# Connecting the Dots in Circular Lifecycle Management:
## *Industrial Data Sharing for Cognitive Analytics & Manufacturing*

EPFL

ICT4SM [ict4sm.epfl.ch/](ict4sm.epfl.ch/)


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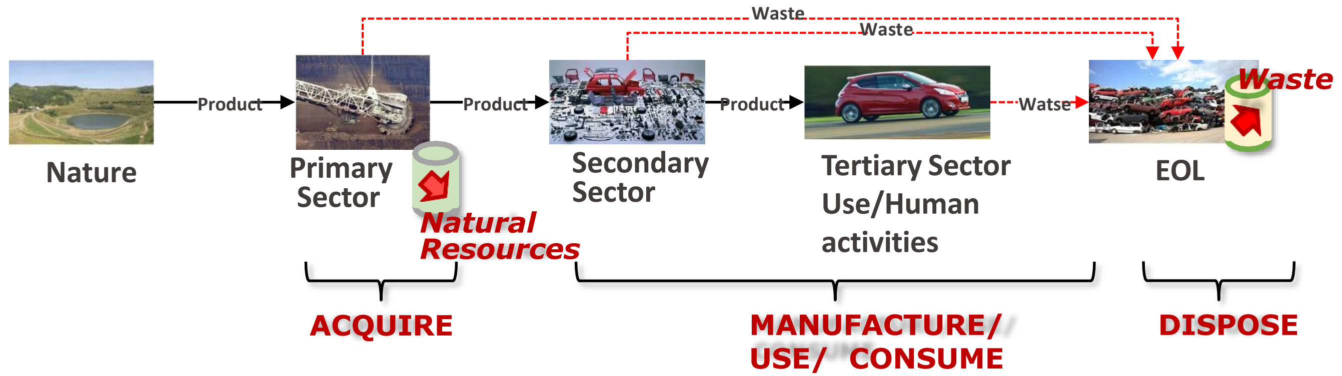
# The current context: Linear Economy








- *Degradation of natural resources*
- *Accumulation of waste*

- *Increase in the world population*
- *Increase in the consumption of goods*

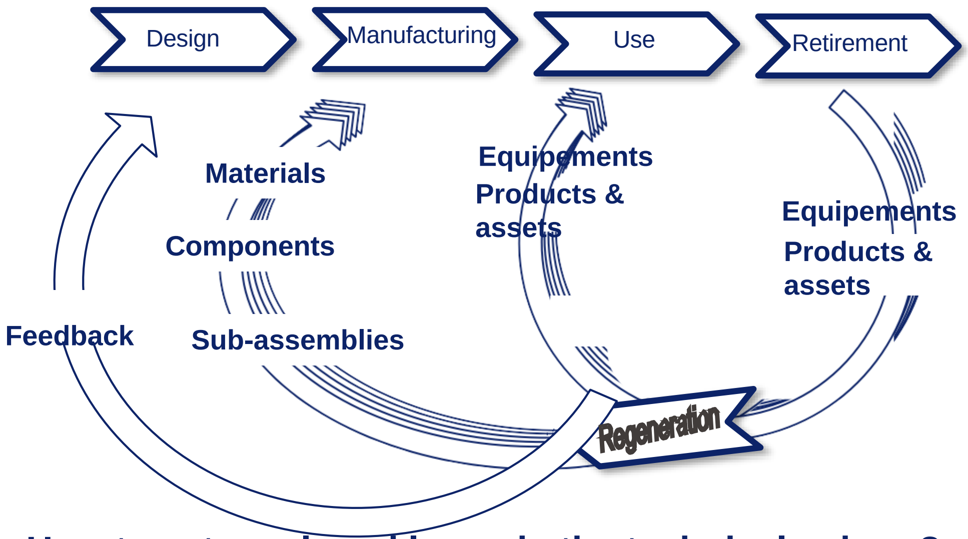
*Unsustainable economy in the long term for humans and the environment*

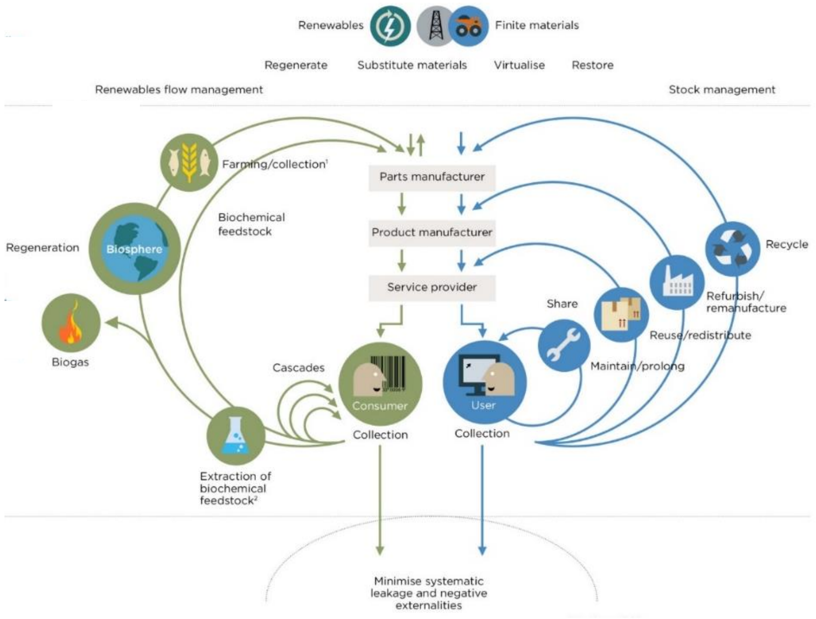
Figure adapted from PhD Thesis Laëtitia Diez, University of Lorraine

# The new context: Circular Economy



*Closed-Loop Lifecycle Management*




## How to set up closed loops in the technical sphere?

- Take into account several cycles of use
  - **Loops** (exploitation - regeneration - exploitation / manufacture)
  - **Types of products** (equipment, subassemblies, components, materials)

