Digitalisation @ Kvaerner – adapting to a new landscape

Jan 2020

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Kvaerner at a glance

The Jackets yard at Verdal

Sverdrup ULQ being built at Stord

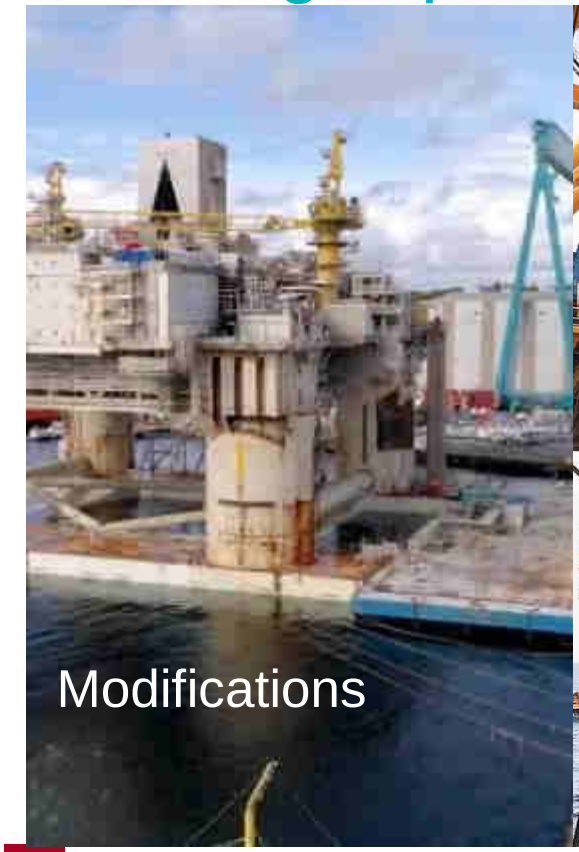
Njord platform retrofit

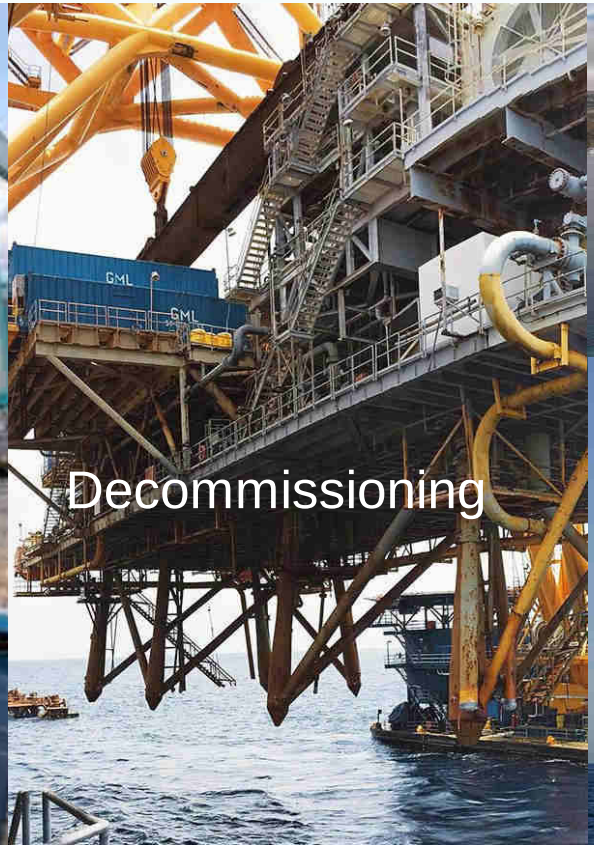
Tow-out of the Hebron platform

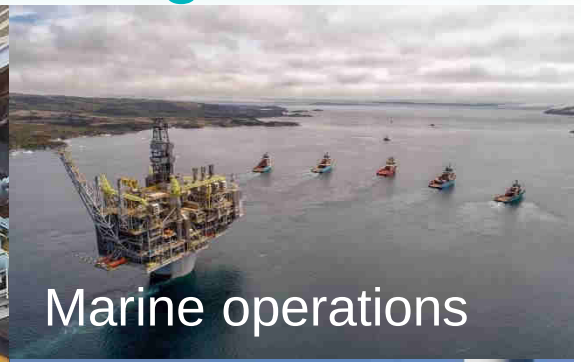
The new landscape

The core NCS market is changing…

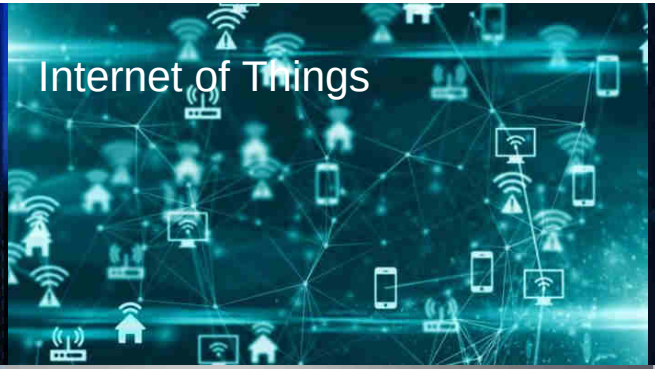
…driving expansion in other market segments

