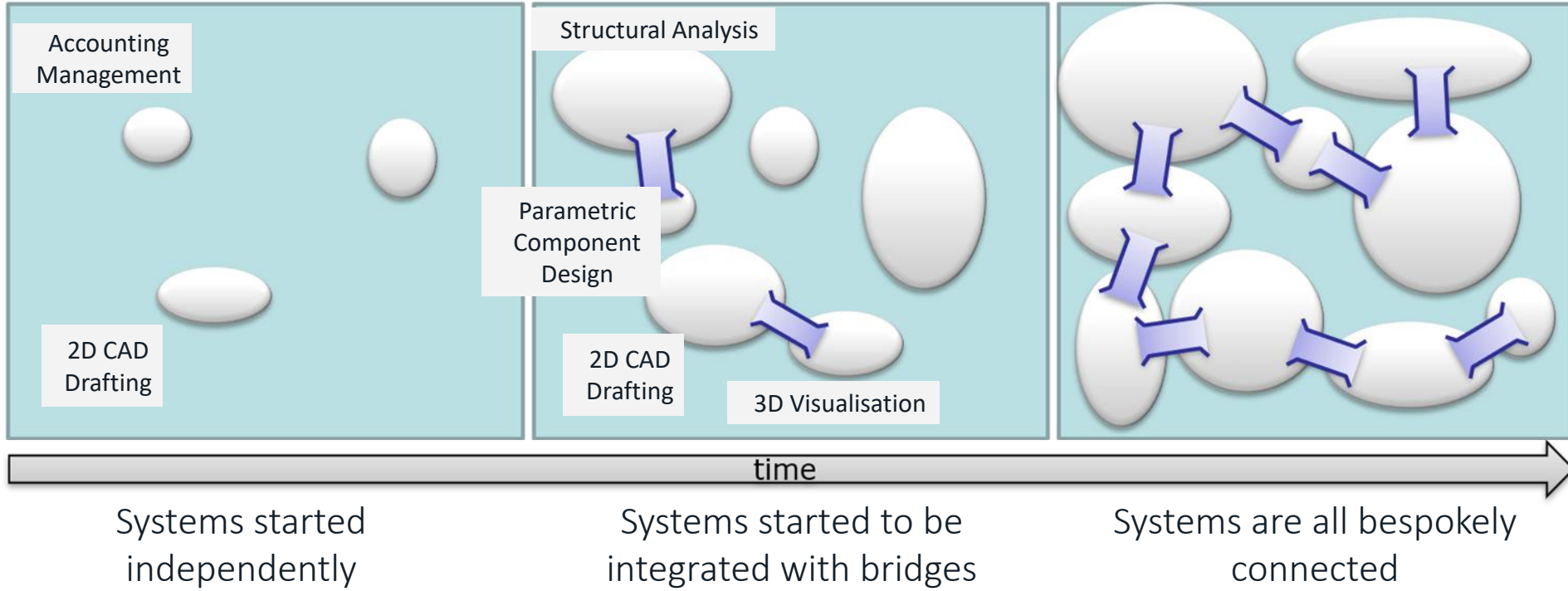


Systems started independently

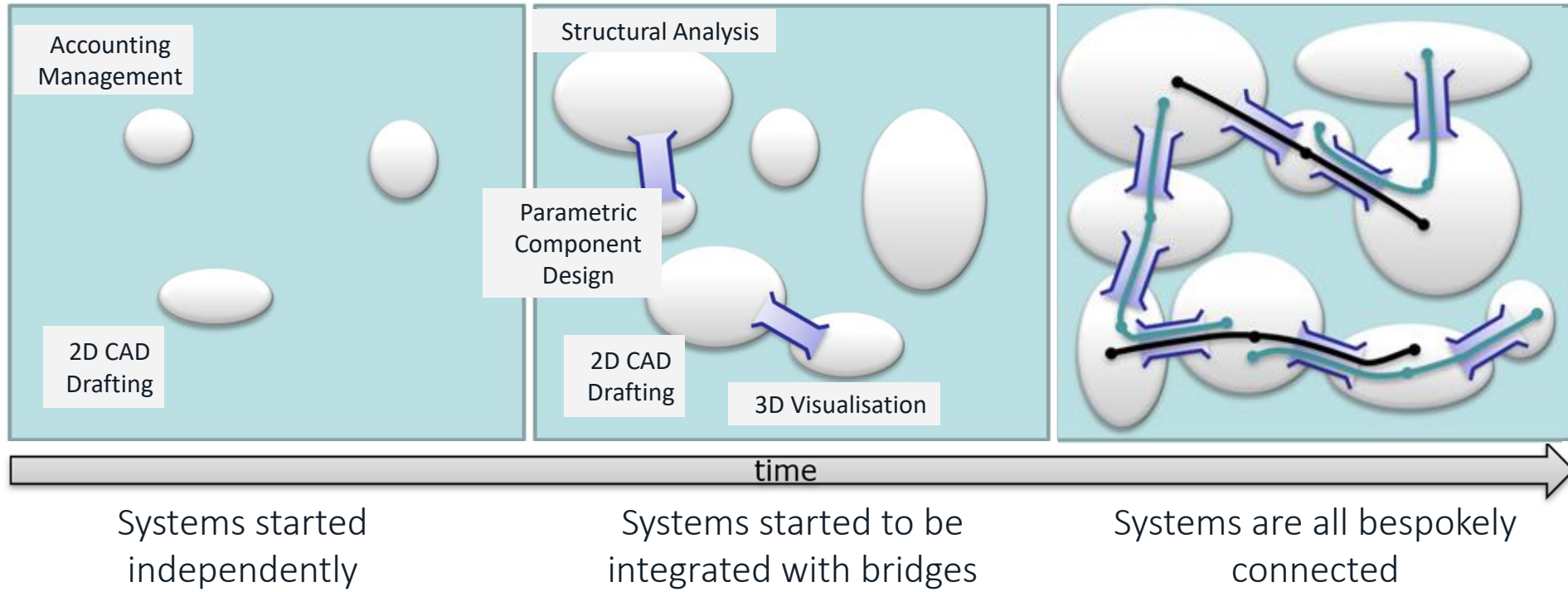
Systems started to be integrated with bridges

[Interoperability, Digitalisation, Innovation, Form](#)
March 2025 Chris Partridge

Evolution of Information Systems (Islands of Automation)



Evolution of Information Systems (Islands of Automation)



Our Current Stovepipe System Approach

Siloes, stovepipes, walled gardens
... choose your analogy.

Our digital systems are highly compartmentalised making it incredibly difficult for people to cooperate when they want to.

Causes of silos

- Free-for-all design decisions
- Software as a black-box product
- Market forces

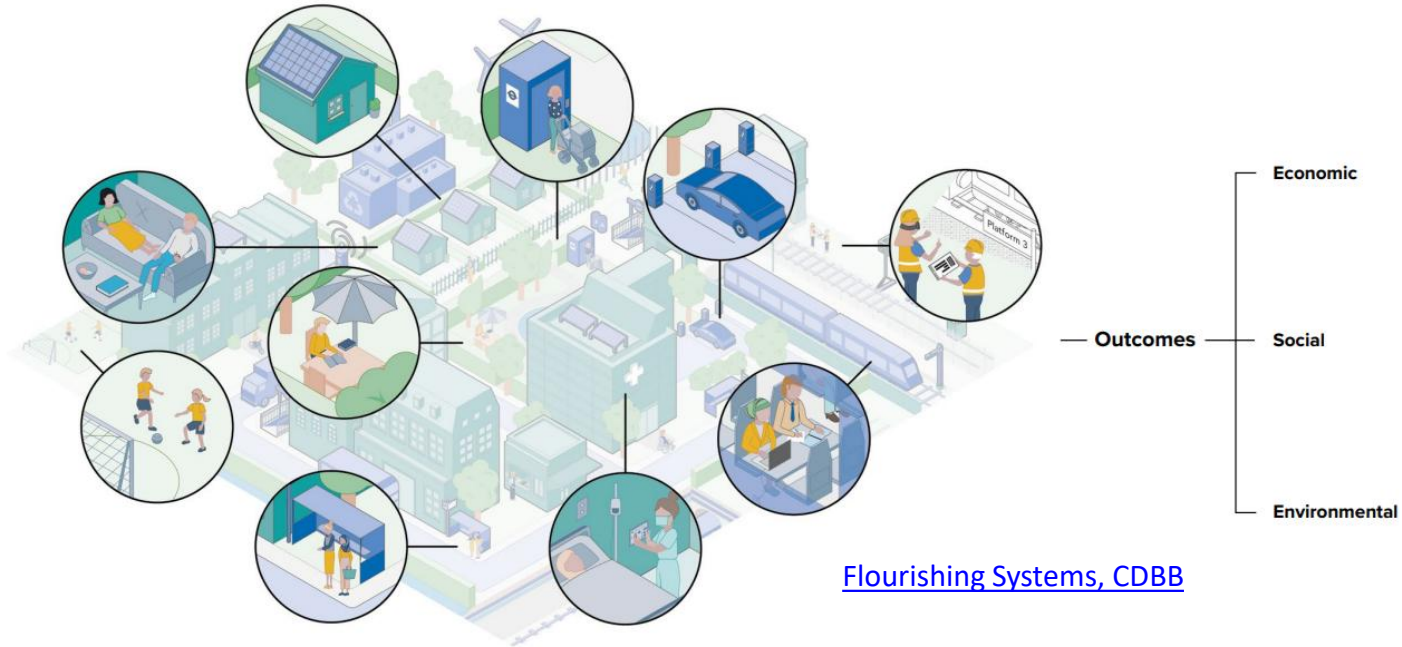


Effects of silos

- Digital collaboration impossible at scale
- Crowding in a monopolised market – digital benefits are grinding to a halt (self-strangulation)
- Effective tax on people and businesses
- Handbrake to innovation
- Development restricted to marketable concepts.
- New powerful techniques (e.g. AI) rely on data – it is just not available.
- Security nightmare – cyber security whack-a-mole
- Swivel chair workplaces



Our Infrastructure Must Address our Socio-Technical Needs



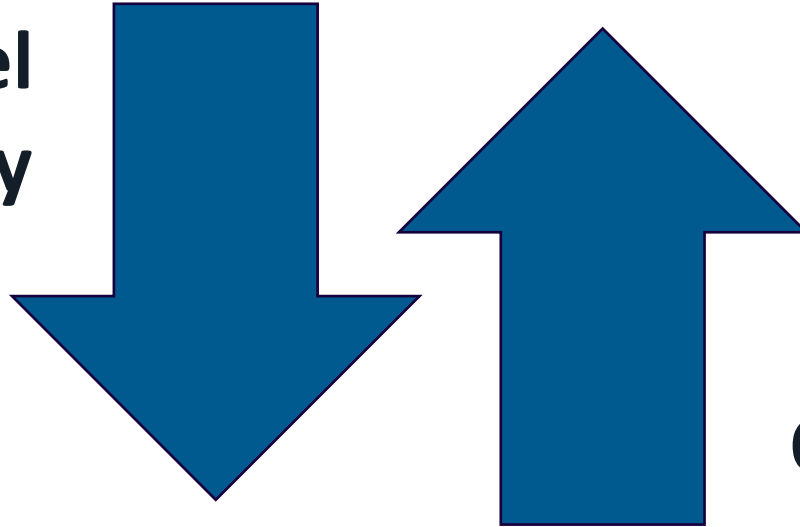
This may not be new, but is being empowered even more with regulations, certifications and assessments including sustainable elements together with economic profit. See [“the triple bottom line”](#) - Elkington, J.

