Scalable, Useful and Maintainable Digital Twins:
Cross-Sector Experience from the Oil and Gas Sector

David Cameron
SIRIUS Centre for Scalable Data Access

ESTEP Workshop, Charleroi
21st November 2018
The SIRIUS Centre for Scalable Data Access

<table>
<thead>
<tr>
<th>Description</th>
<th>Details</th>
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<tr>
<td>Eight years’ financing from Norwegian Research Council</td>
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<td>13 Industrial Partners (11 in 2017)</td>
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<td>3 Leading Academic Institutions</td>
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<tr>
<td>Centre for Research-Based Innovation</td>
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<td>Funding for 20 Ph.D. students</td>
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<td>Innovation through prototypes and pilots</td>
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<td>45 affiliated researchers</td>
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UiO: University of Oslo

NTNU

Simula

University of Oxford

DEPARTMENT OF COMPUTER SCIENCE
The hype of digital twins
The reality?
Why am I qualified to speak on this?

<table>
<thead>
<tr>
<th>Year</th>
<th>Experience and Accomplishments</th>
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<tr>
<td>1982</td>
<td>Chemical engineering and trainee in steel industry. Thesis on physical properties of oil and CO₂</td>
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<td>1986</td>
<td>Blast furnace simulation and on-line systems. New steel technologies.</td>
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<td>1988</td>
<td>Dynamic data reconciliation using process simulators. Apply Kalman filters to chemical processes.</td>
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<td>1993</td>
<td>Simulation and optimization of fertilizer, chemical and petroleum plants.</td>
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<tr>
<td>2007</td>
<td>Virtual flow metering and on-line systems for complex subsea plants.</td>
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<tr>
<td>2011</td>
<td>Technical and business consultancy in chemicals and petroleum</td>
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<tr>
<td>2013</td>
<td>Business development in petroleum, energy &amp; industrial sector</td>
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<tr>
<td>2015</td>
<td>Centre for Scalable Data Access. Research entrepreneur and translator between business and academics</td>
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Parallels between oil and gas and steel

Upstream

- NG
- LNG
- LPG
- Condensate
- Crude

Downstream

- Slab
- Bloom
- Billet
- Rod

Wide variety of products with tight quality constraints and specifications
What is a digital twin?

“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

Users with diverse roles and interests

Best estimate of system state

Simulations and Analyses

Asset Configuration (LCI)

Measurements
Oil and gas assets
The oil and gas asset life-cycle

The sub-surface (underground) lifecycle: > 80% of capital cost

Seismic Evaluation → Exploration Drilling → Production Drilling, Well Workovers, Interventions

The production facility lifecycle: < 20% of capital cost

Concept Evaluation → FEED → EPC → Commissioning → Operation and Modifications

2-6 years → 5-50 years

Design basis

Operational data

Alphabet soup:
• EPC: Engineering, Procurement and Construction
• FEED: Front-end Engineering and Design

> 80% of capital cost

< 20% of capital cost

2-6 years

5-50 years
A digital twin success story: on-line flow assurance
How the flow assurance digital twin works

- **Plant configuration**
  - **Data collection and cleaning**
    - **Boundary conditions**
    - **Tuning measurements**
  - **Tracking Model**
    - Tracks status of plant
  - **Offline Model**
    - Analyzes status of plant
  - **Look-ahead Model**
    - Predicts status of plant

Data for decisions
Current and planned twin applications

• Established practice
  – Flow assurance twins
  – High-quality visualization of operational data with 3-D model of facility

• Commercial but novel
  – On-line top-side operations simulators for prediction and data reconciliation
  – Structural and other special-purpose twins

• Future
  – Whole field twin: reservoir, flow assurance and top-side in interaction
  – Integrated twin along asset lifecycle and product lifecycle
Challenges to be addressed

Business Models, Security and Confidentiality

Work practices

Scope

Usability

Integration

Maintenance

Computational overload: edge and cloud

Uncertainty, validation and data science
Business models, security and confidentiality

• An enabler of new business models?
  – New ways of procurement, engineering and operations.
  – Challenges are commercial and contractual.

• Security and confidentiality
  – Twins bring together all data: access by role
  – Securing applications that are connected to the Internet by a wide variety of not-very-smart devices.
  – Sharing data and sharing rewards, while not running a cartel
Work practices

• Tangible and measurable benefits to managers, engineers and operators.
• Safety and availability are paramount.
• A help, not a hindrance.
Scope

• If you try to do everything, you will do nothing well.
• Just enough functionality: Shell’s ALOS: Appropriate Level of Smartness
• Support different granularities and time constants:
  – Compressor (ms), pipes and wells (days), reservoir (weeks).
Usability

• All data is available!
• But I have to wade through huge amounts of irrelevant data.
• How can I filter down to the data I need for my job?
  – Superintendent, operator, process engineer, electrical engineer...
Integration

• How do we avoid the “point-to-point” nightmare?
• Everybody has a platform, with the aim of being the master.
• A digital twin must integrated multiple platforms and legacy sources.
Maintenance

• Need simple tools to build and configure digital twins.
• Need to maintain the system through the life of the asset: planned modifications and maintenance
• Easy to justify for a blower, but harder to justify for a software system?
Computational overload: edge and cloud

- Large systems, complex models and optimization = large resources
- Implemented in a hybrid, heterogeneous cloud
- Implementation needs to be designed
Uncertainty, validation and data science

• Measurements and models are both wrong
• ... And the plant can malfunction too
• Models must be tuned to follow the facility
  – Parameter estimation
• Measurements must be validated and reconciled
• Fruitful area for data science:
  – When combined with the physical models that constrain reality
A research program for digital twins

Pilot Projects with Oil Companies, EPC and Vendors

Gaps and needs

Research and Prototyping Projects

Semantic backbone

Simulation of cloud deployment

Use of unstructured data

Support for data science work flows

Faceted user interfaces

Standardization of semantics & interfaces

Use of streaming data from sensors

Hybrid analytics

Research Solutions