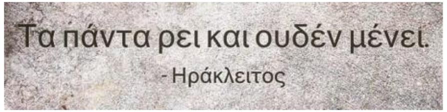


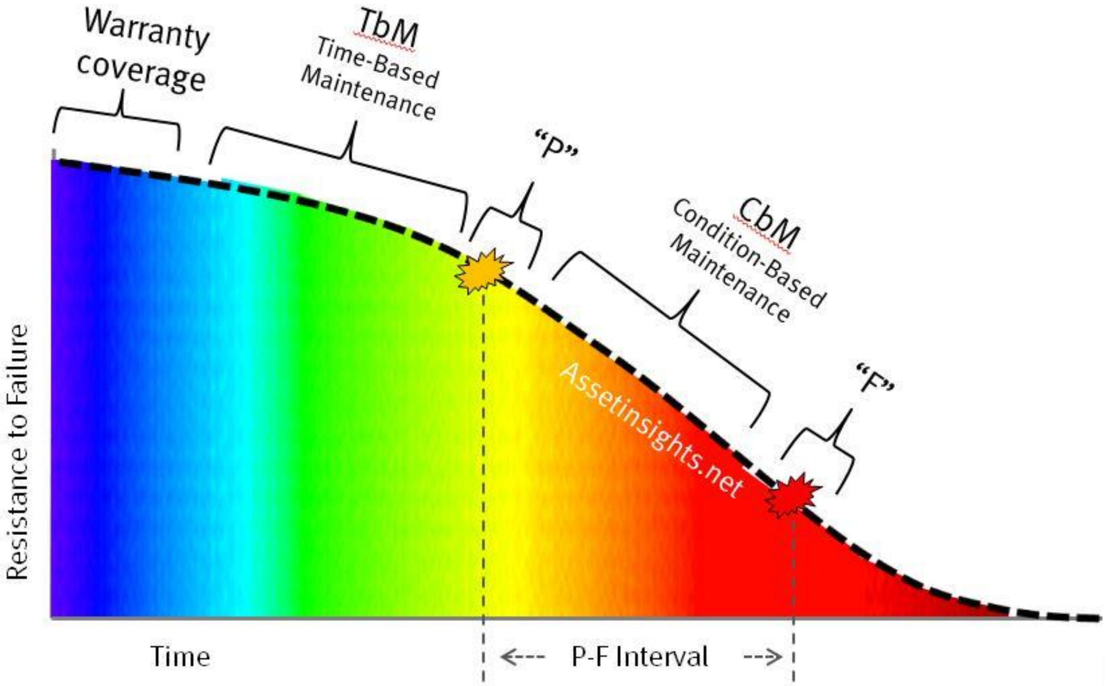

Figure adapted from PhD Thesis Laëtitia Diez, University of Lorraine

# The problem: Degradation and Failure





- ***Resistance to Failure** : An indicator of performance or condition*
- ***Potential Failure** : the starting point to observe the potential state or condition of not meeting a desirable or intended objective, and may be viewed as the opposite of success.*
- ***Functional Failure** : the starting point of the state or condition of not meeting a desirable or intended objective, and may be viewed as the opposite of success.*
- ***Premature failure***
  - ***Premature P***: Earlier Potential Failure than intended
  - ***Premature F***: Earlier Functional Failure than intended
- ***Degradation Phases***
  - ***Pre-P Period***(<P)
  - ***P-F Interval***(P-F)
  - ***Post-F Period***(>F)




Refer to http://www.assetinsights.net/Glossary/G_P-F_Curve.html

# Defects



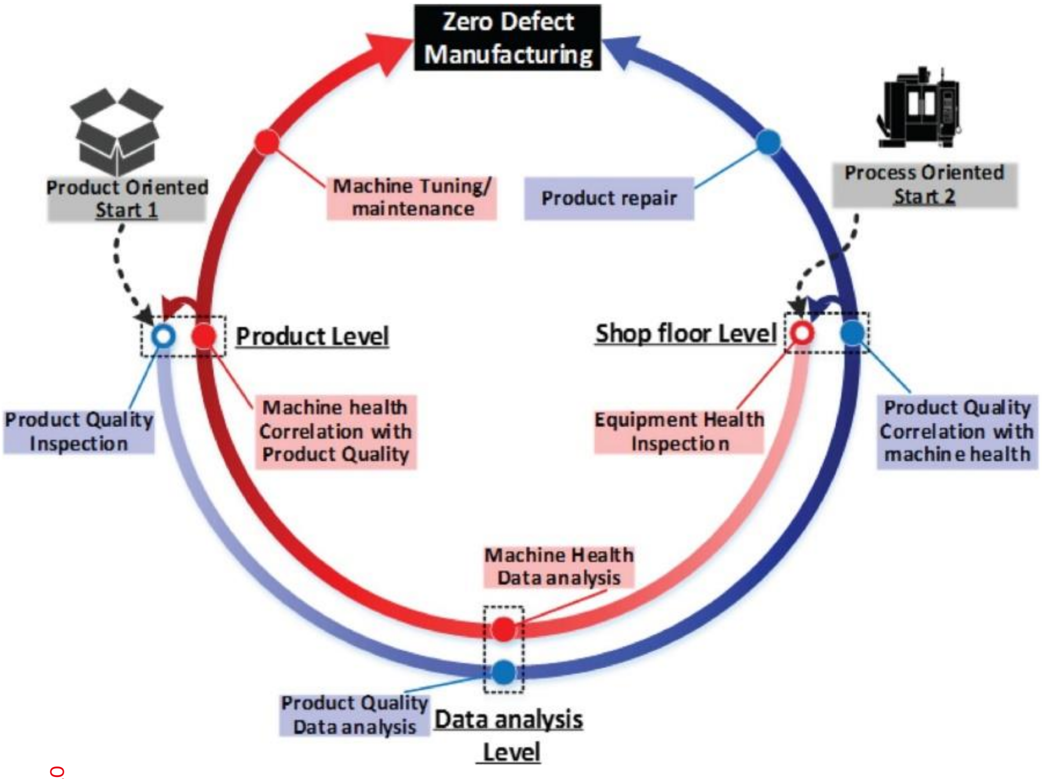
Defects are occurring and can be avoided at the **Shop-floor** level

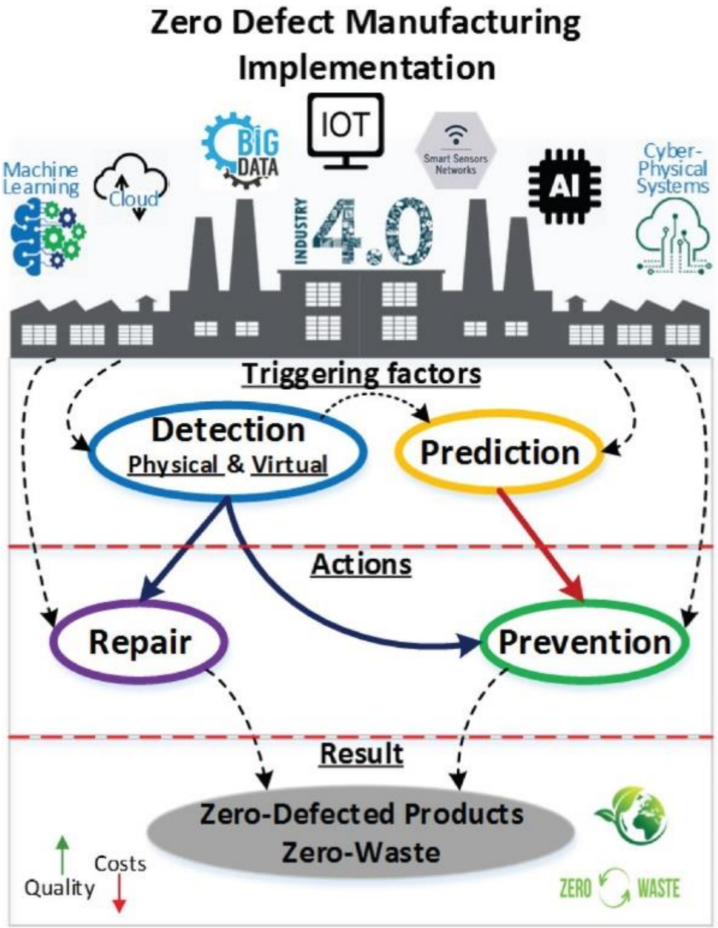
Better and more efficient **production management** and **operations**, by better **resource allocation**, based on **product & process quality measurements**