Part 2:

Today's Missing Practices

The Need for a Bottom Up and Top Down

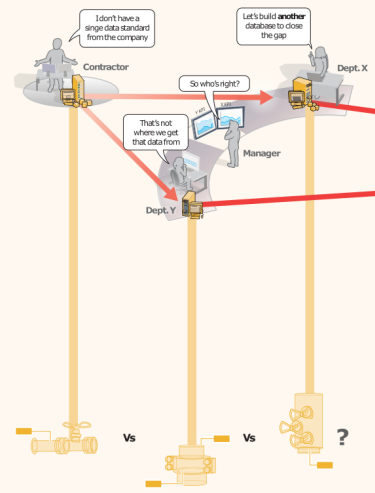
**Top Level
Ontology**



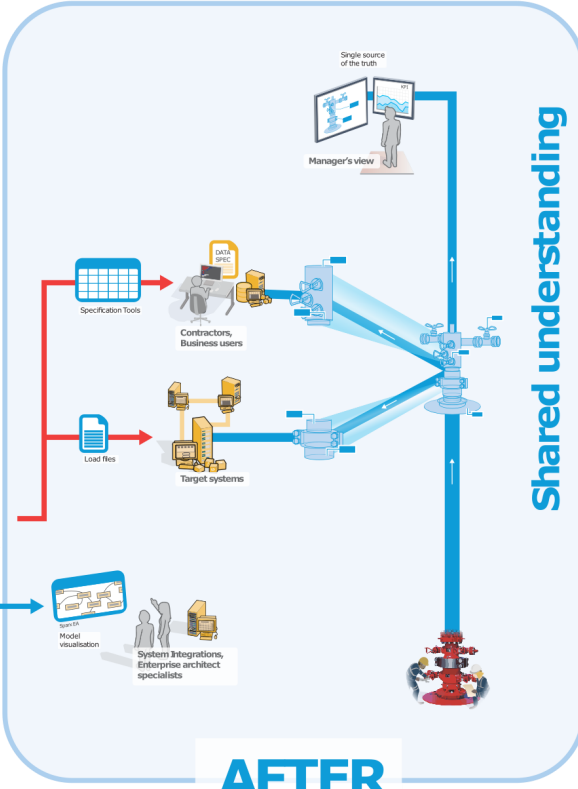
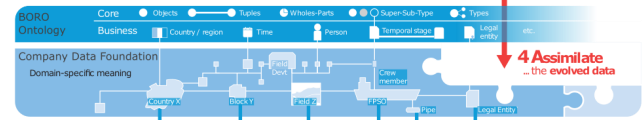
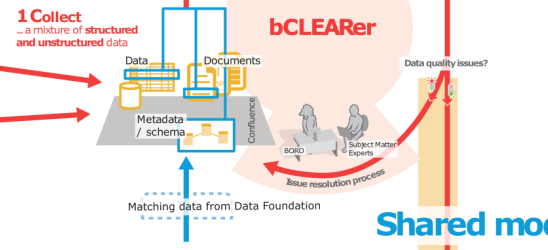
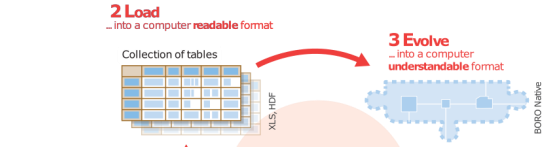
**Pipeline
Operations**



Fragmented data

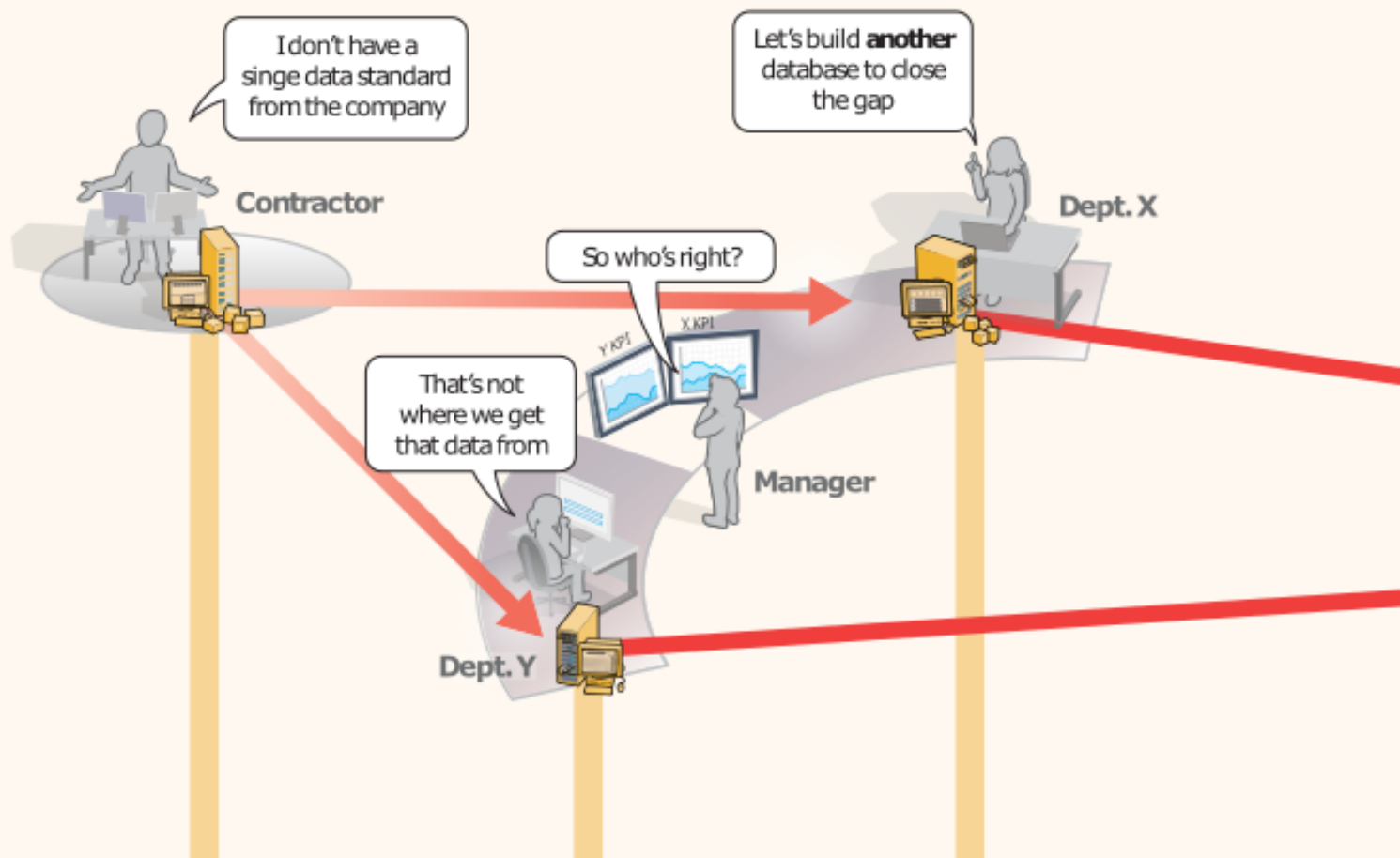


BEFORE



AFTER

Fragmented data



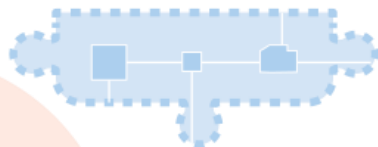
2 Load
... into a computer **readable** format

