The Whole Plant Digital Twin: What Can Semantic Technologies Contribute?

Advances in Process Automation and Control

Manchester

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SIRIUS: A Centre for Research-Driven Innovation

8 years
14 partners
3 universities
2 institutes
20+ PhD
45 + workers

Academia

UiO : University of Oslo

University of Oxford Department of Computer Science

NTNU Norwegian University of Science and Technology

simula

SINTEF

Industrial end-users

Schlumberger

equinor

TechnipFMC

aibel

AkerSolutions

DNV·GL

IT Vendors

KADME Knowledge and data management expertise

OSIsoft.

SAP

IBM

computas

Evry

Dolphin

NUMASCALE BIGGER DATA ANALYTICS

Scalable Data Access in the Oil & Gas Domain

We have lots of data

We have unprecedented processing capability

Why is it so hard to get access to the data we need?

Industrial Digital Transformation		Empirical studies of industrial data projects: Best practices
Analysis of Complex Systems		Simulation and optimization of complex systems: ABS simulator
Data Science		Domain-adapted data science and language processing
Ontology Engineering		Making ontology usable by non-specialists: OTTR templates
Semantic Integration		Robust semantic databases and data access: RDFox & OBDA
Scalable Computing		Cloud, architecture and HPC interconnects: Melodic + hardware

Applied to beacons that address industry needs

Geological Assistant

Integrated Digital Planning

Subsurface Data Access & Analytics

Digital Twins

Digital Field & Reservoir Management

Digital Field Development

Personalized Medicine

Environmental Applications

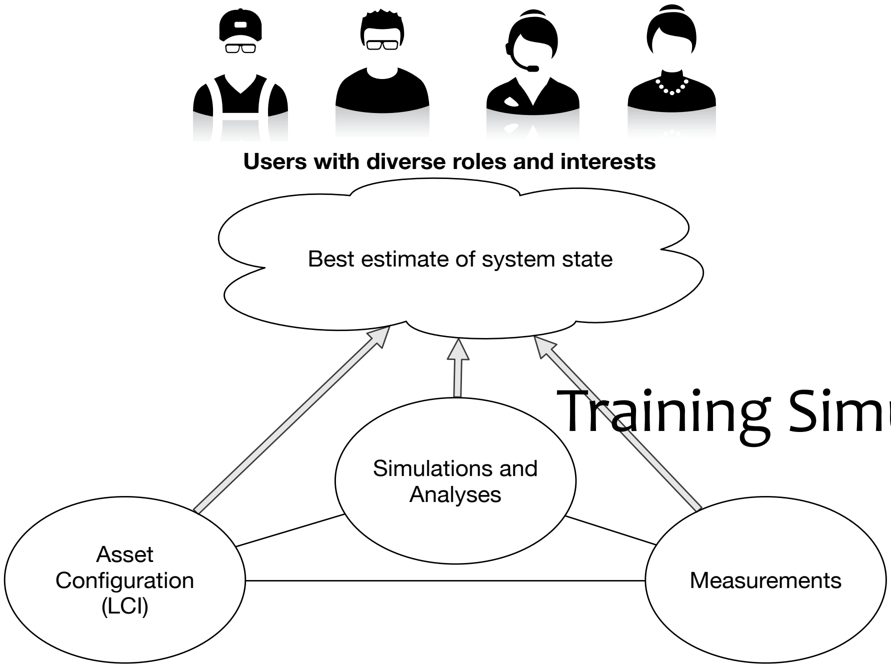
The hype of digital twins

What is a digital twin?