# The solution: Zero Defect Manufacturing - ZDM





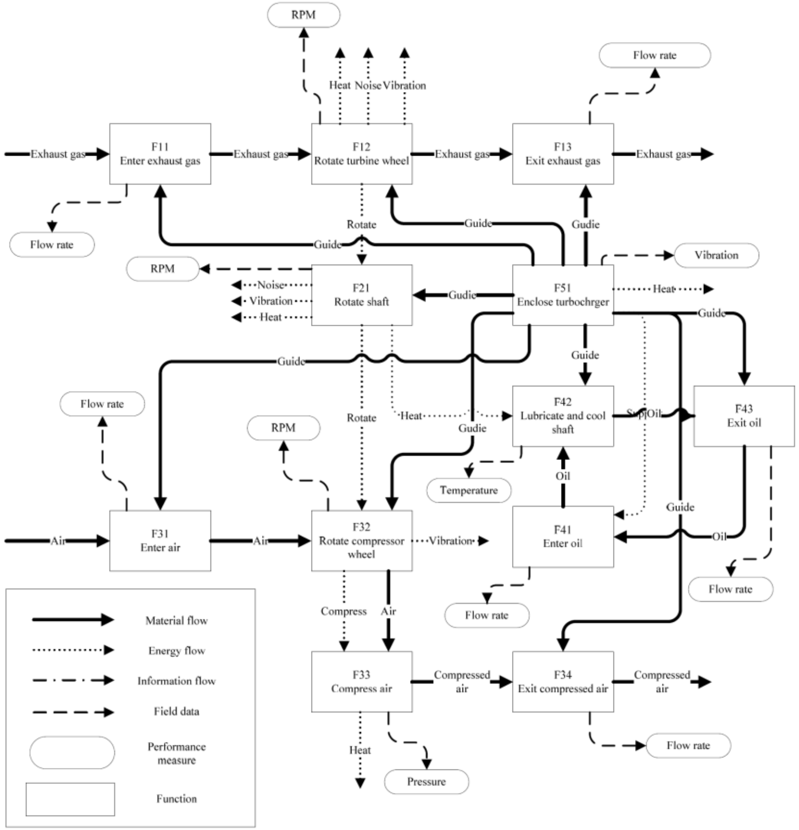


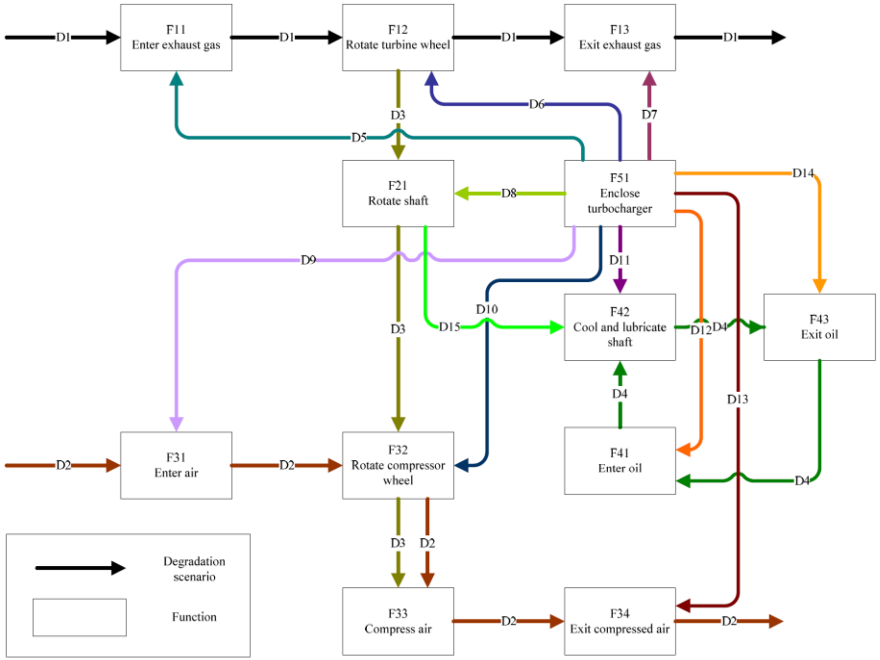



# Understanding degradation: Model Based Systems Engineering







# Measuring degradation: with elements of intelligence/cognition of products

- Sensors (sensing)

- Memory chips (memory)

- Micro-processors + Software (logic)


- Barcodes, RFID, … (identity)

- Bluetooth, WiFi, IoT, … (communication)

# Four Levels of Intelligence

- **Intelligence Level 1:** physical products without any embedded system (device or software). They do not interact with their environment.

- **Intelligence Level 2:** physical products with embedded simple sensors. Their embedded sensors allow them to interact with their environment.

- **Intelligence Level 3:** physical products with embedded sensors, memory and data processing capabilities. Such system of embedded devices and software (data processing) allows a product to adapt quickly to sophisticated changing environments.

- **Intelligence Level 4:** physical products with Product Embedded Information Devices (PEID). Examples of PEIDs are ID devices such as RFID tags, sensors or sensor networks, on board computers etc.

# Intelligent Autonomous Products





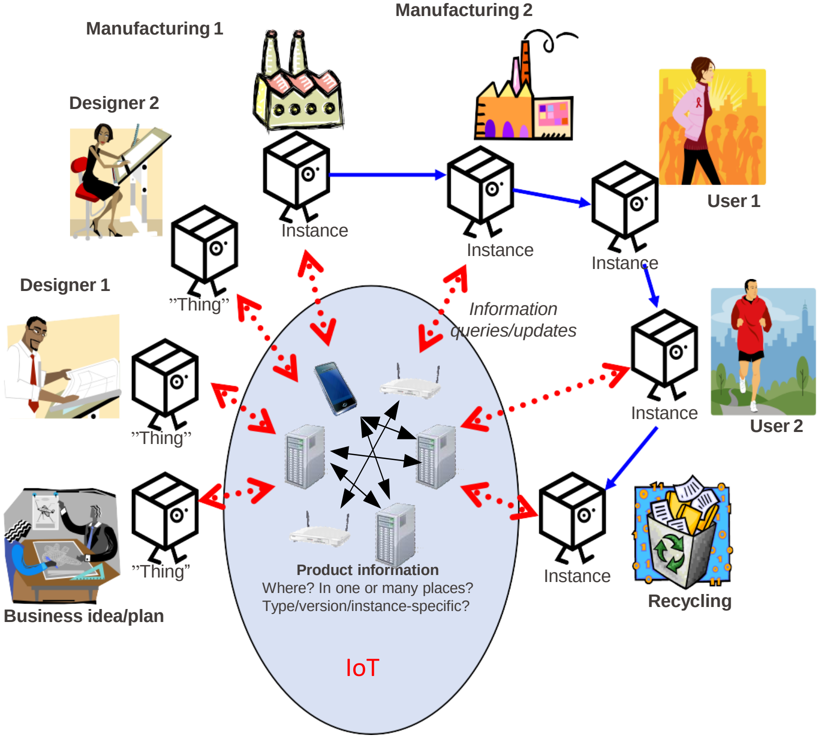
- **Intelligent Products** may develop advanced intelligence capabilities and become **Autonomous**, since they have:

  i. **identity** and, in addition to that, with their
  ii. **sensing** & **computing** & **communication** capabilities, they may
  iii. develop **reasoning** (at various levels of decision making, from local to distributed) and
  iv. keep track of their **history**.

- ***These elements are similar to the elements which allow us, humans, to develop our own "intelligence", "cognition" and "autonomy" .***

***What if a product could tell you what do do with itself next?***

# Systems of Systems: *Closed Loop Lifecycle Management*




- **Lifecycle view**: IoT is about managing **all information** about **any Product/Thing**
- Information is **Distributed over Systems** (devices, servers, applications, ...)
- Information is **Distributed over Organizations** (companies, individuals, authorities, …)
- Product (and its parts) are **unique instances**
- How to manage **identities**, **access rights**, …?
- **IoT** should provide necessary capabilities for **Closed Loop Lifecycle Management**