Collection of tables



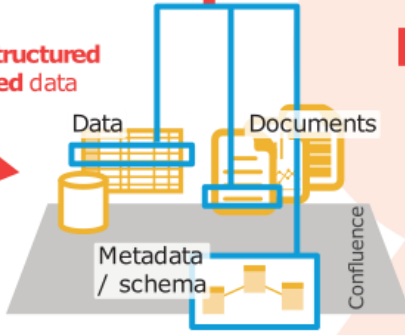
XLS, HDF

3 Evolve
... into a computer **understandable** format



BORO Native

1 Collect
... a mixture of **structured**
and **unstructured** data



bCLEARer



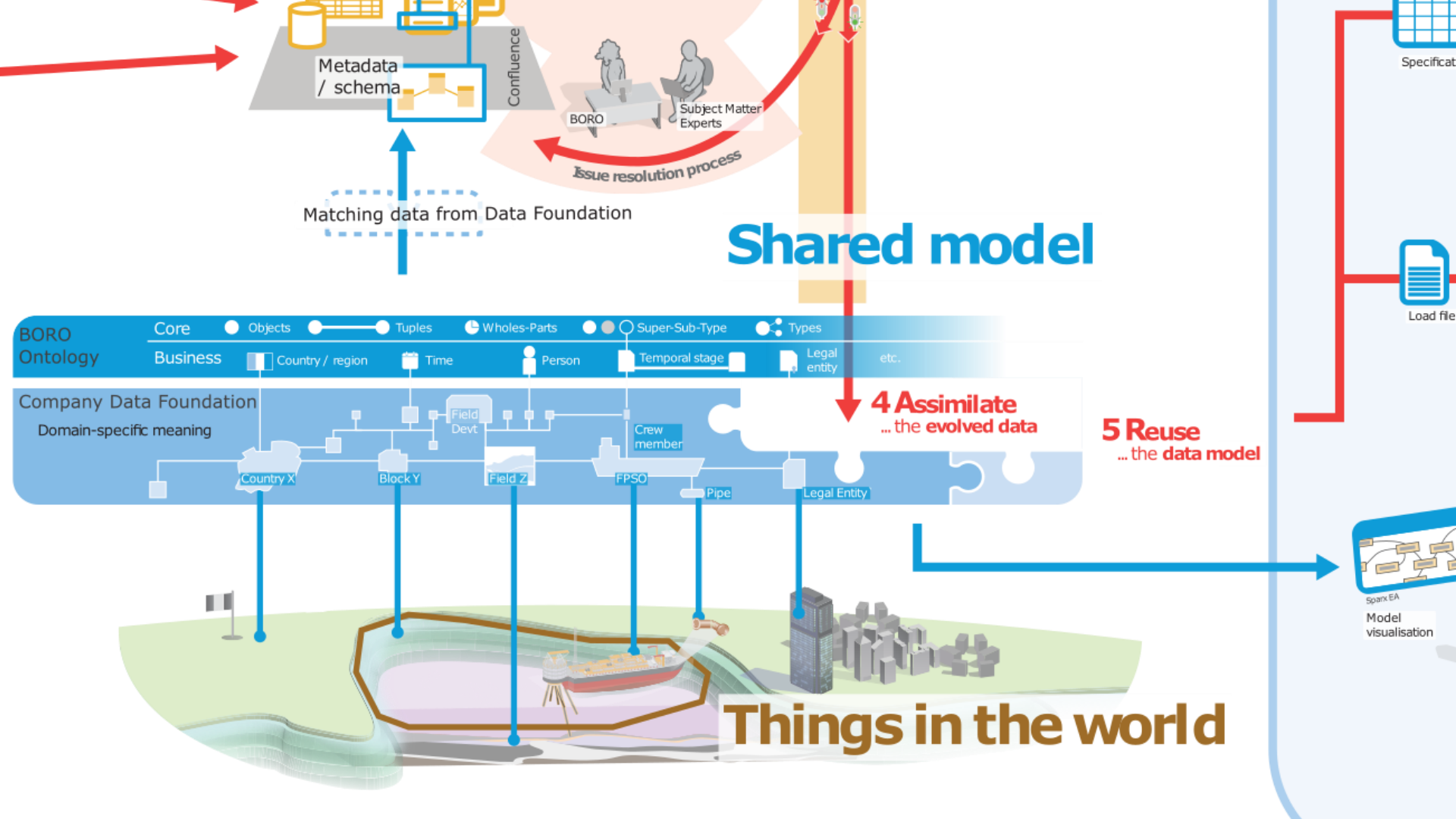
Issue resolution process

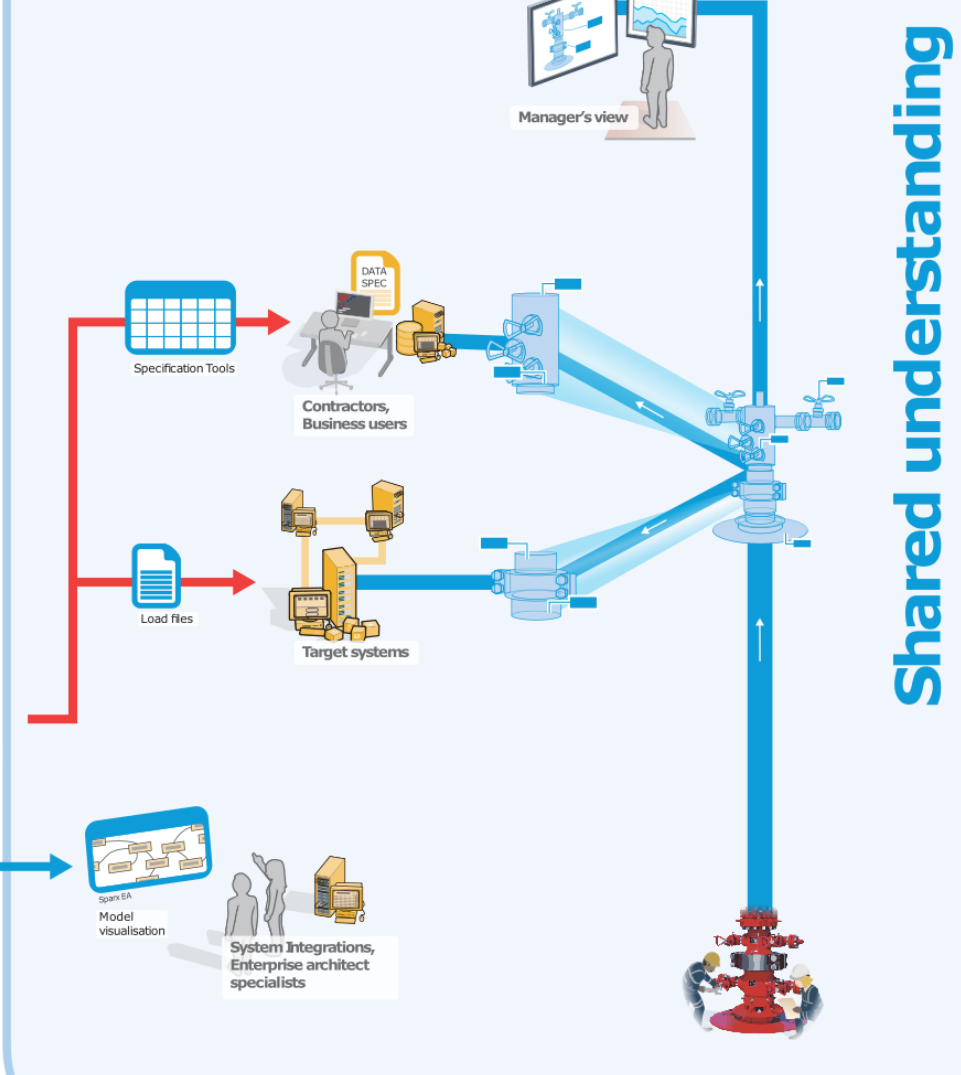
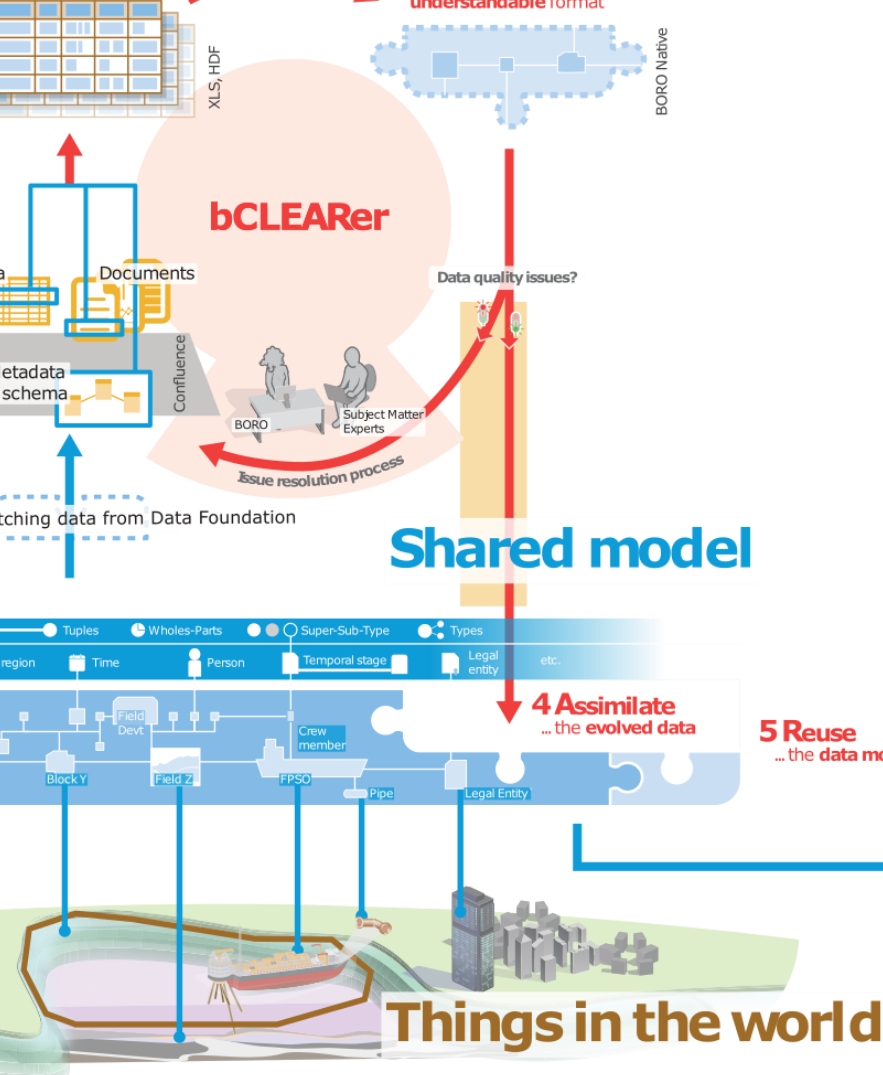
Data quality issues?



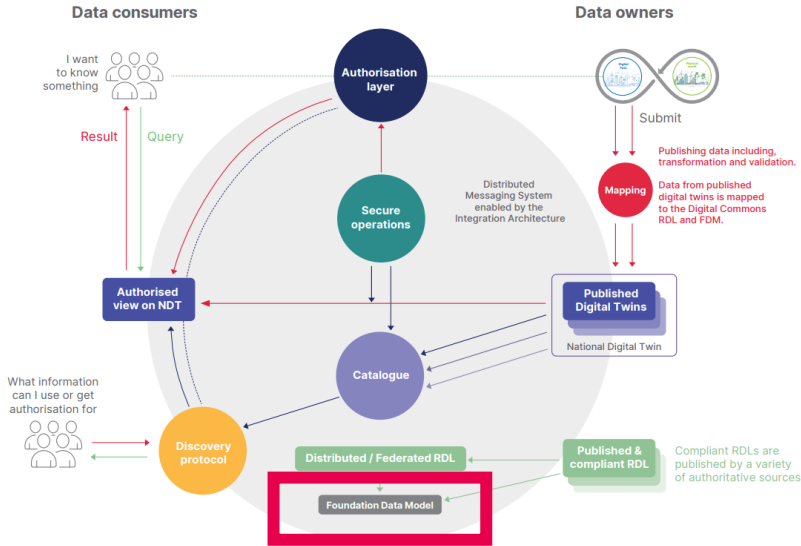
Matching data from Data Foundation

Shared model



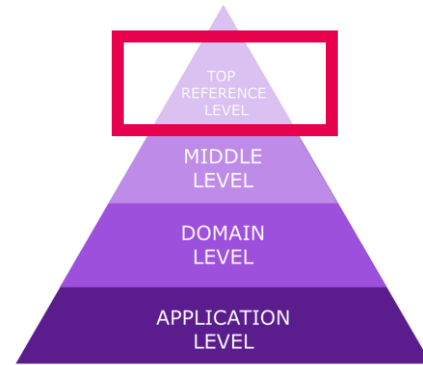


Top Level Ontologies are Well Established



https://www.cdbb.cam.ac.uk/files/architecture_principles_final.pdf

[Enterprise Data Modelling: Developing an Ontology-Based Framework for the Shell Downstream Business, Matthew West](#)



ONTOLOGIES

<https://ontocommons.eu/>

<https://digitaltwinhub.co.uk/information-management-framework-imf/7-circles-of-information-management/>

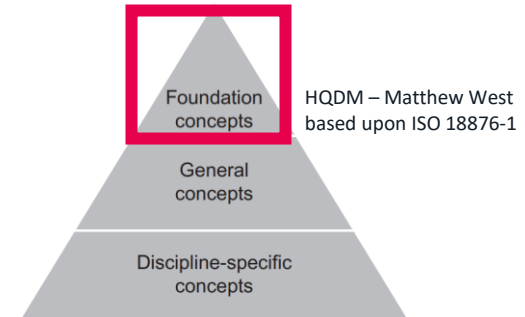
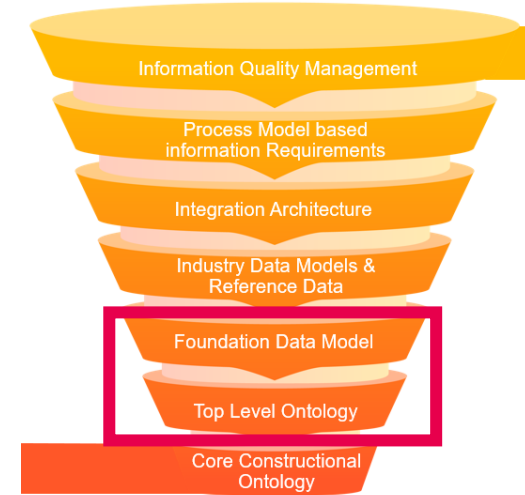
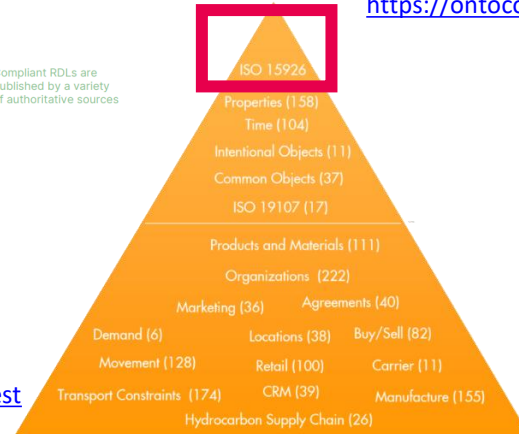
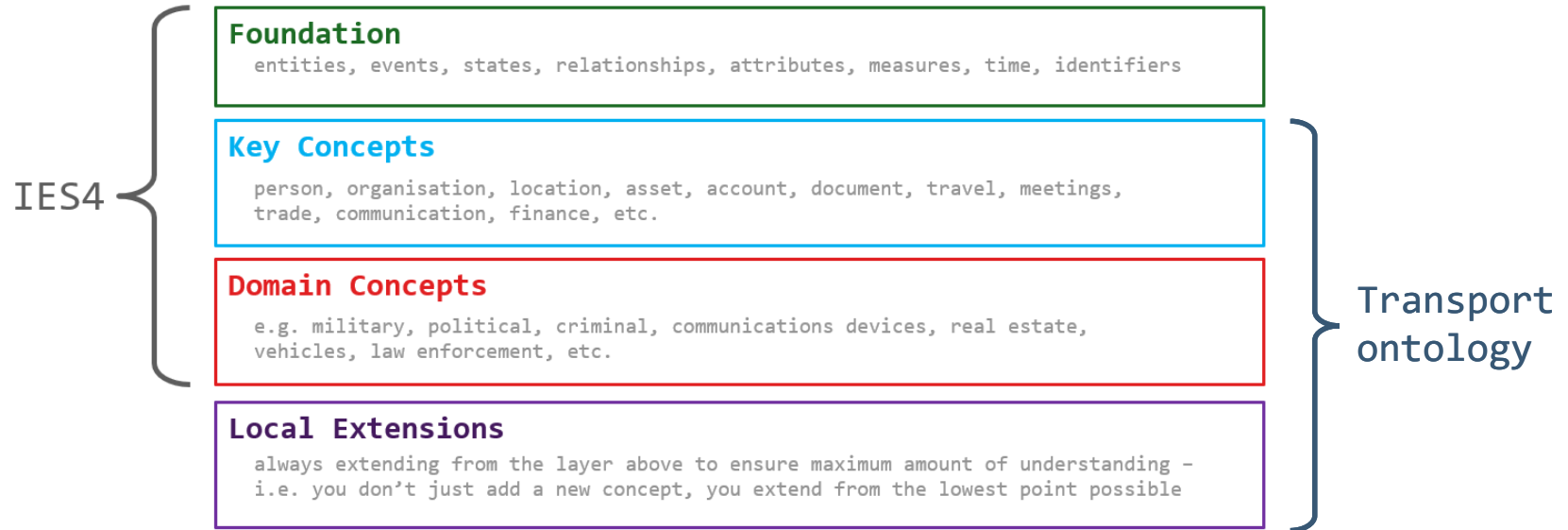
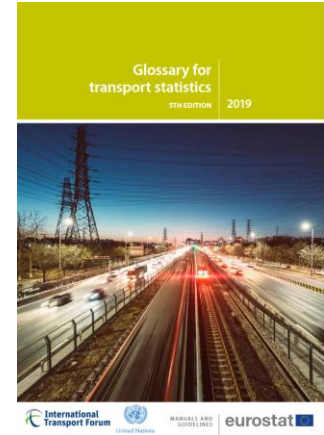
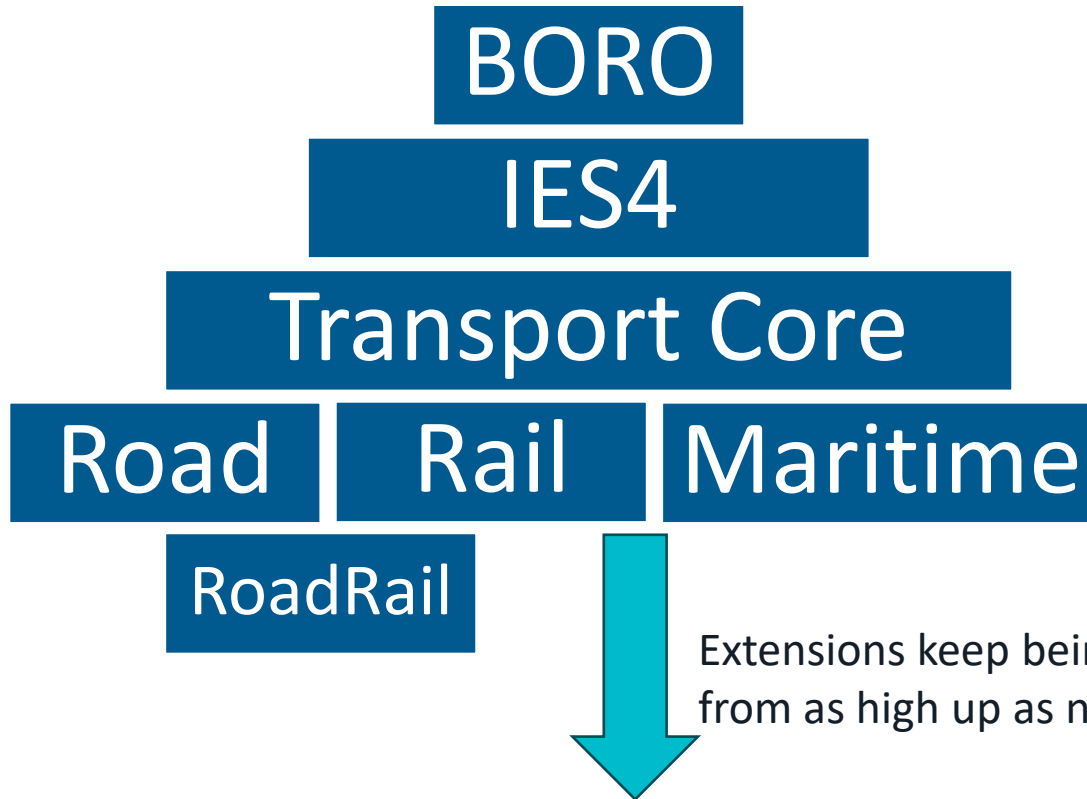


Figure 3-9 Primitive concepts.