"An integrated multi-physics, multi-scale, probabilistic simulation of an as-built system, … that uses the best available models, sensor information, and input data to mirror and predict activities/performance over the life of its corresponding physical twin."

www.dau.mil/glossary/pages/3386.aspx

A conceptual framework for twins

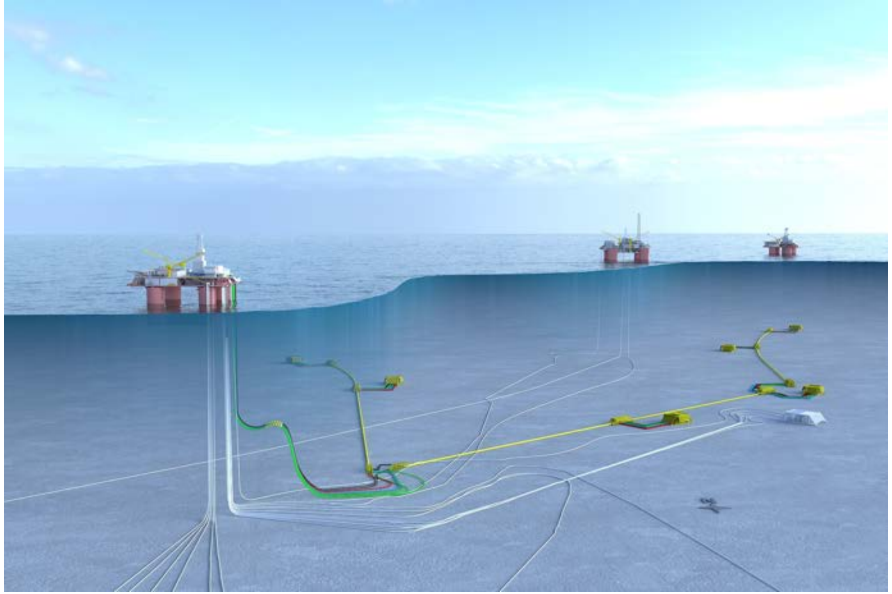


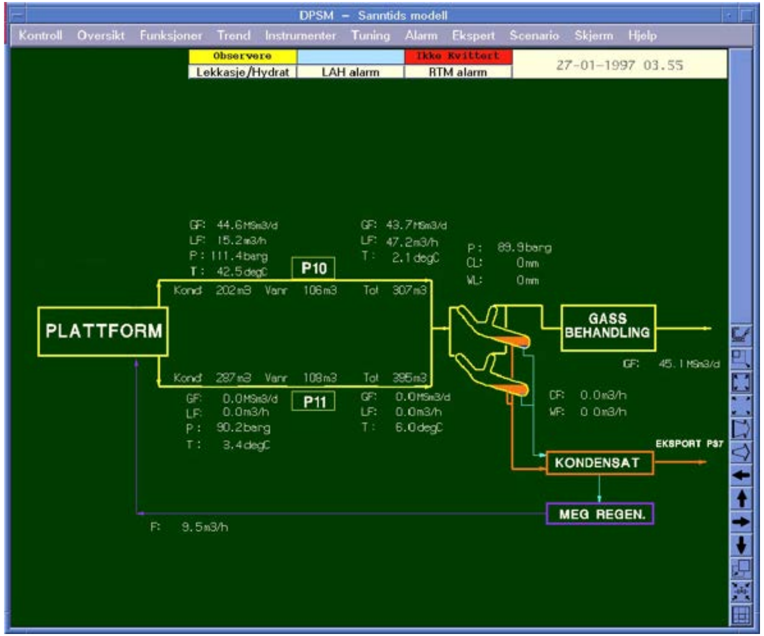
Training Simulator

3D viewer

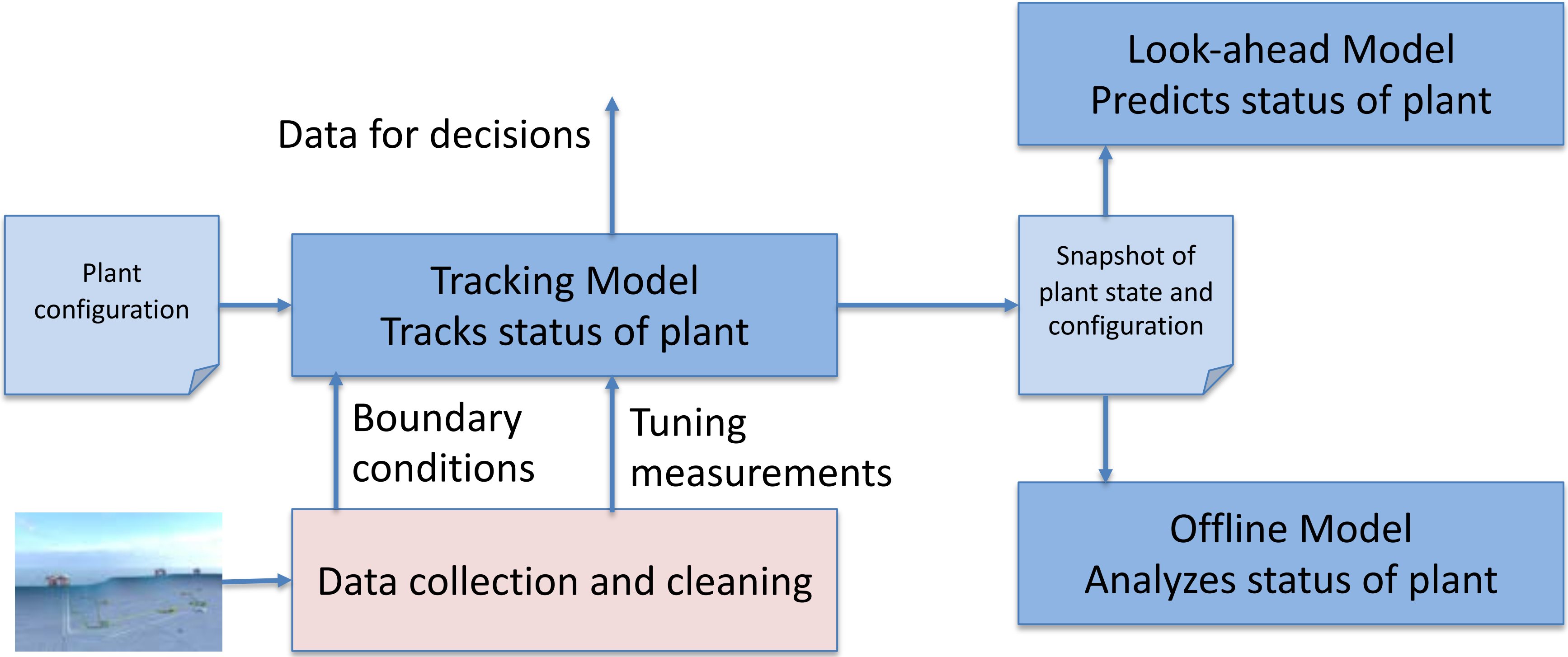
Glorified SCADA