Red arrows: **O-MI & O-DF standards**

https://publications.opengroup.org/c14b

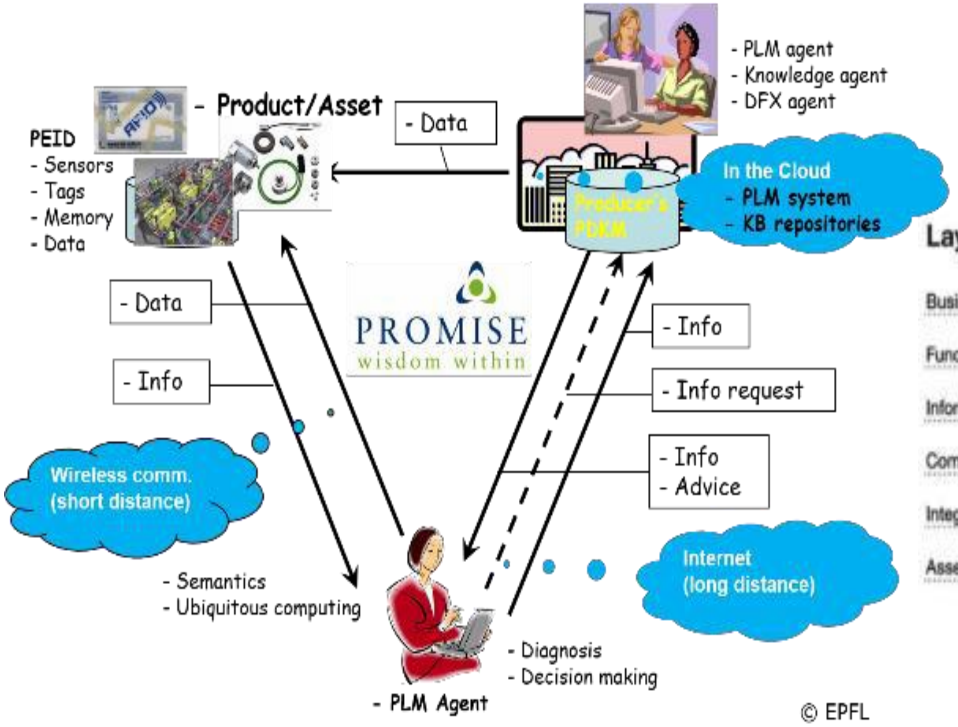
https://publications.opengroup.org/c14a

THE Open GROUP Making standards work®

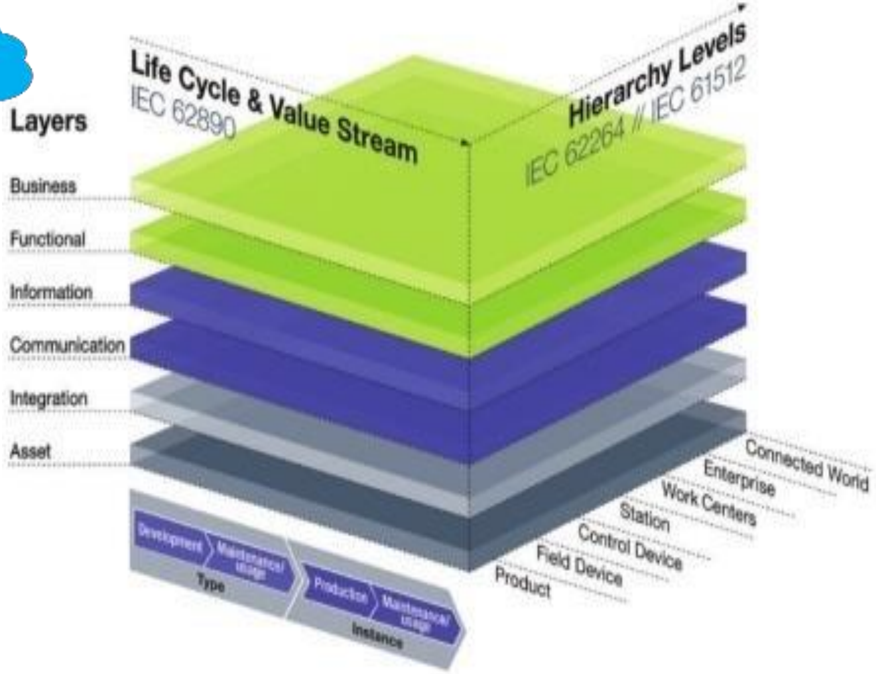
Taking the LEAP: The Methods and Tools of the Linked Engineering and Manufacturing Platform (LEAP)

# Industry 4.0 - RAMI 4.0 as enabler of Closed Loop Lifecycle Management





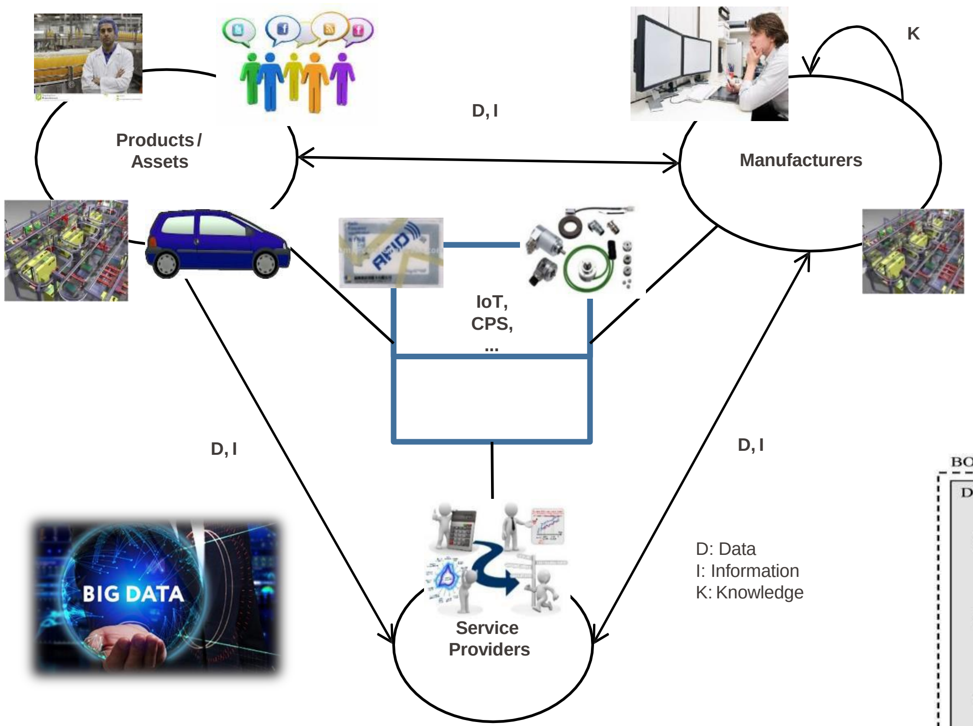

Closed Loop Lifecycle Management



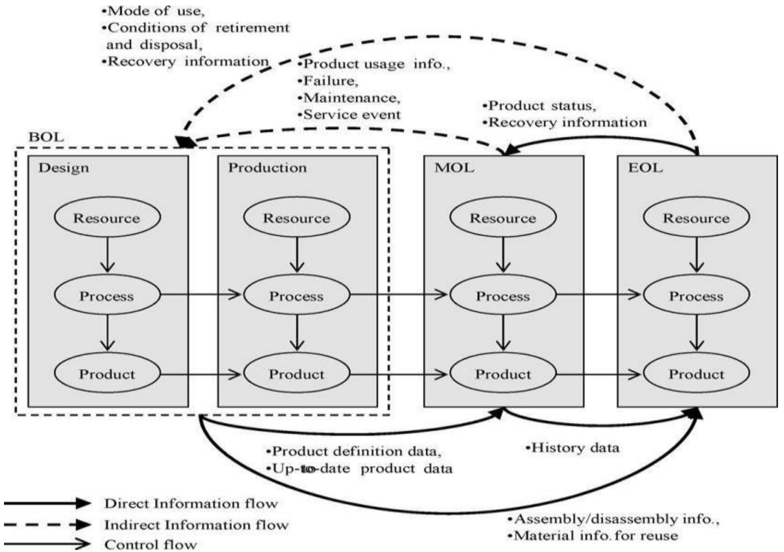

RAMI 4.0

# It is all about Big Life Cycle Data Transformations






- Closed-Loop Life cycle Data-Information-Knowledge Transformations
- Semantic Model-Based Systems Engineering for Industrial Data Analytics






LinkedDesign ZFactor ZBre4k Boost 4.0 BIG DATA FOR FACTORIES QU4LITY FACTLOG ONTO COMMONS Eur3ka ICT4SM