Layering of Reusable Reference Data Libraries



Case Study - Department for Transport Ontology Structure

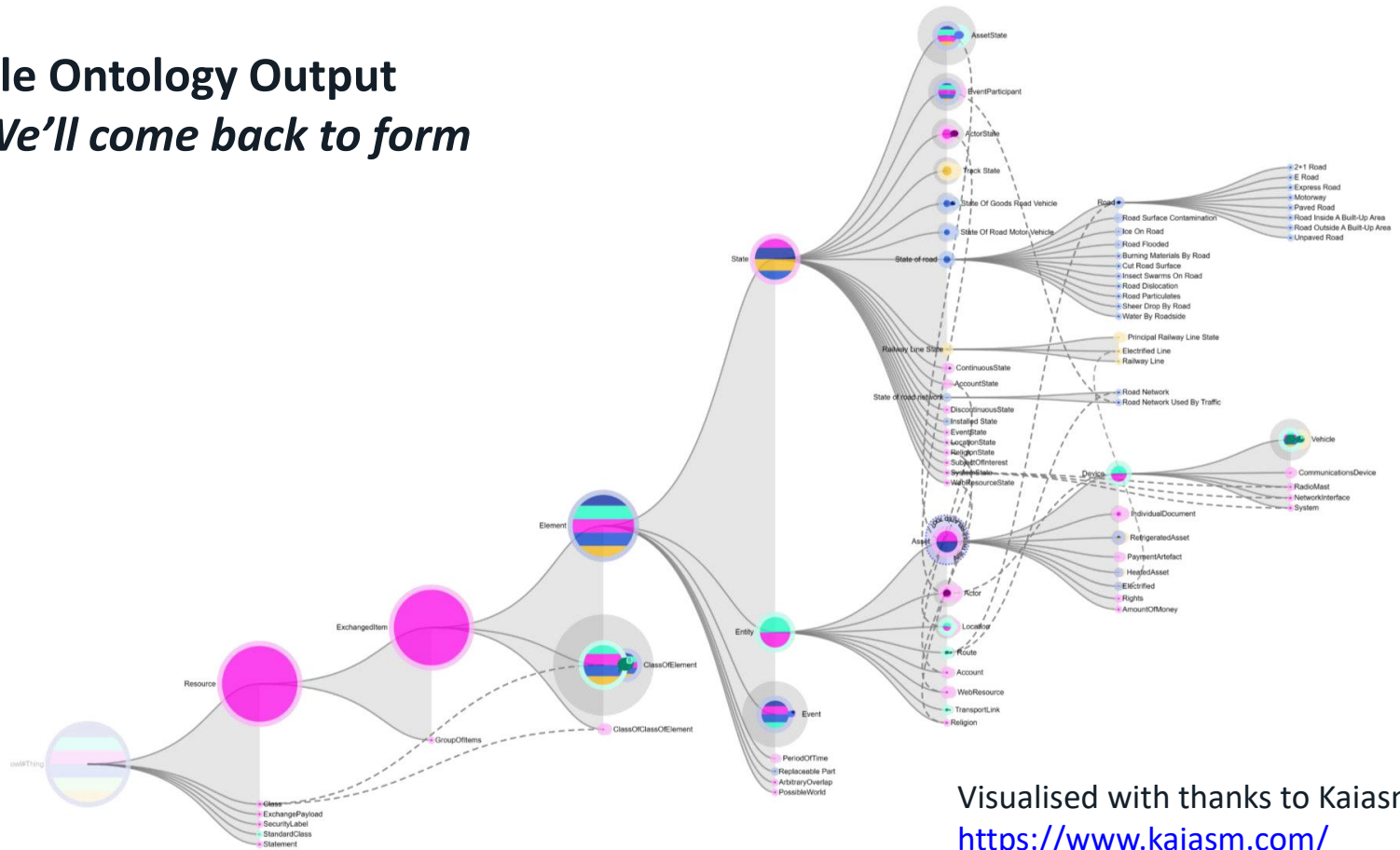


+ many other sources

Extensions keep being made extending from as high up as needed.

An Example Ontology Output

We'll come back to form



Visualised with thanks to Kaiasm.
<https://www.kaiasm.com/>

Department for Transport Ontology

Scope and Scale

1,658

Total Definitions

292

Transport Core

292 entities:
cross-modal
concepts and
shared
infrastructure.

456

Road

456 entities:
infrastructure,
vehicles, and
operational
elements.

355

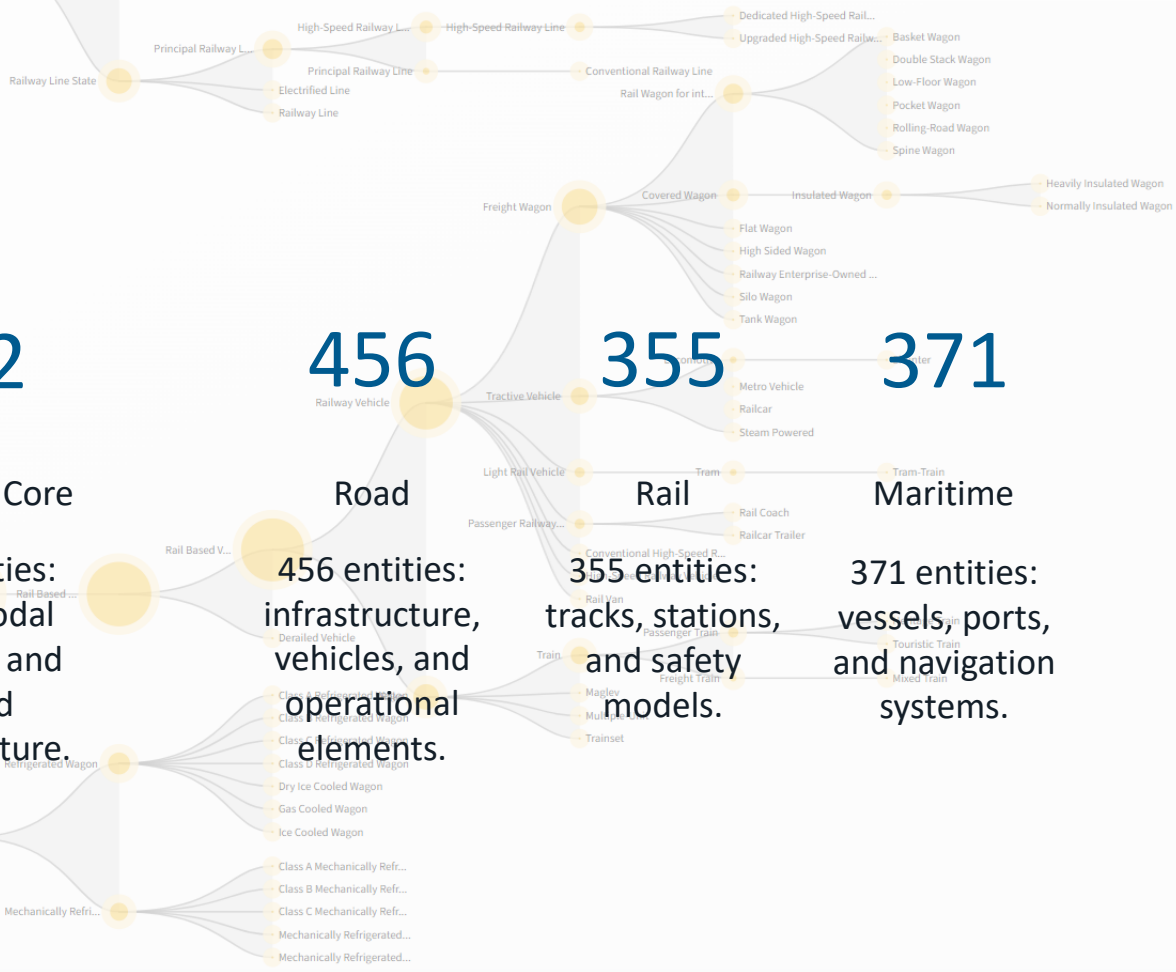
Rail

355 entities:
tracks, stations,
and safety
models.

371

Maritime

371 entities:
vessels, ports,
and navigation
systems.



A Second Missing Practice

Why do we need information?

To make decisions!

It must be of sufficient quality.

Respond to change
Reduced cost

Business

Drives

Reduced risk

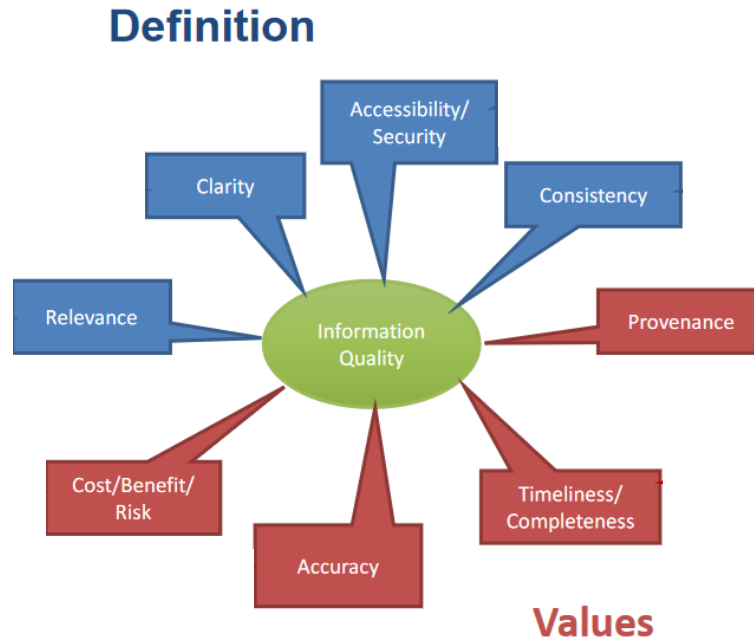
Decisions

Supports

Identify Business
Opportunities

Information

Information Properties



Critical properties of information quality by Matthew West, HQDM, Figure 1-1

Efforts rarely fail from bad intentions — they fail from what was overlooked.

Information doesn't manage itself.

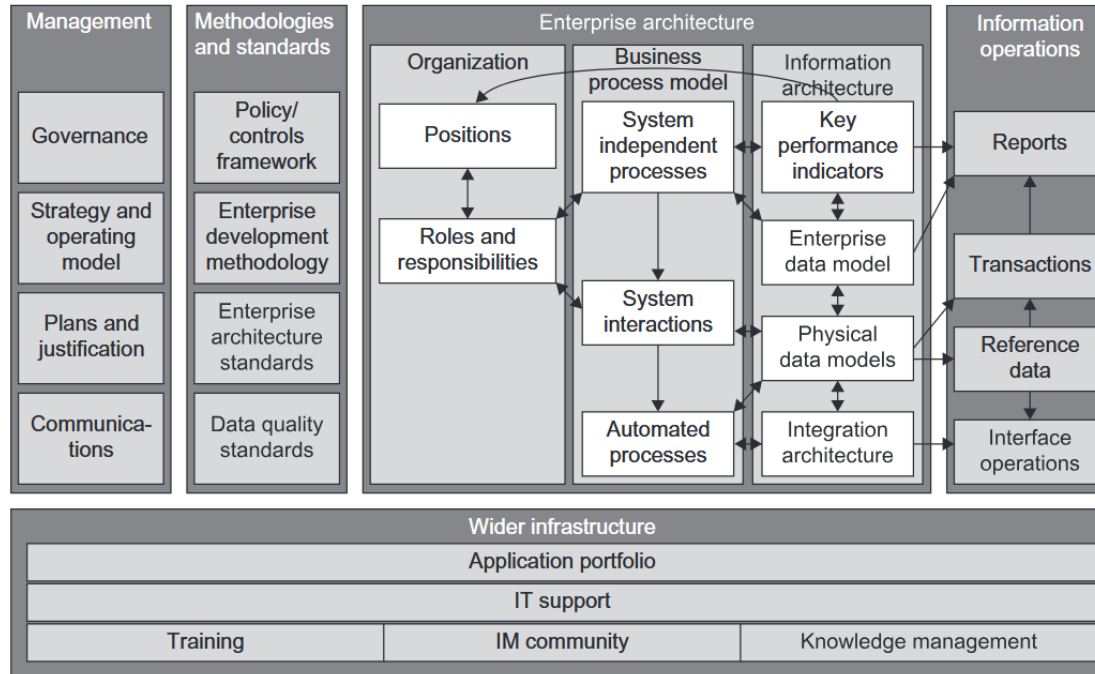


Figure 4-1 An information-centric view of Enterprise Architecture.