A digital twin success story: on-line flow assurance





How a simulation digital twin works



Our current generation of twins

Demands

from regulators

from company

from partners

Operating procedures

Operations and optimization

Requirements

Digital twin

Design

Design basis

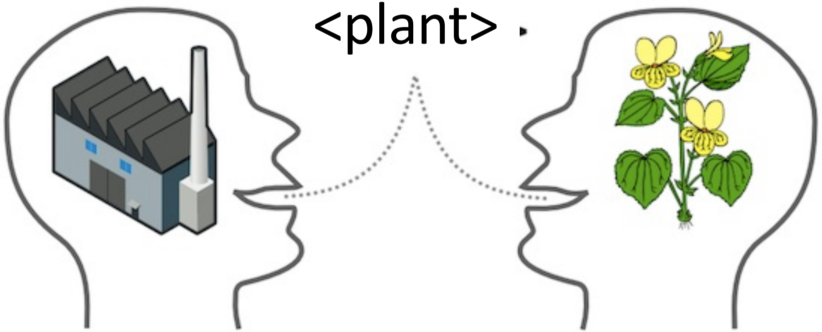
Construction and commissioning

As built

Facility

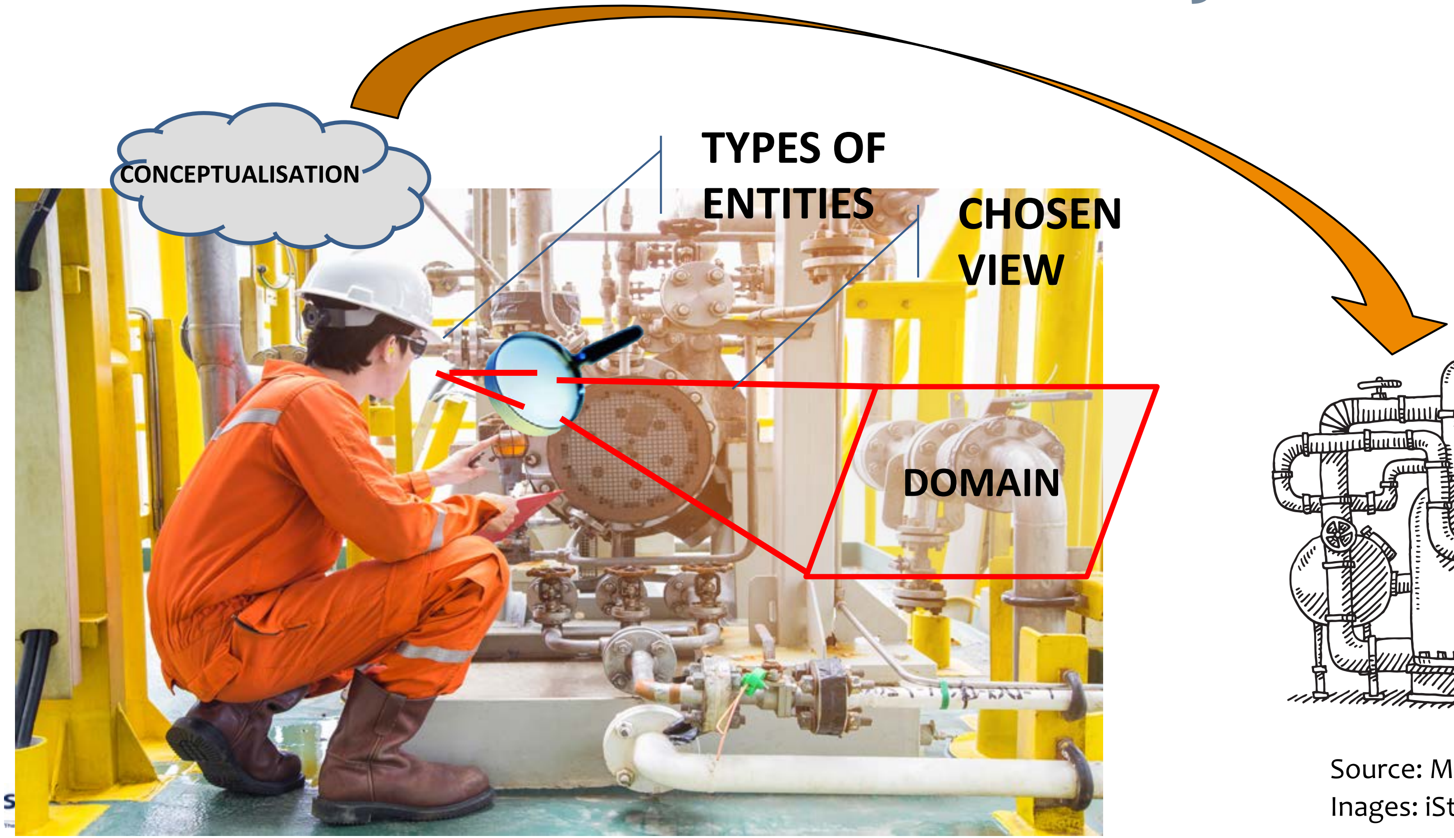
Semantics

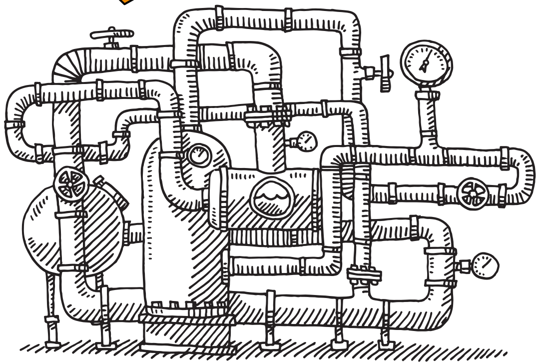
- Describes the significance of a language