# Data Sharing for Manufacturing

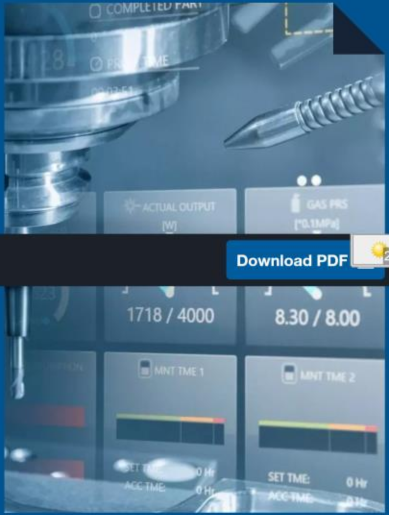
WORLD ECONOMIC FORUM

Agenda Platforms Reports Events Videos English TopLink

White Papers

Published: 13 January 2020

## Share to Gain: Unlocking Data Value in Manufacturing




White Papers

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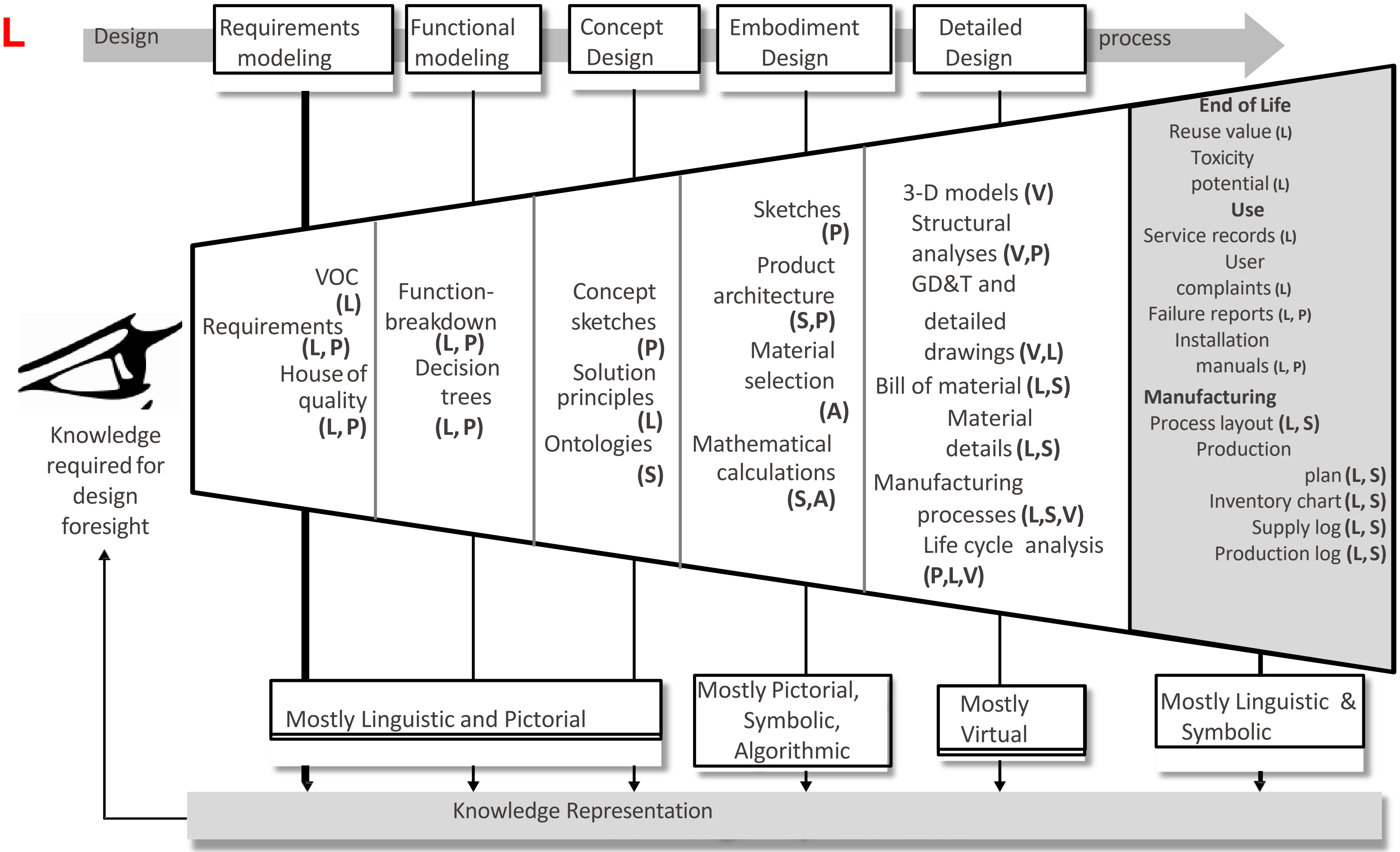
Emerging technologies such as advanced analytics and artificial intelligence (AI) are transforming the world of production. Although manufacturers are making strides in applying data-driven technologies, most focus on applications within their companies and have difficulty maximizing their return on investment. By sharing data across companies, manufacturers can unlock additional value and accelerate innovation. The potential value of data sharing simply by focusing on manufacturing process optimization has been estimated at over $100 billion, based on best practices.

https://www.weforum.org/whitepapers/share-to-gain-unlocking-data-value-in-manufacturing




*Legend:* **(P)** pictorial **(L)** linguistic **(V)** virtual **(A)** algorithmic **(S)** symbolic

Senthil Chandrasegaran, Karthik Ramani, Ram D. Sriram, Imre Horvath, Alain Bernard, Ramy Harik, Wei Gao
The evolution, challenges, and future of knowledge representation in product design systems
Computer-Aided Design Volume 45, Issue 2, February 2013, Pages 204-228.

# Characteristics of Data




Data Source

Value

Context



Transformation

Interpretation


Visualisation

# The Meaning of Data



Body temperature



38.5 °C

Oven temperature

**Ontologies allow the interpretation of the right meaning of data**

Reasoning

Domain disambiguation

Data Silos



**Essay by Verscheure & Kiritsis in 2018 WMF Report:** https://www.worldmanufacturingforum.org/report/

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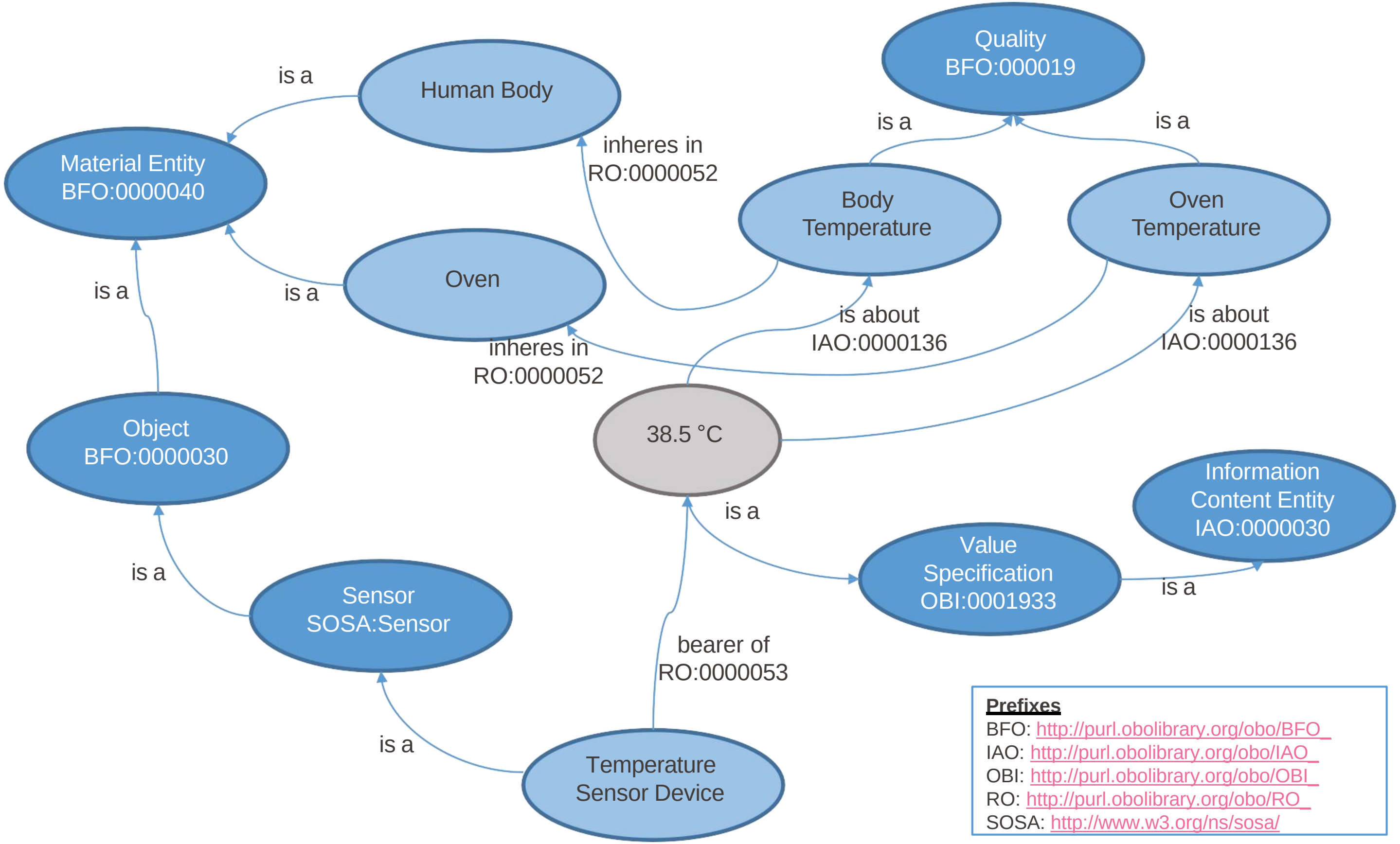
# The Meaning of Data is captured in *Ontologies*