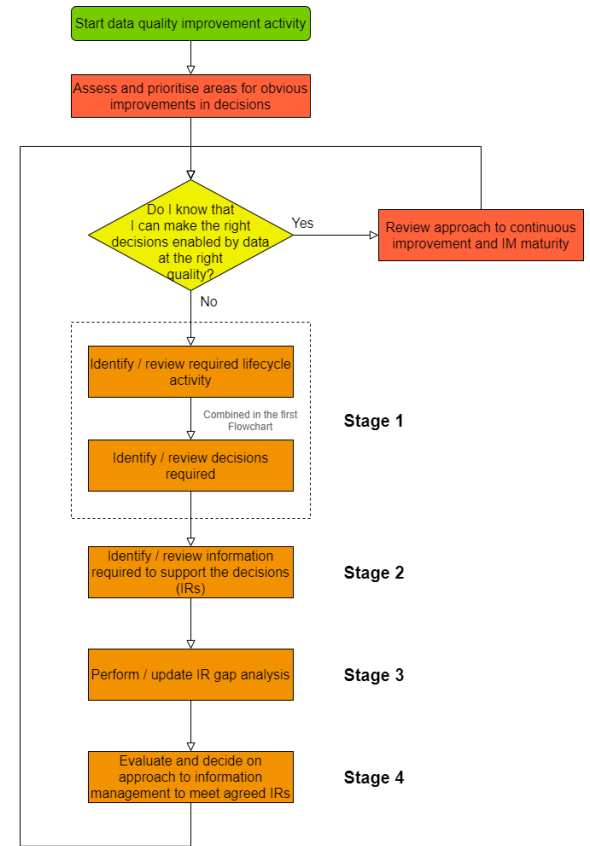
Matthew West, HQDM, Figure 4-1

Information Requirement Methodology

- How can you feed a system new behaviour?
- Or how can you assess if a system is fit for purpose?

The Information Requirements (IRs) methodology is a structured approach to identifying the need for information and meeting it with sufficient quality.

- Analyse activities to identify decisions
- Identify information required to support those decisions
- Perform a gap analysis
- Evaluate and decide on information management approach to meet the IRs.

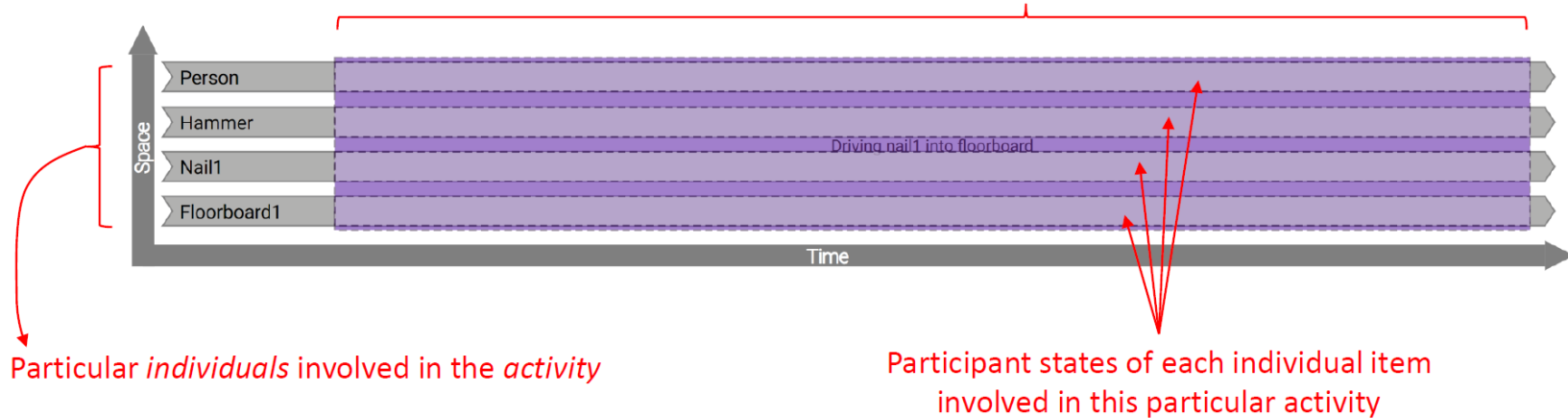


<https://github.com/Apollo-Protocol/information-requirement-methodology/blob/main/information-requirement-methodology.md>

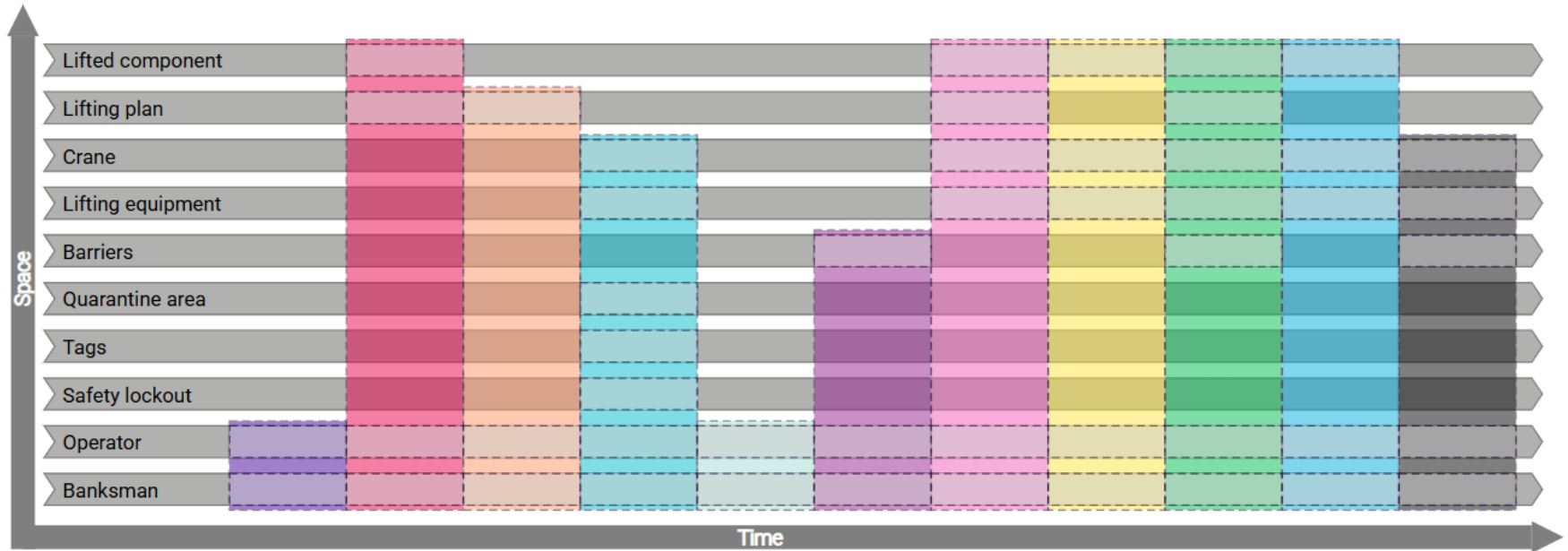
A Simple Example

Basic example: Driving a nail into a floorboard

A particular *activity*
Activity is anything that could, did or possibly happen

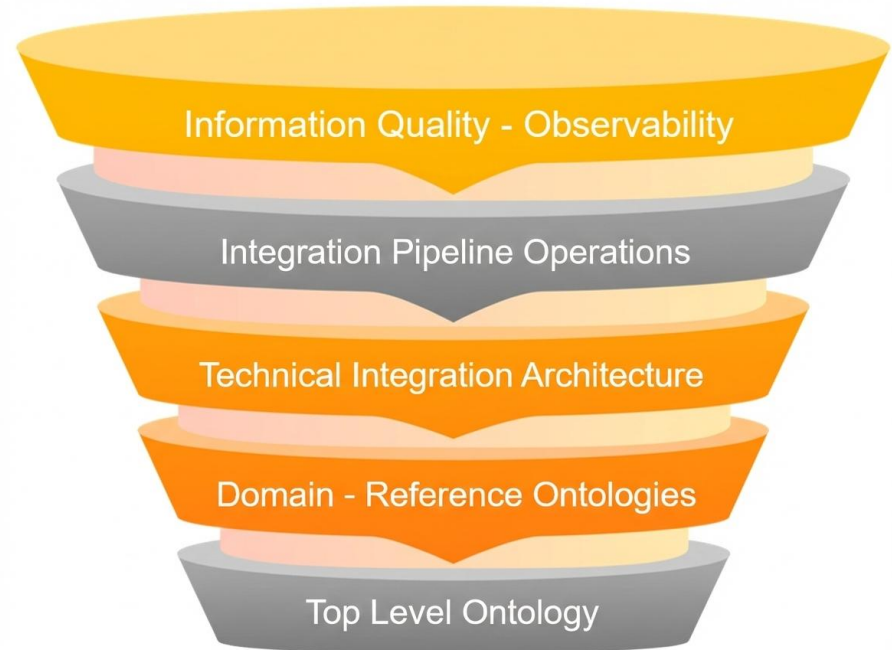


More Detailed Example – A Crane Lift



Summary: The Missing Practices

- Integration Pipeline Operations
 1. Development of pipelines for exchanged information between systems.
 - Should use real data from both the schema and instances.
 2. Information requirement methodology.
 - Articulating what the system needs to be doing.
- Adoption of a Top Level Ontology (TLO).
 - *There is not a single TLO to rule them all.*



Part 3:

Exploration of data structures and how they affect communication.

**“All data models are wrong,
some are useful”**

- George E. P. Box.

What does this data mean to you? What would it mean if we shared it?

Date	Outside temperature at 1200
27 Jan 83	12
28 Jan 83	15

- Data requires some kind of context to capture what it 'means'.
 - In day-to-day life we might casually tabulate data with headings.
- Typical questions may include:
 - 1200 local, or GMT, or .. ? Degrees F, or C, or Kelvin, or .. ? 1983, or 1883, or .. ?
 - Where ?
 - As measured by what ?

Understanding the Form of Data Structures

- A data model / ontology is a “theory of what exists” i.e. the things that exist and the rules that govern them.
- An ontology is the most powerful approach to enable people to accurately, and flexibly, capture ‘meanings’.
- They do not force context, but do allow arbitrarily precision with what they mean (extensionalism).
- Without this construct, data (e.g. 4) can be literally meaningless.
- Ontologies sit at the top of the family of approaches that include dictionaries and taxonomies.
- The following series of slides are heavily based upon the survey of top-level ontologies.



A survey of Top-Level Ontologies

To inform the ontological choices for a Foundation Data Model

Version 1



https://www.cdbb.cam.ac.uk/files/a_survey_of_top-level_ontologies_lowres.pdf

Data Modelling Choices and Commitments

Commitments help compare the differences in form, and can be broadly split into three areas:

1. General Level
2. Formal Structure
3. Universal

At least once example is covered to some level in the presentation but are not called out.