- Discusses the relations between signifiers: words, phrases, signs and symbols, and how they relate to reality.



Source: Mara Abel, UFGRS

Semantics in software systems





Source: Mara Abel, UFGRS
Inages: iStock.

Knowledge Representation

- Create an vocabulary
  - Geosciences
  - Standards and requirements
  - Process plants
  - Piping
- Define relationships between things:
  - Geosciences: Sandstone A - is constituted of - Upper Jurassic Sand
  - Requirements: Chemical Injection Valve – is documented in – product data sheet
  - Process equipment: Butterfly valve – sub-class of – Valve
  - Piping: Flange ACME 66 NPS 1 CL150 – has pressure rating – CL150
- Represent as computable logical statements
  - Using a tool like Protégé and a triple-store database
  - This is hard.
  - We are developing **templates** that:
    - Avoid tedious repetition.
    - Support tabular data entry
    - Allow engineers to write knowledge models

Perfect or pragmatic?

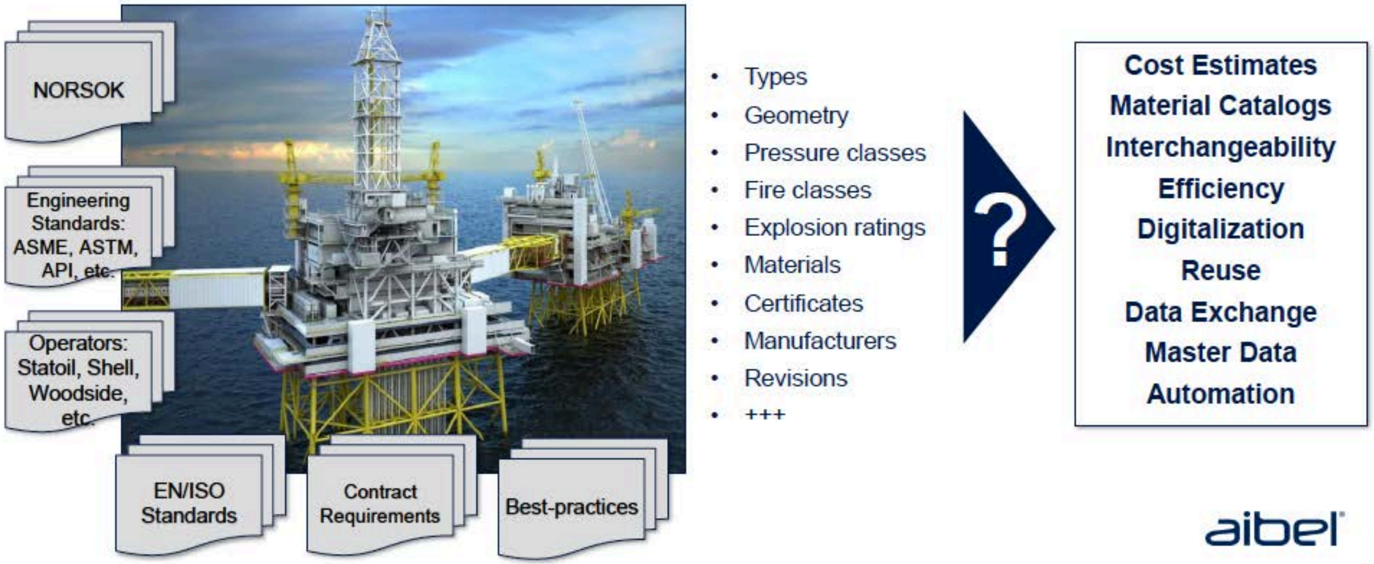
Reuse standards!

