Industry Ontologies Foundry: 
*Industrial applications of ontologies*

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Some words about DK…

- **STI-IGM**
  - Prof. ICT for Sustainable Manufacturing

- **EC – AG LEIT-NMBP**
  - Individual Member

- **IFIP WG5.7 – Advanced Production Management Systems**
  - Chair

- **Member (representing EPFL)**
Closing the information loops of product life cycles
It’s about big lifecycle data transformations

**Lifecycle Data-Information-Knowledge Transformations**

- D: Data
- I: Information
- K: Knowledge

- IoT, CPS, ...

- Modes of use, Conditions of retirement and disposal, Recovery information
- Product usage info, Failure, Maintenance, Service event
- Product status, Recovery information

- BOL: Design, Production, MOL, EOL
- Resource, Process, Product
- History data, Assembly/disassembly info, Material info for reuse
The Meaning of Data

38.5

38.5 °C

Body temperature

Oven temperature
Characteristics of Data

- Source of data
- Measurement (sensors, assessment, observation, records, ...)
- Value
- Transformation / Interpretation
- Visualisation
- Meaning / Context
Smart Manufacturing challenges

- **Domain modeling** for Big Industrial Data Analytics

- **Content analytics** enriched with semantic meaning

- **Recommend data and analytics** based on information / decision need

- **Improve the ability of analysts** to rapidly find and process relevant information in support of decision making

- The issue of **interoperability**:  
  - *How do we get the domain modeling going on in different communities* to coalesce?
Ontology Based Lifecycle Engineering
Ontologies

Ontologies bring together the Physical (Real)–Cyber (Digital)–Bio (Human/Cognitive) worlds.
Ontologies & Big Data

- Scattered data in several sources, systems and services
- Different actors with multidisciplinary skills
What algorithm to apply?

Taking the LEAP: The Methods and Tools of the Linked Engineering and Manufacturing Platform (LEAP)
https://www.elsevier.com/books/taking-the-leap/kiritsis/978-0-12-805263-1
(Manufacturing) Industry Ontologies Foundry (IOF)
IOF Architecture

http://ieportal.ncor.buffalo.edu/ontologies
Draft of a generic **PLC** (Product Life Cycle) Ontology

based on

**BFO** (Basic Formal Ontology)

*With acknowledgments and thanks to Barry Smith (NCOR, Buffalo) for his ontological engineering approach*
Following the BFO principles

- For some processes we have also process boundaries (beginning of process, end of process) at determinate Temporal Intervals.
- For some processes beginnings or endings may be indeterminate.
## Material Entity instance examples

<table>
<thead>
<tr>
<th>Material Entity</th>
<th>Information Entity</th>
<th>Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portion of Material</td>
<td></td>
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<tr>
<td>Part/Component</td>
<td></td>
<td></td>
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<tr>
<td>Switch</td>
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<td>Boiler</td>
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<td>Furnace</td>
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<td>Tank</td>
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<tr>
<td>Factory</td>
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<td>Access road</td>
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<tr>
<td></td>
<td></td>
<td>Delivery vehicle</td>
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</tbody>
</table>
## Information Entity instance examples

<table>
<thead>
<tr>
<th>Material Entity</th>
<th>Information Entity</th>
<th>Process</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Product Model</td>
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<td></td>
<td>(output of CAD</td>
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<td></td>
<td>system)</td>
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<td>Requirement</td>
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<td></td>
<td>Specification</td>
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<td></td>
<td>Process Plan</td>
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<td></td>
<td>Production Plan</td>
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<td></td>
<td>Part/Component List</td>
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<td></td>
<td>Maintenance Plan</td>
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<td></td>
<td>Maintenance Report</td>
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<tr>
<td></td>
<td>Maintenance History</td>
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</tr>
<tr>
<td>Material Entity</td>
<td>Information Entity</td>
<td>Process</td>
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<tr>
<td>-----------------</td>
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</tr>
<tr>
<td>Design Process</td>
<td>Production Process</td>
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<tr>
<td>Production Plan Generation Process</td>
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<tr>
<td>Product Use Process</td>
<td>Product Maintenance Process</td>
<td>Product Inspection Process</td>
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<tr>
<td>End Of Life Process</td>
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</tbody>
</table>
Following the time
PLC ontology: the complete schema
An FALCON upper ontology is a generalization of the five business scenarios of the FALCON project serving as an upper template for all FALCON business cases as well as future business cases in terms of Product-Service System. The FALCON ontology plays the roles

- To define the structure and contact of the Triple Store
- To be used to define semantic search parameters for social media
- To be used to query PUI
Process to create ontology

1. Identify taxonomies using USM for five business scenarios
2. Generalization of five business scenarios
3. Refine taxonomies through comparison with reference ontologies
4. Create and update ontology
5. Discuss with end-users and experts
6. Test the ontology and refine
Product Service System (PSS): a marketable set of products and services capable of jointly fulfilling a user’s need

Product system: a set of material products needed to jointly fulfill a user’s needs

Product: a tangible commodity manufactured to be sold

Service: an activity (work) done for others with an economic value and on a commercial basis
Basic Formal Ontology

- Formal ontology framework developed by Barry Smith and his associates (Smith et al., 2014).
- Entities in the FALCON semantic framework are arranged based on the Basic Formal Ontology (BFO) in BFO.
- Two varieties
  - Continuants comprehending continuant entities such as three-dimensional enduring objects
  - Occurrent comprehending processes conceived as extended through (or as spanning) time

Red font: Entities from BFO
Black font: Entities originated from FALCON context
FALCON Ontology-Alignment to BFO

Red font : Entities from BFO
Black font : Entities originated from FALCON context
Predictive Manufacturing

http://www.z-fact0r.eu/
BOOST 4.0: Big Data Value Spaces for COnpetitiveness of European COnnected Smart FacTories 4.0
Merci

Thank You