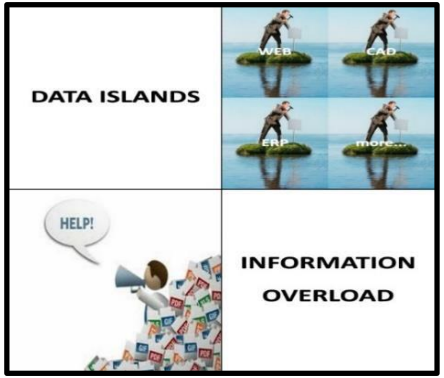

**Prefixes**
BFO: http://purl.obolibrary.org/obo/BFO_
IAO: http://purl.obolibrary.org/obo/IAO_
OBI: http://purl.obolibrary.org/obo/OBI_
RO: http://purl.obolibrary.org/obo/RO_
SOSA: http://www.w3.org/ns/sosa/

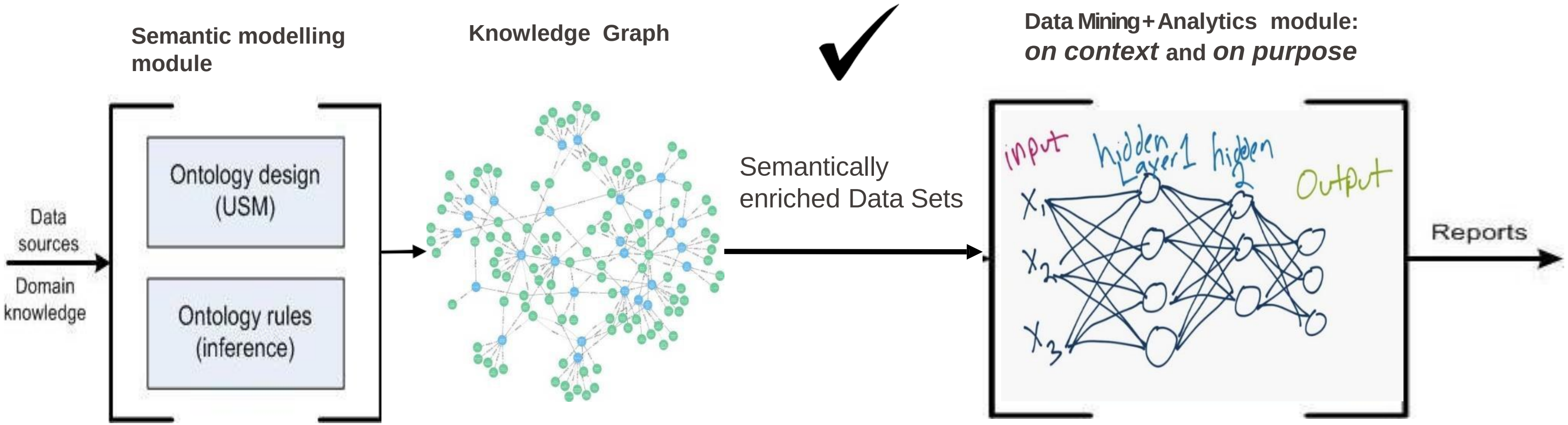
# Ontologies & Big Data



➢Scattered data in several sources, systems and services

➢Different actors with multidisciplinary skills



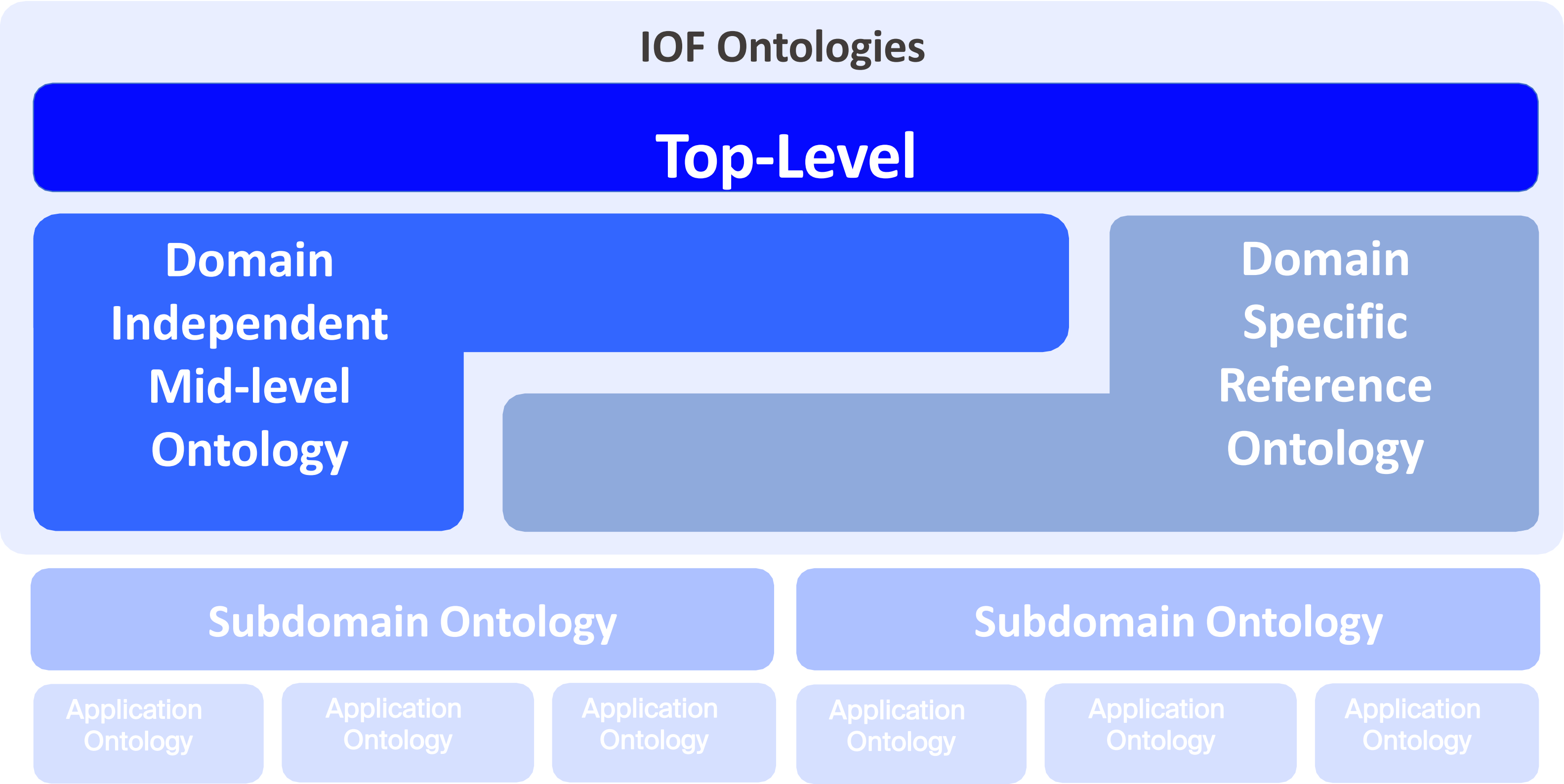
# Industrial Ontologies Foundry (IOF)