Triples!

Without a PhD in computer science!

Aibel's challenge

Managing Complex Requirements

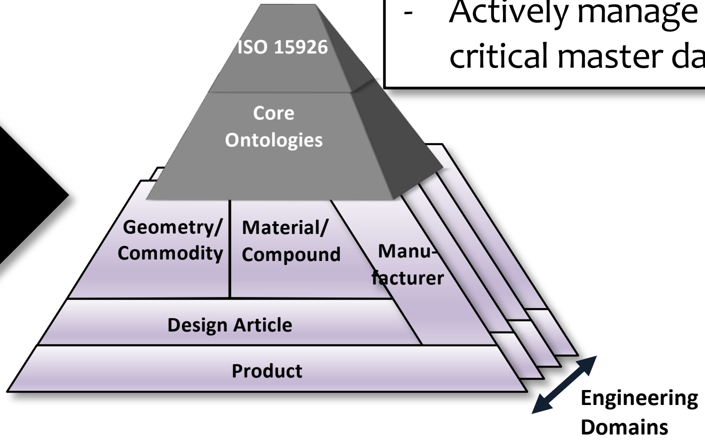


Source: Christian M. Hansen, Aibel

Material Master Data (MMD) for Piping Systems

Benefits:
- Efficiently create more accurate material catalogs
- Eliminate type duplicates
- Actively manage business-critical master data

Axioms	1.840.769
Logical axioms	535.512
Declaration axioms	106.674
Class count	98.133
Object property count	135
Data property count	723
Individual count	20.412
SubClassOf	505.376
EquivalentClasses	745
DisjointClasses	27
AnnotationAssertion	1.198.266



- Represent the contents of documents as an *ontology*
  - PDF documents: Engineering standards, client specifications
- Hierarchy of types and requirements for type membership
- Make explicit the *meaning* of document contents
  - Available to both humans and computers

Ambitions for digitized requirements

- Requirements both machine- and human-readable
- Better verification of requirements
- Easy discovery of inconsistent requirements
- Remove ambiguity in requirements
- Better searching to find requirements

The READI concept

Requirements

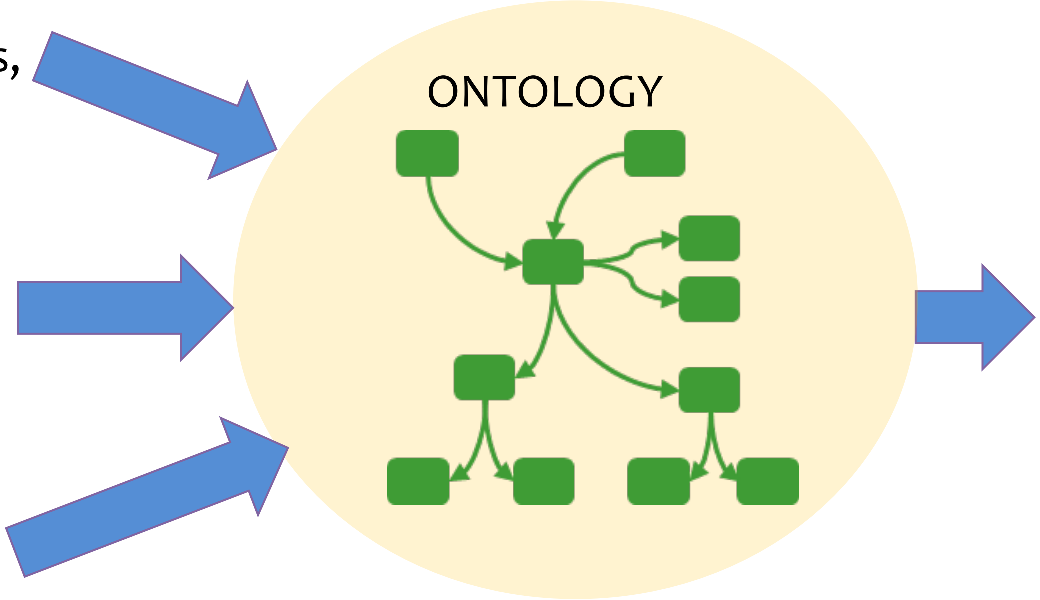
(Scope, conditions, demands)