Basic Requirements

Pragmatic Requirements

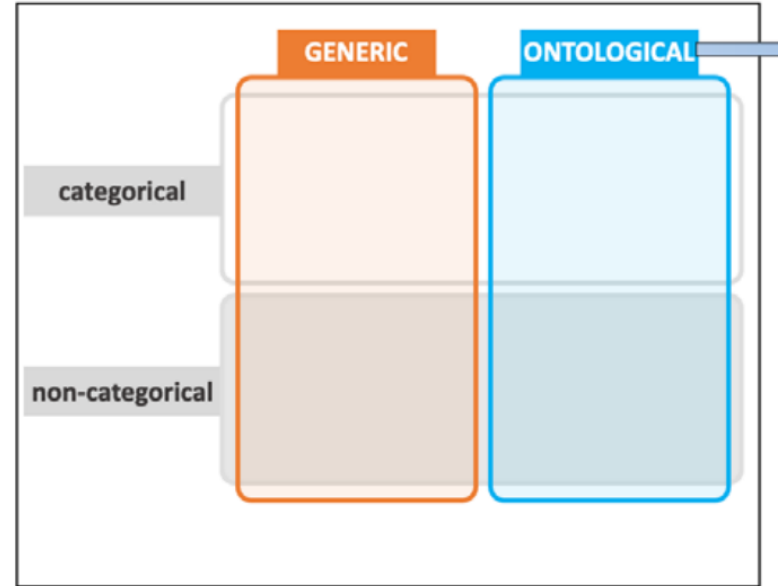
- *It will need to reflect the world of science and engineering*
- *It will need to be extensible.*
- *It will need to be stable.*
- *It will need to be capable of consistent extension by independent teams.*

Technical Requirements

- *A principled and rigorous approach*
- *Rooted in a science and engineering view of the world*
- *A comprehensive scope*
- *As simple as possible (**but no simpler**)*

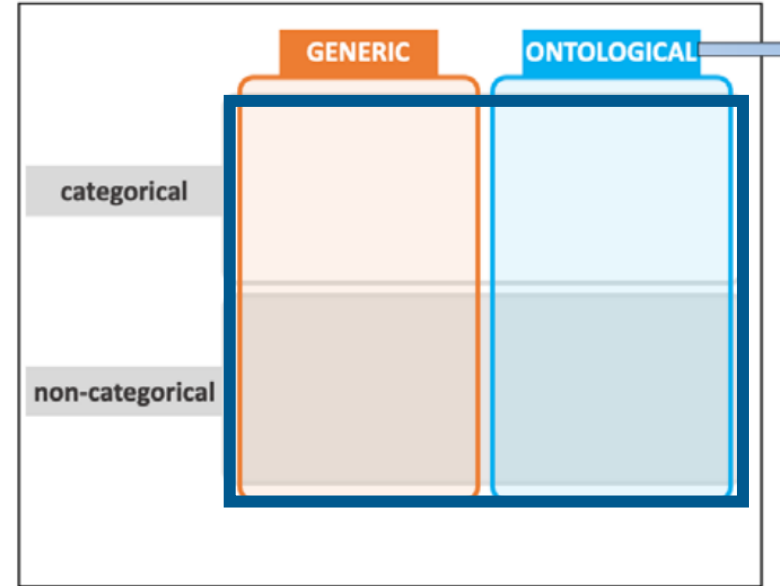
Data Modelling Classifications

- Are you trying to make data generally work together? Or are you committing to ontological forms?



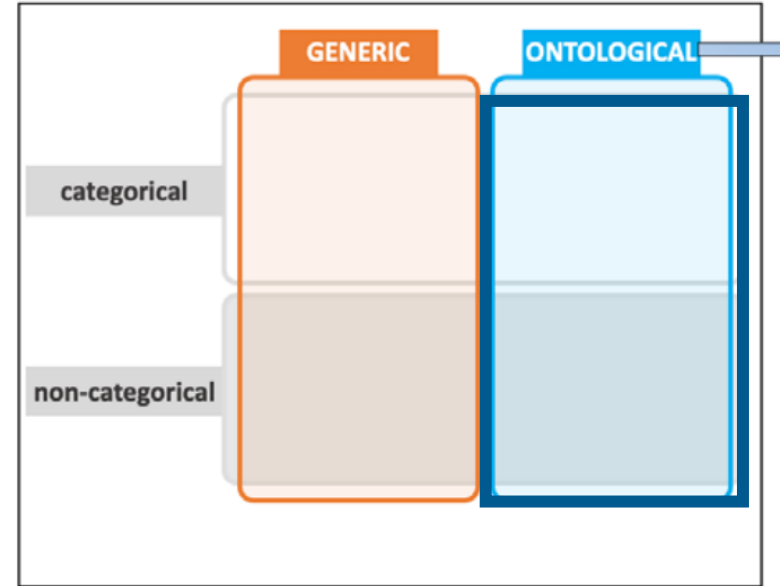
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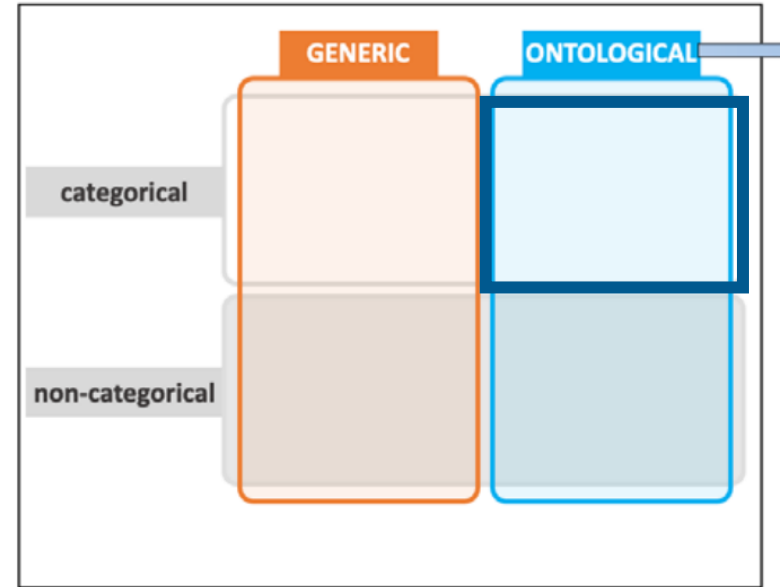
Data Modelling Classifications

- Are you trying to make data generally work together? Or are you committing to ontological forms?
- Are categories being used to categorically cover everything?



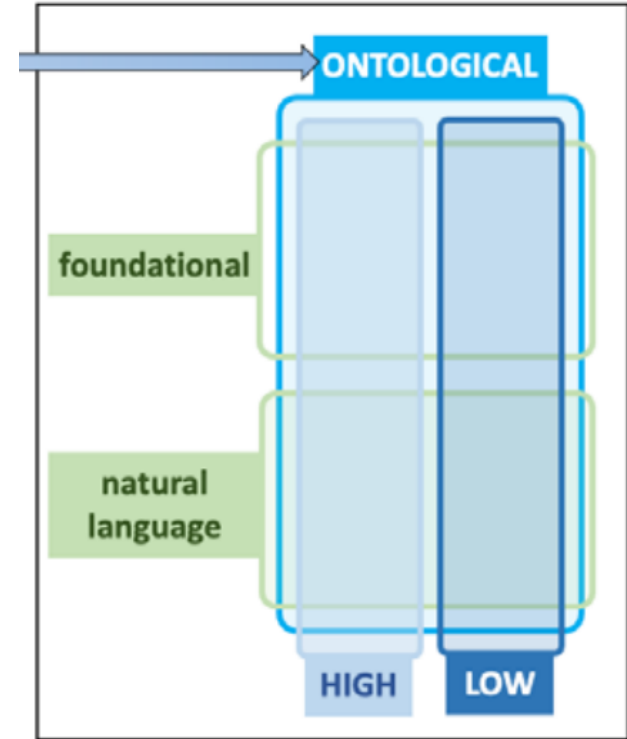
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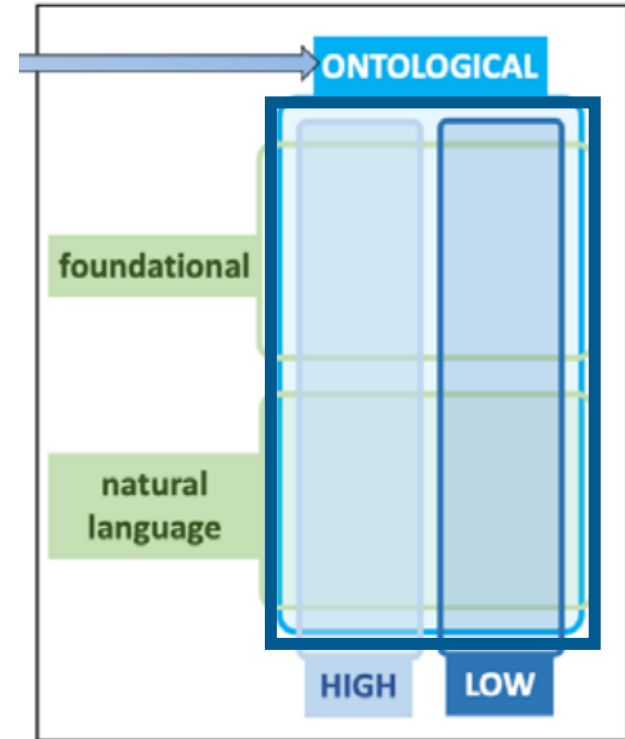
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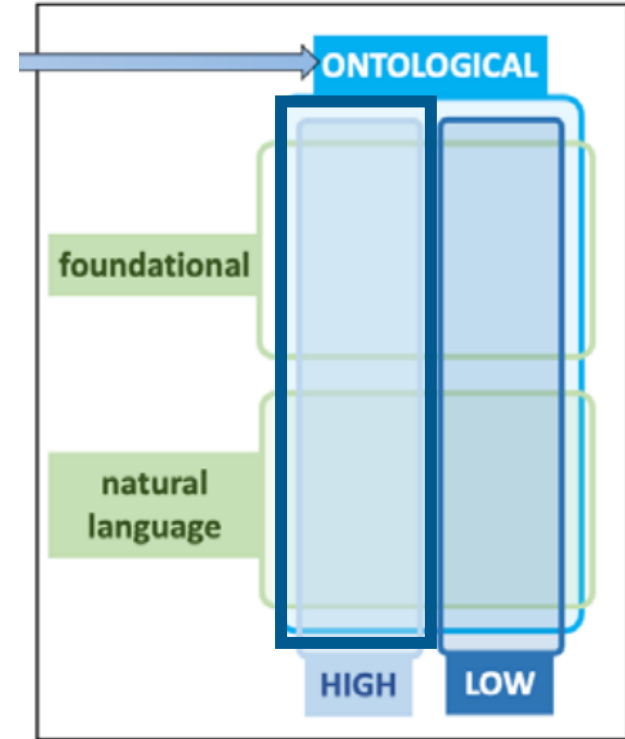
Data Modelling Classifications

- Are you trying to make data generally work together? Or are you committing to ontological forms?
- Are categories being used to categorically cover everything?
- Are any commitments made clear to be highly ontological?



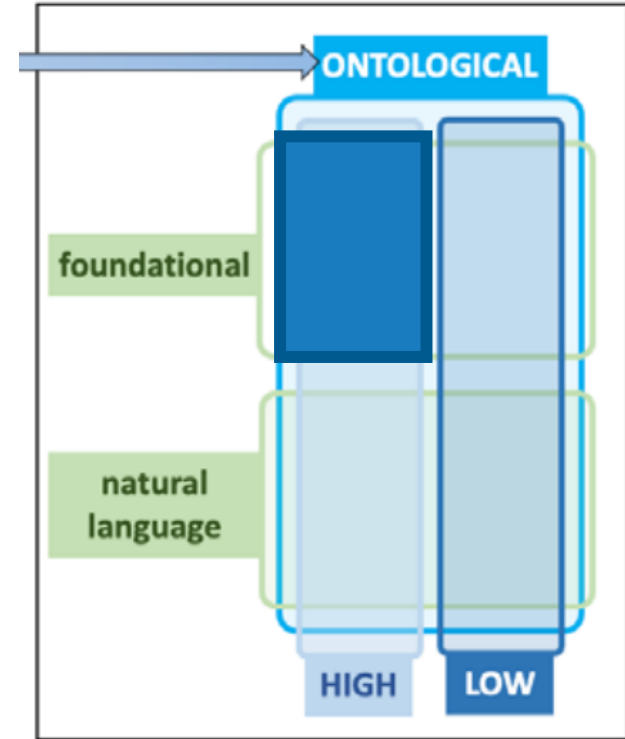
Data Modelling Classifications

- Are you trying to make data generally work together? Or are you committing to ontological forms?
- Are categories being used to categorically cover everything?
- Are any commitments made clear to be highly ontological?
- Is the subject matter based upon natural language or of what 'really' exists?