D. Kiritsis

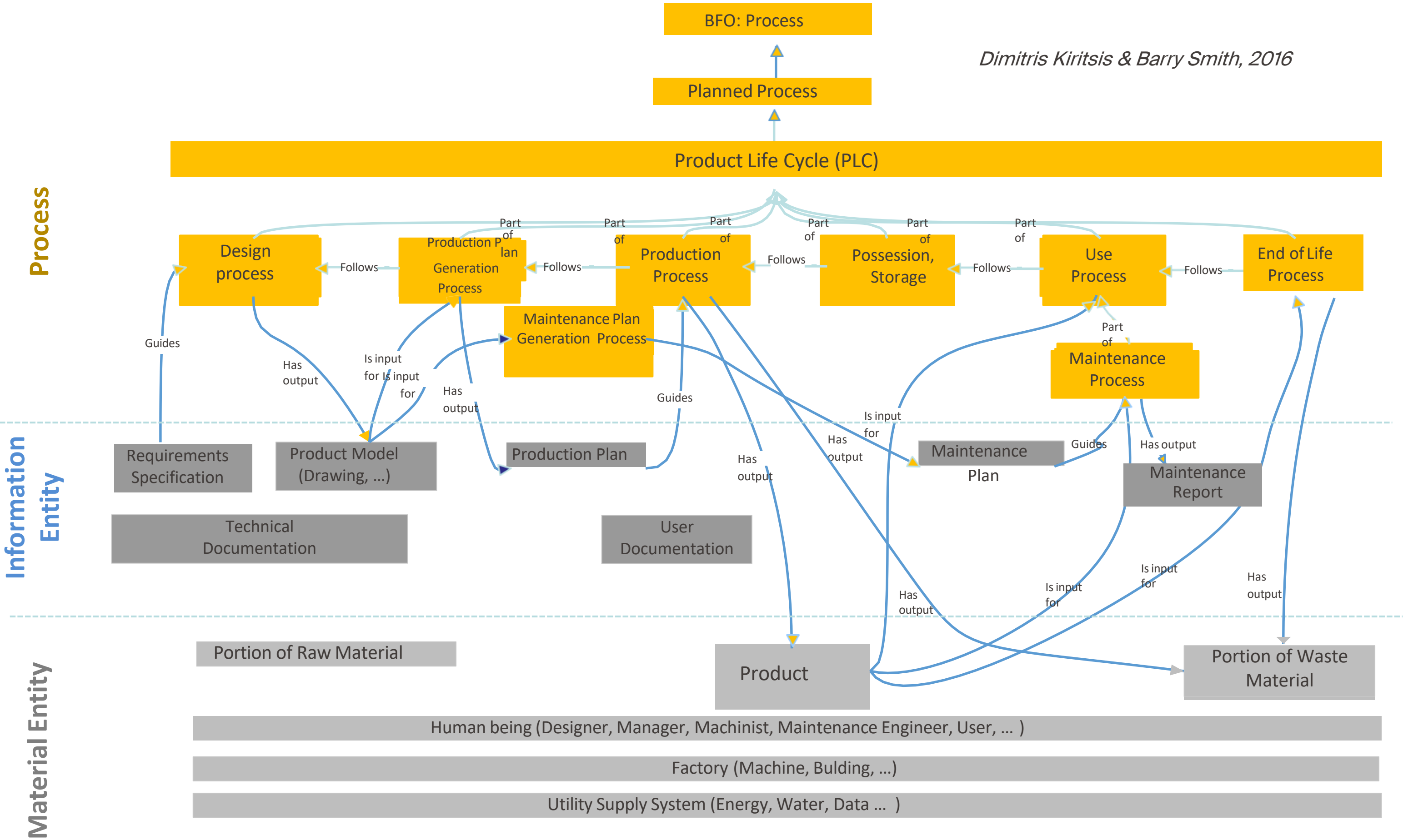
IOF as a source of principles and guidelines for Ontology **Design**, **Development** and **Use**

https://www.industrialontologies.org/



# Sketch of a Product Life Cycle Ontology Framework

*Dimitris Kiritsis & Barry Smith, 2016*




https://content.iospress.com/articles/applied-ontology/ao190210

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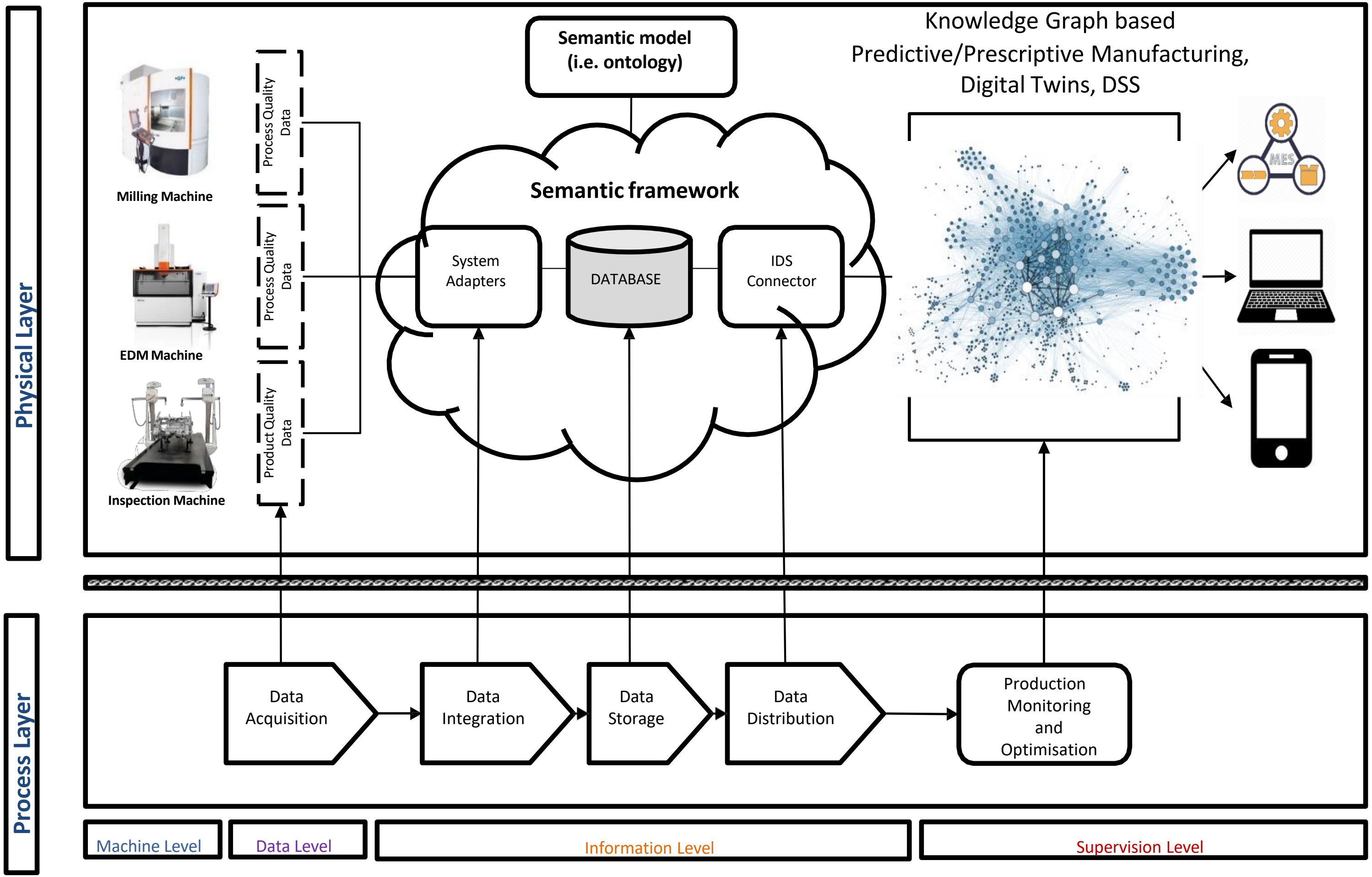
# Predictive Manufacturing Framework