Dictionaries

(Common terms and language)

Asset Model

(links to PDMS, SAP, COMOS…)



Browse

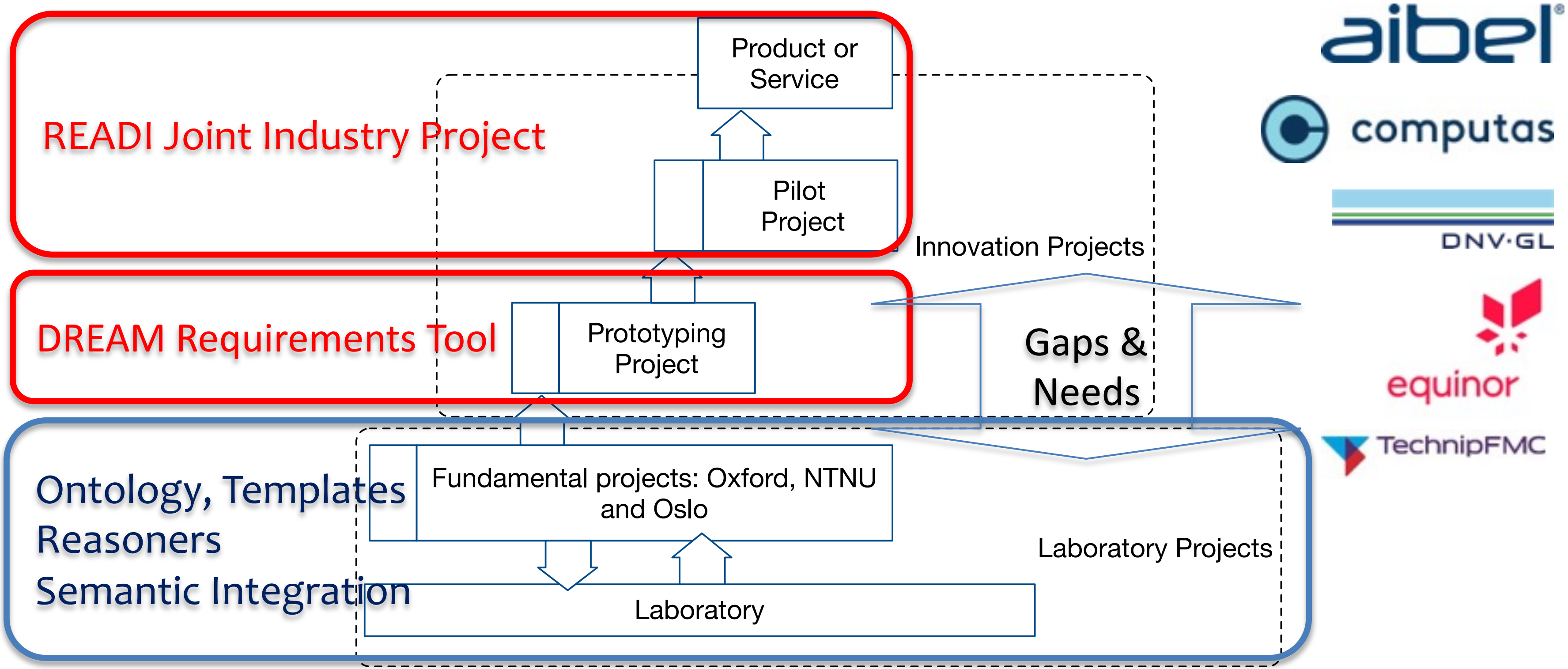
Report

Reason

Analyze

Verify

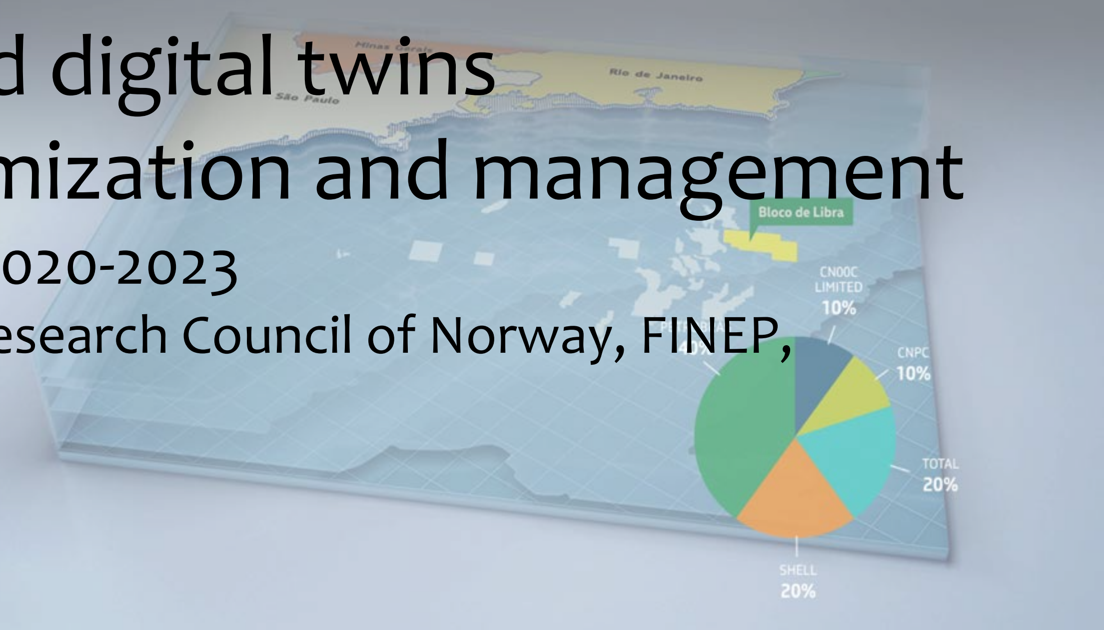
How the SIRIUS innovation model works



PeTWIN: Whole-field digital twins for production optimization and management

Petromaks/FINEP Project: 2020-2023

28M kr project sponsored by Research Council of Norway, FINEP, Equinor, Shell and Petrobras



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equinor

BR PETROBRAS

Finep FINANCIADORA DE INOVAÇÃO E PESQUISA

Impact of the PeTWIN project

From…	To…
Unclear and hyped	Robust, research-based best practice
Point-to-point, ad-hoc integration	Model-driven integration
Multiple applications in silos	Integrated applications
Vendor lock-in	Standards-based interoperability
Ad-hoc and manual change control	Lifecycle model for change control
DSML is hard to scale	DSML is automated and supported by models
Semantic models are hard to build	Engineers and geologists can build models
Separate user interfaces	Standard, semantic user interfaces
Integration in a data lake	Data is kept where it is most useful
On-site deployment	Best possible deployment
Small-scale academic projects	Realistic oil and gas systems.

A research program for digital twins

We have lots of data

We have unprecedented processing capability

Why is it so hard to get access to the data we need?

Industrial Digital Transformation		Empirical studies of digital twin projects – how to avoid failure
Analysis of Complex Systems		Design effective deployment of complex multi-cloud twins
Data Science		Combine text and structured data. Process legacy documents.
Ontology Engineering		Engineers build their own semantic models using familiar tools
Semantic Integration		Task-oriented data access, search and queries.
Scalable Computing		It runs fast, even though it is big and complex!

Thank You!

www.sirius-labs.no

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