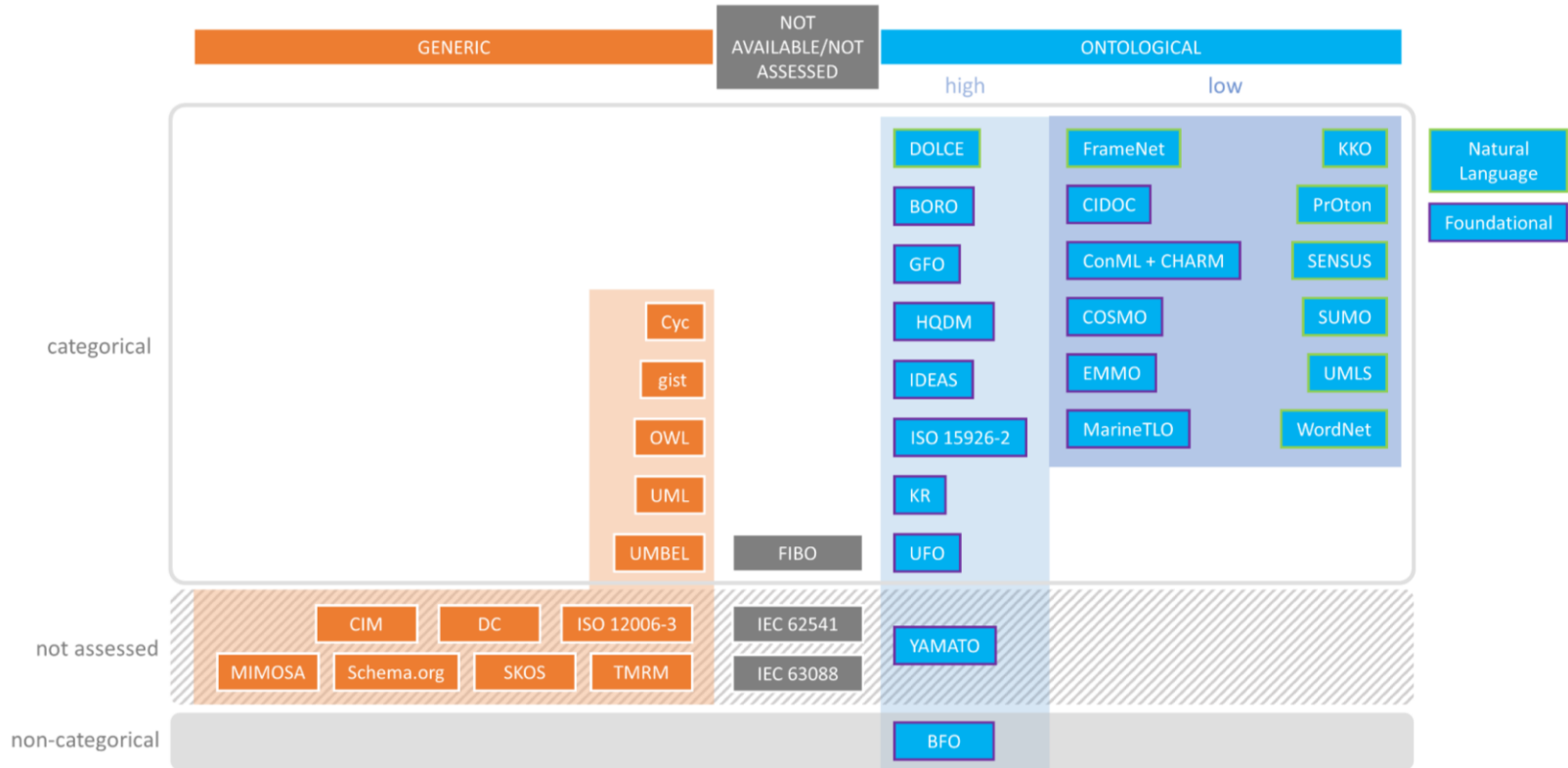


Data Modelling Classifications

- Are you trying to make data generally work together? Or are you committing to ontological forms?
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General Choices Visualisation



Three Core Relationships

An aerial photograph of a residential estate with many houses. A large blue oval highlights a central area of the estate. Within this oval, a smaller blue circle highlights a single house. The text is overlaid on the image.

Whole-Part

A house is a part of the housing estate

Type-Instance

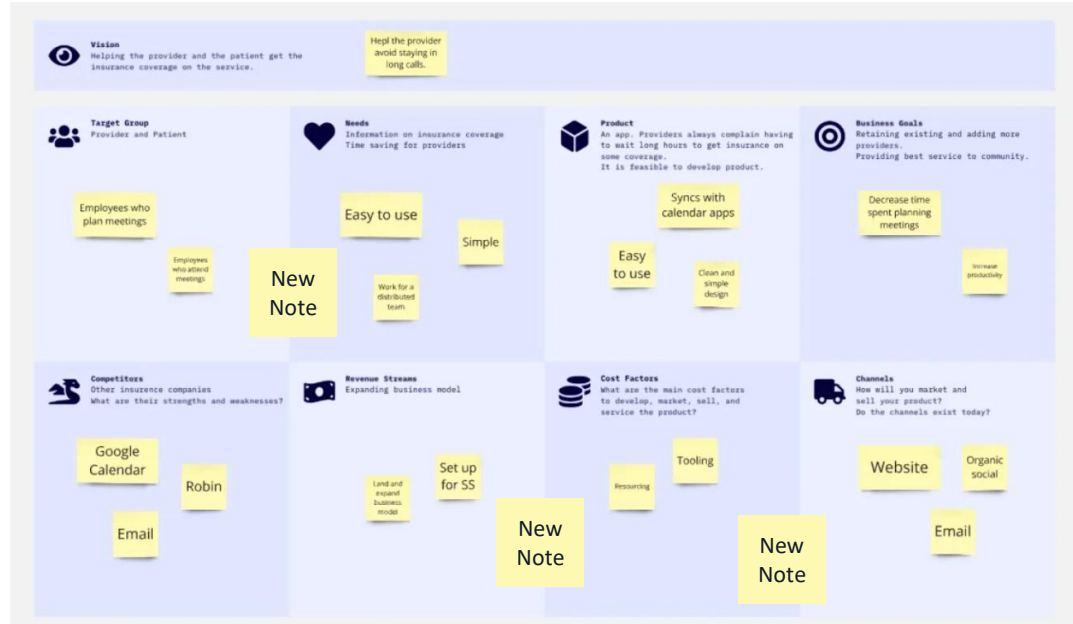
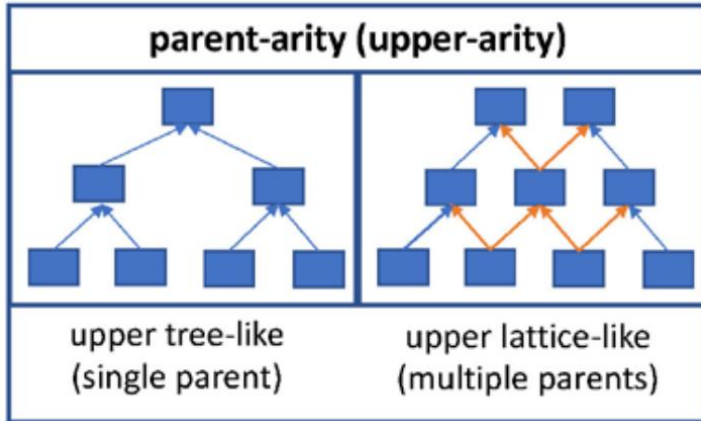
This house is an instance of the type house

Super-Sub-Type

A house is a sub-type of building

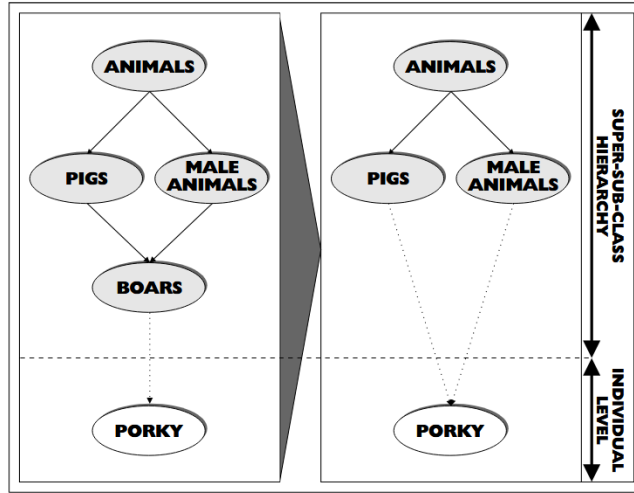
Putting Sticky Notes on a Page

- Must a sticky always fit inside a single box?



Parent-arity

Figure 6.16:
Shift to multiple classification



A quick aside: If every Boar is a Pig, and every Pig is an Animal. Is every Boar an Animal?
Commitment of Transitivity

Simpler extensions when the patterns emerge.

Business objects: re-engineering for re-use,
Chris Partridge

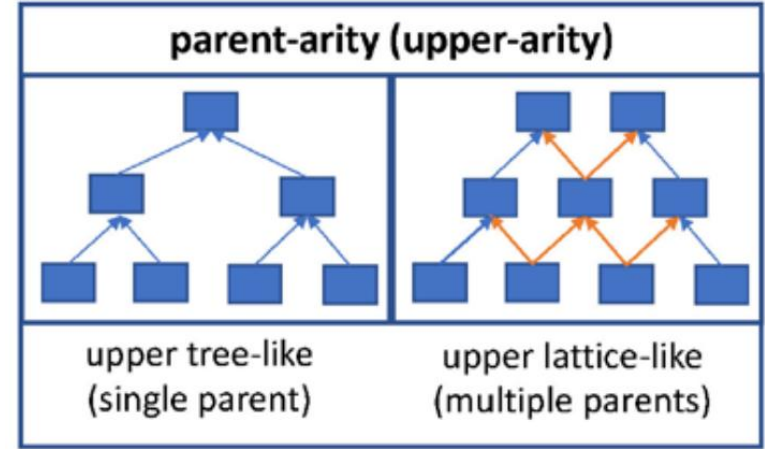
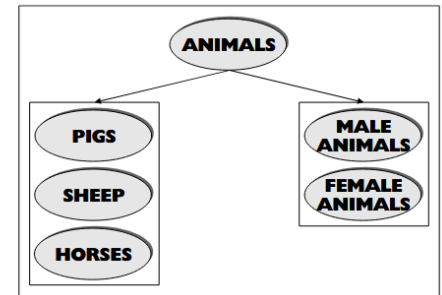
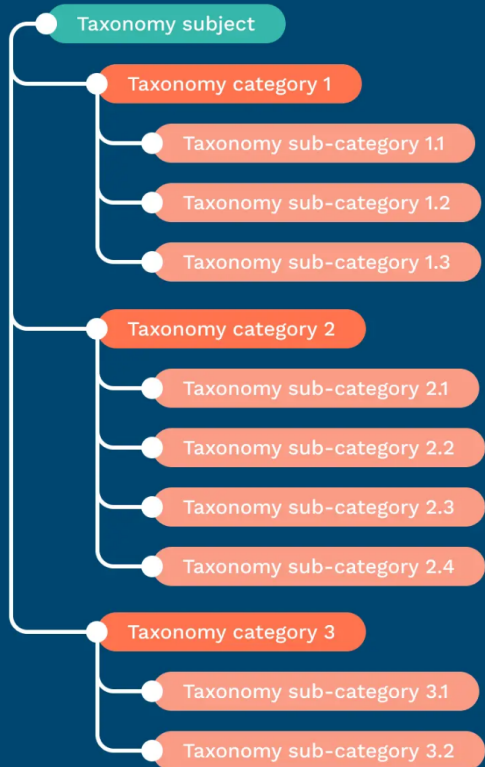


Figure 6.18:
The generalised classes

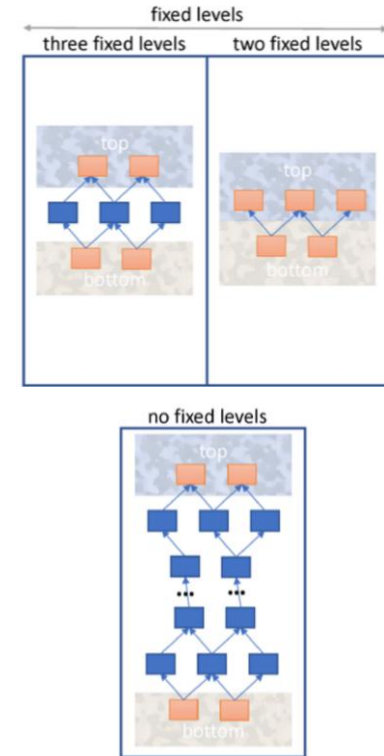


Structure of a taxonomy



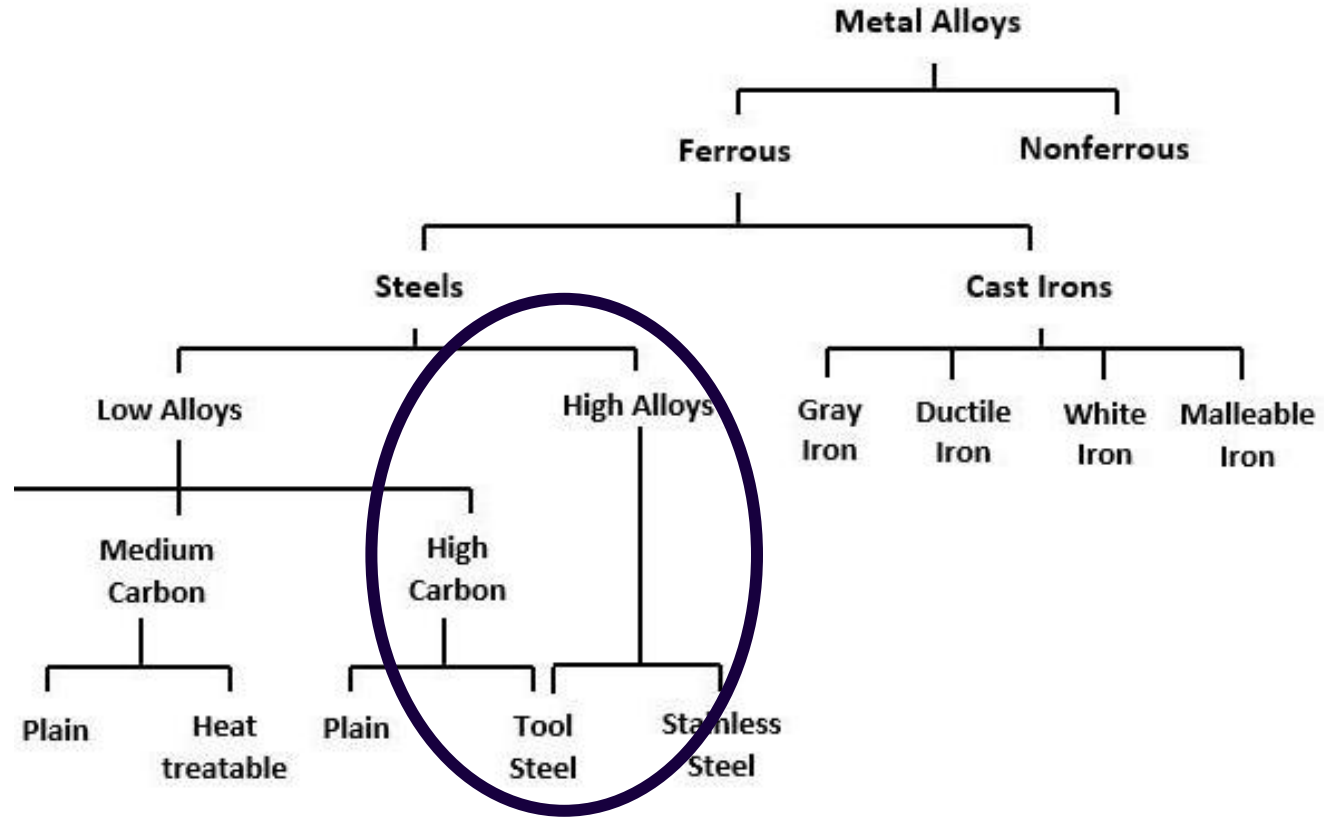
An Example Taxonomy Structure

- What are the potential problems?
- Can I have only have a single category and a single sub-category?
- Do I always need to have a major category before just defining a sub-category?
- Can I jump across ranks with a categories from different ranks?