D. Kiritsis

Z-BRE4K

Boost 4.0 BIG DATA FOR FACTORIES

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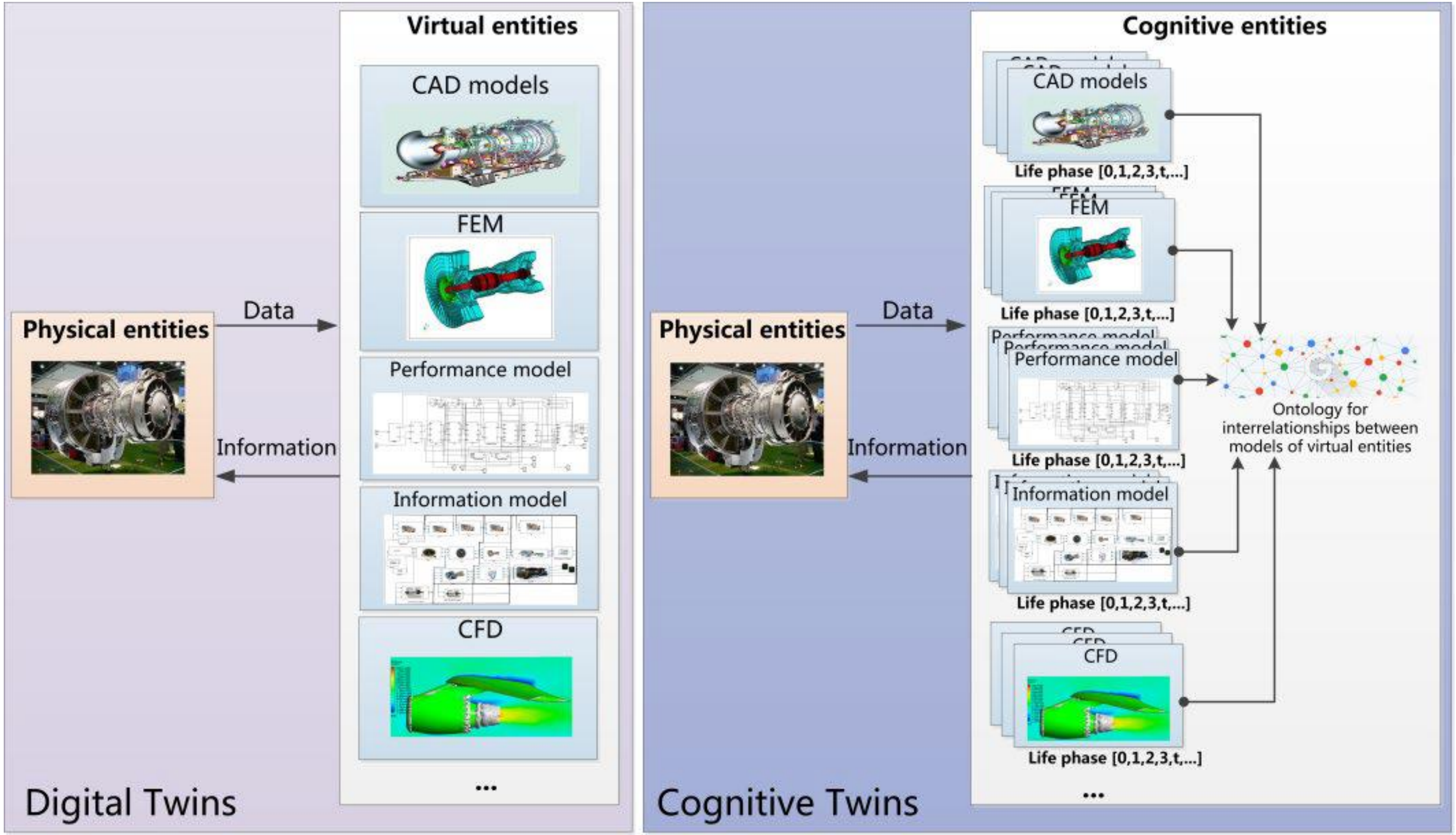
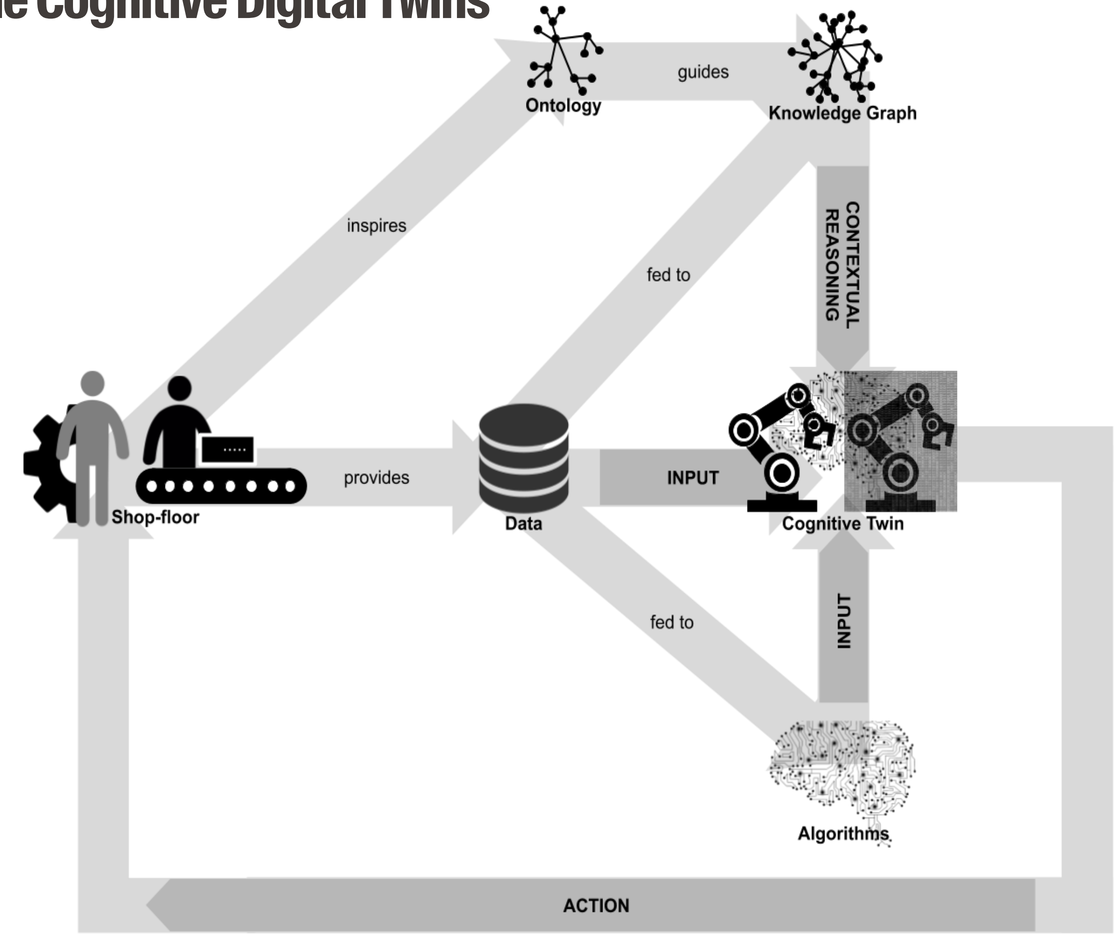
# Cognitive Twins – vs - Digital Twins




https://arxiv.org/ftp/arxiv/papers/1912/1912.08547.pdf

# Actionable Cognitive Digital Twins






http://ceur-ws.org/Vol-2615/

# *Thank you for your attention!*

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