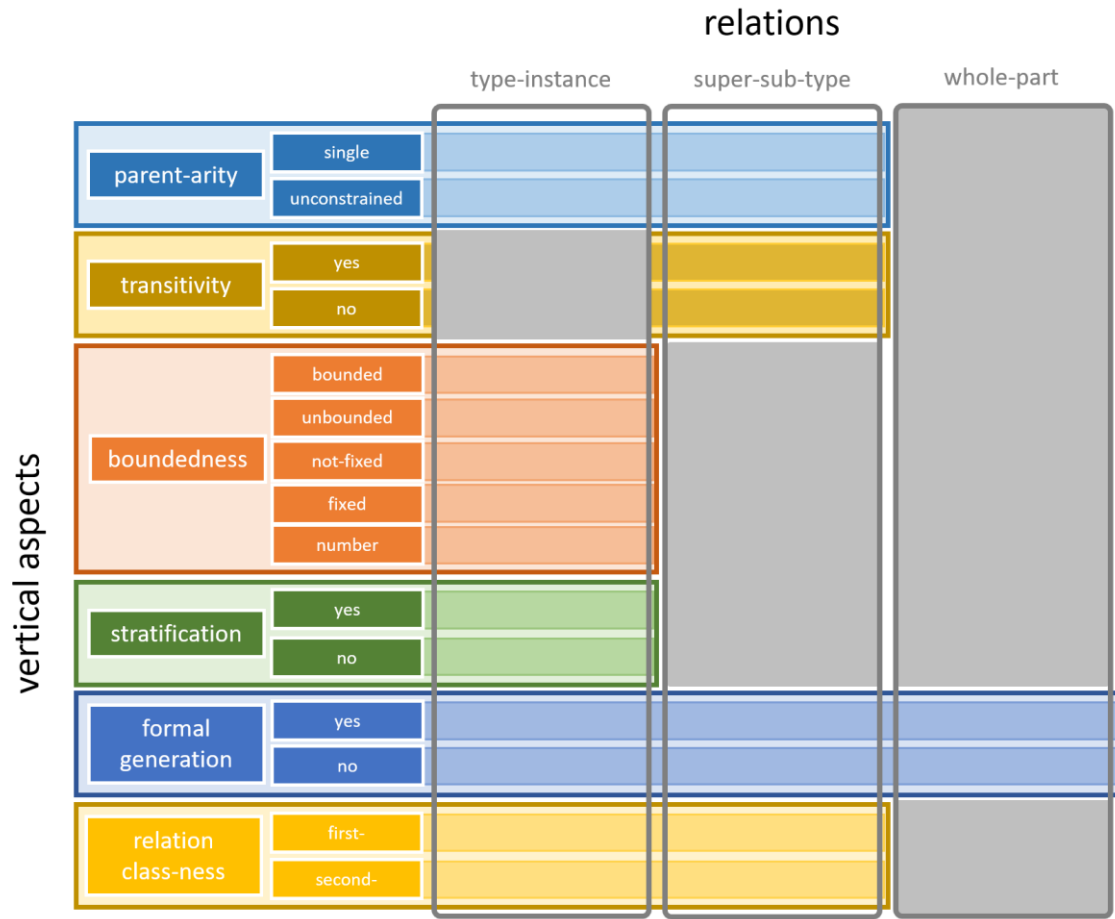
Stratification

If you enforce all categories to be extended onto each rank equally then you over-generate classes it becomes parsimonious - as a model it becomes less-expressive.

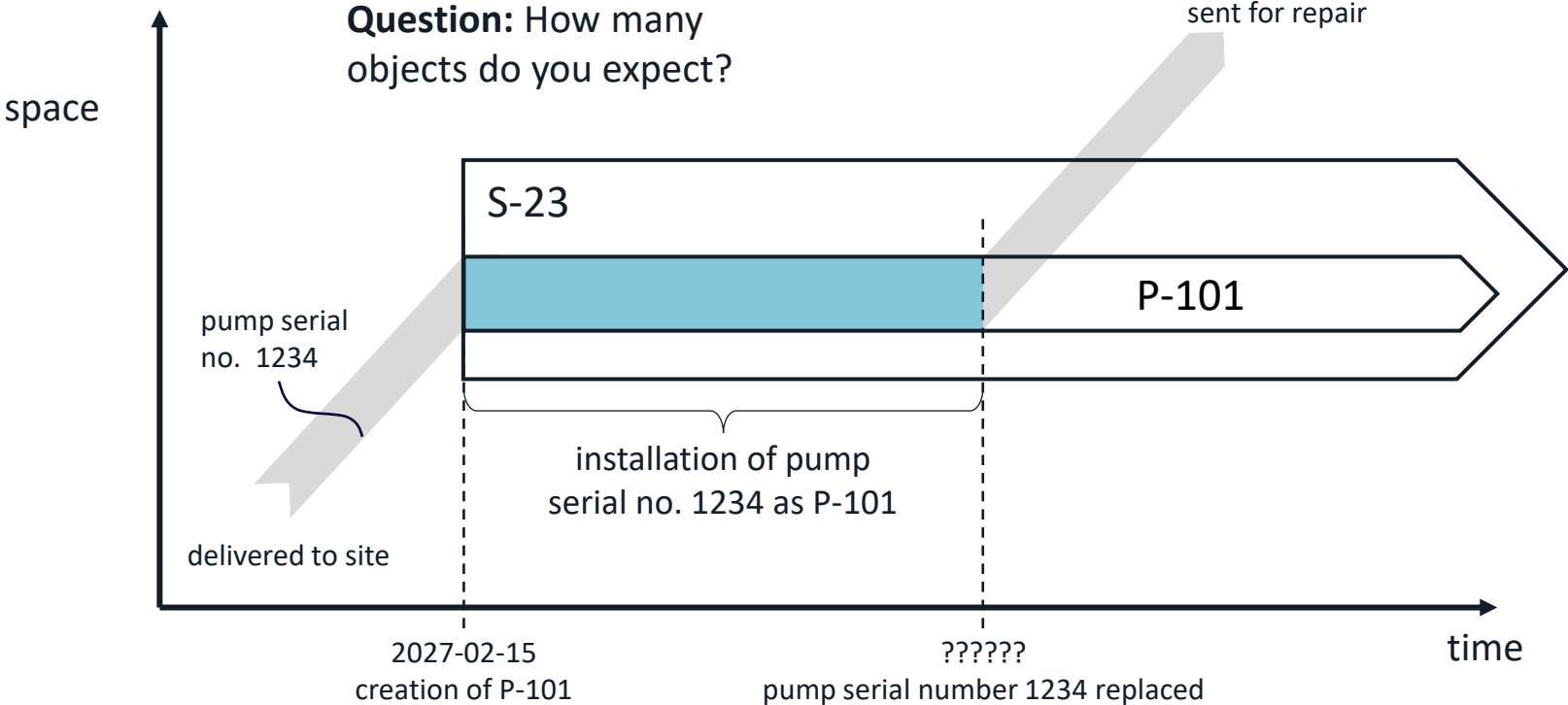


Making Choices

- Going to this level of detail is about making the choices explicit.
- It is also about working with these modelling principles and practices in mind.
- The survey presents what it considers are the commitments to be supportive of.



A System Modelling Example



Summary of Data Models at this Point

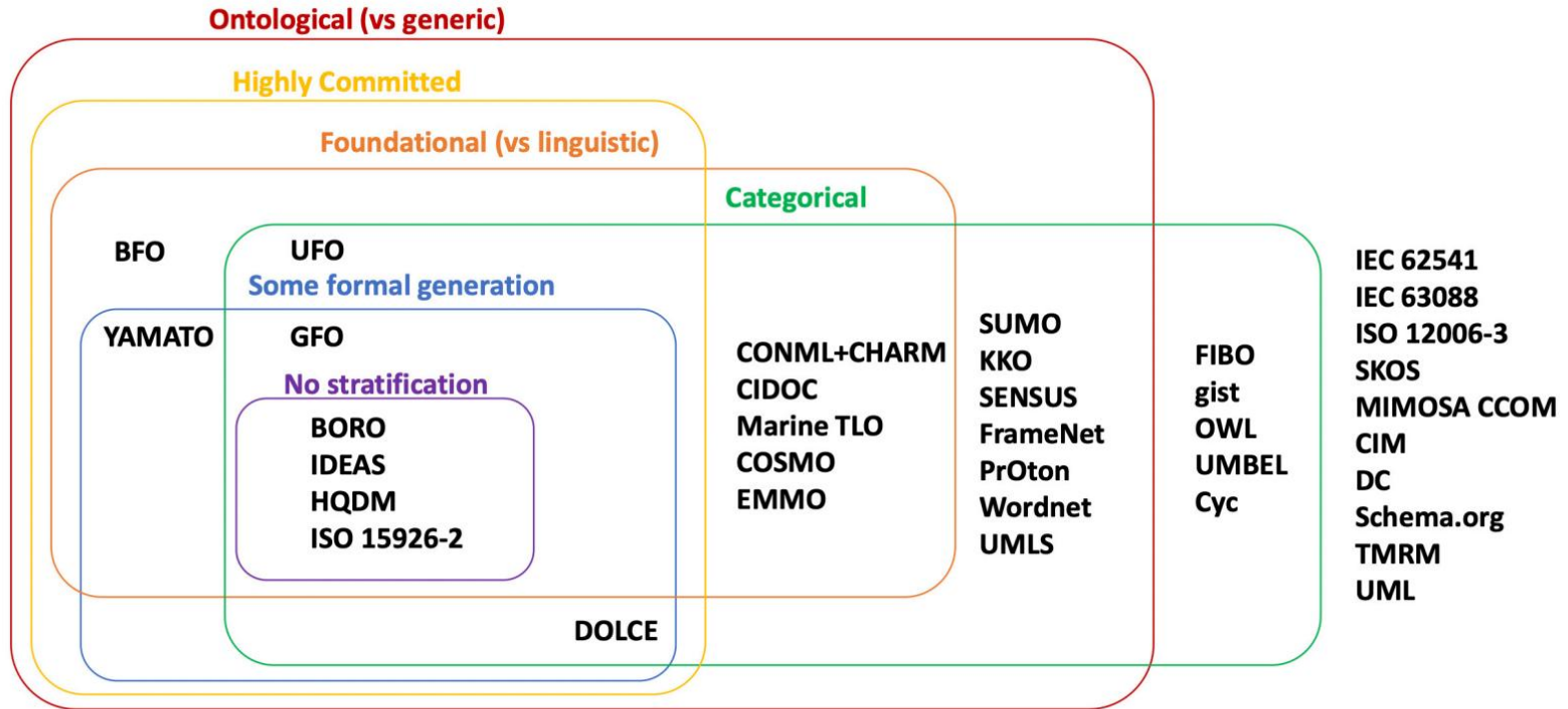


Figure 3: A Venn diagram showing classifications of Top-Level Ontologies.

Summary

- 1) Data siloes – why are we where we are?
- 2) Today's missing practices:
 1. *Integration Pipeline Operations*
 1. *Develop pipelines for exchanged information between systems.*
 2. *Information requirement methodology.*
 2. *Adopting a Top Level Ontology better supports system interoperability.*
- 3) Explored how data structures affect communication.

Thank you.

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