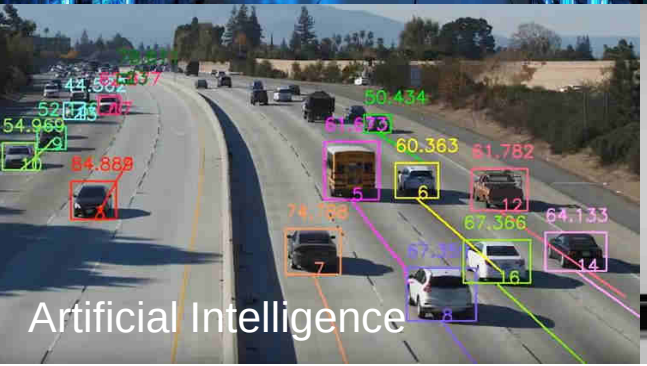






Technology developments afford new opportunities

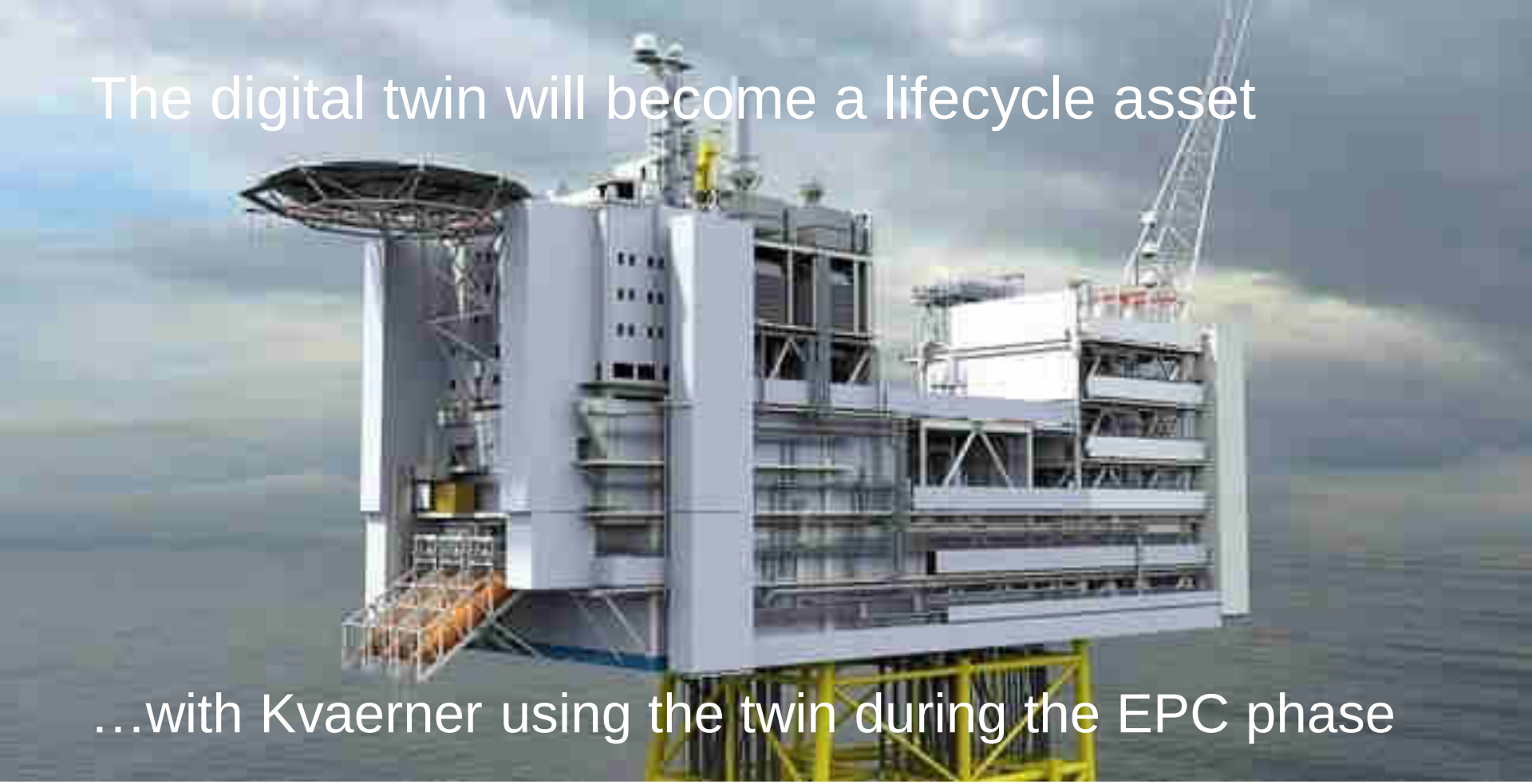




Core beliefs about digital EPCI

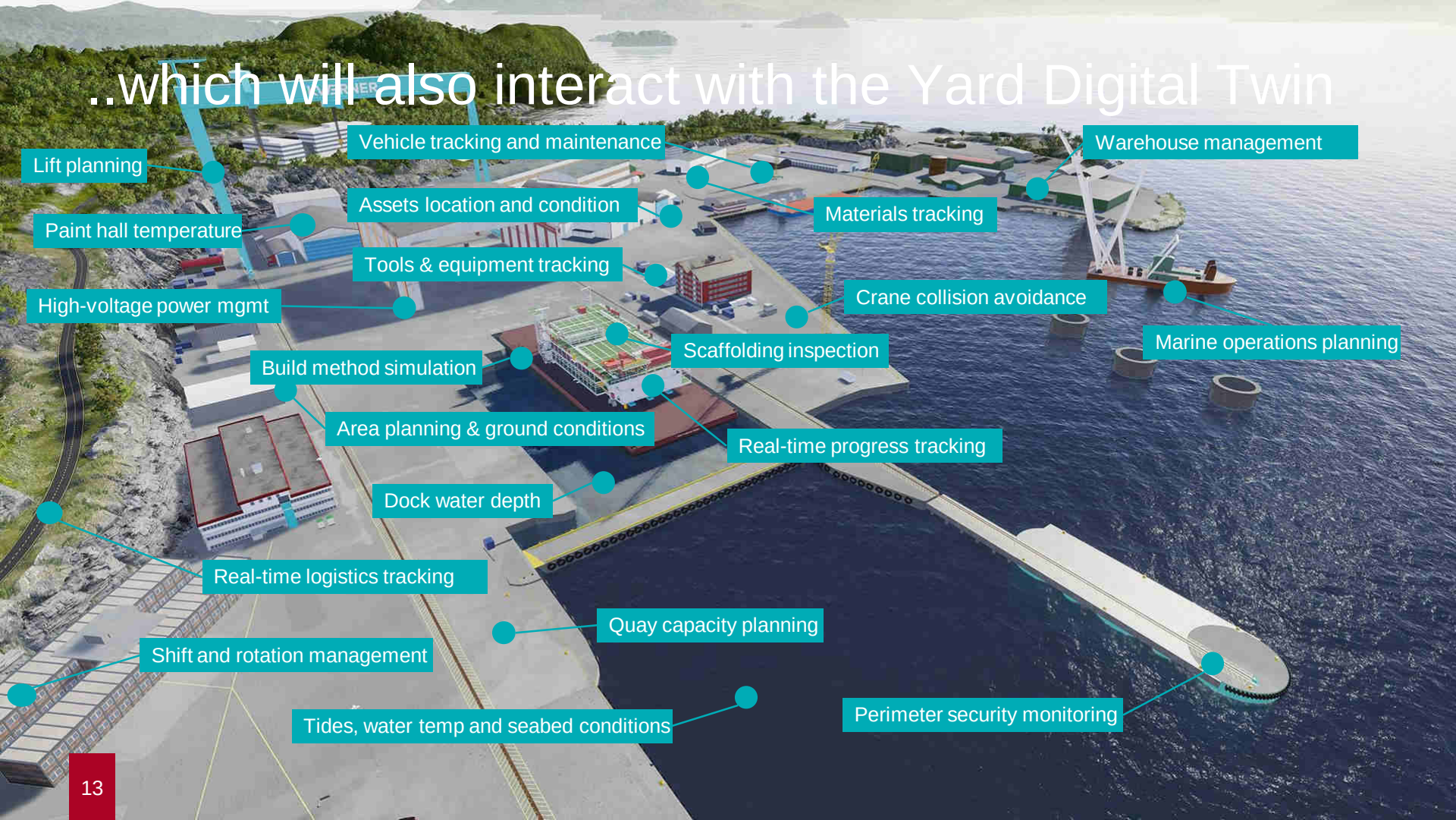
How digital will shape EPCI	Implications for Kvaerner
1 The digital twin will be the central asset	Build capability to interact with any Digital Twin, including interaction with our Yard Digital Twins
2 The value chain will be digitally integrated	Build solutions around industry standards for seamless information exchange
3 All physical objects will be sensorised	Develop Yard Digital Twin, using the Cognite Data Platform, and a underlying multi-vendor sensor architecture
4 The workforce will be digital and mobile	Develop capability to deliver digital tool suite for all roles, and make tool set available to hired-ins, suppliers, partners
5 Analytics will drive efficiency	Make data available across enterprise, build data-driven culture, with analytics capabilities
6 Automation will be prevalent	Invest selectively to increase productivity, and integrate data from new assets into Yard Digital Twin

The digital twin will become a lifecycle asset

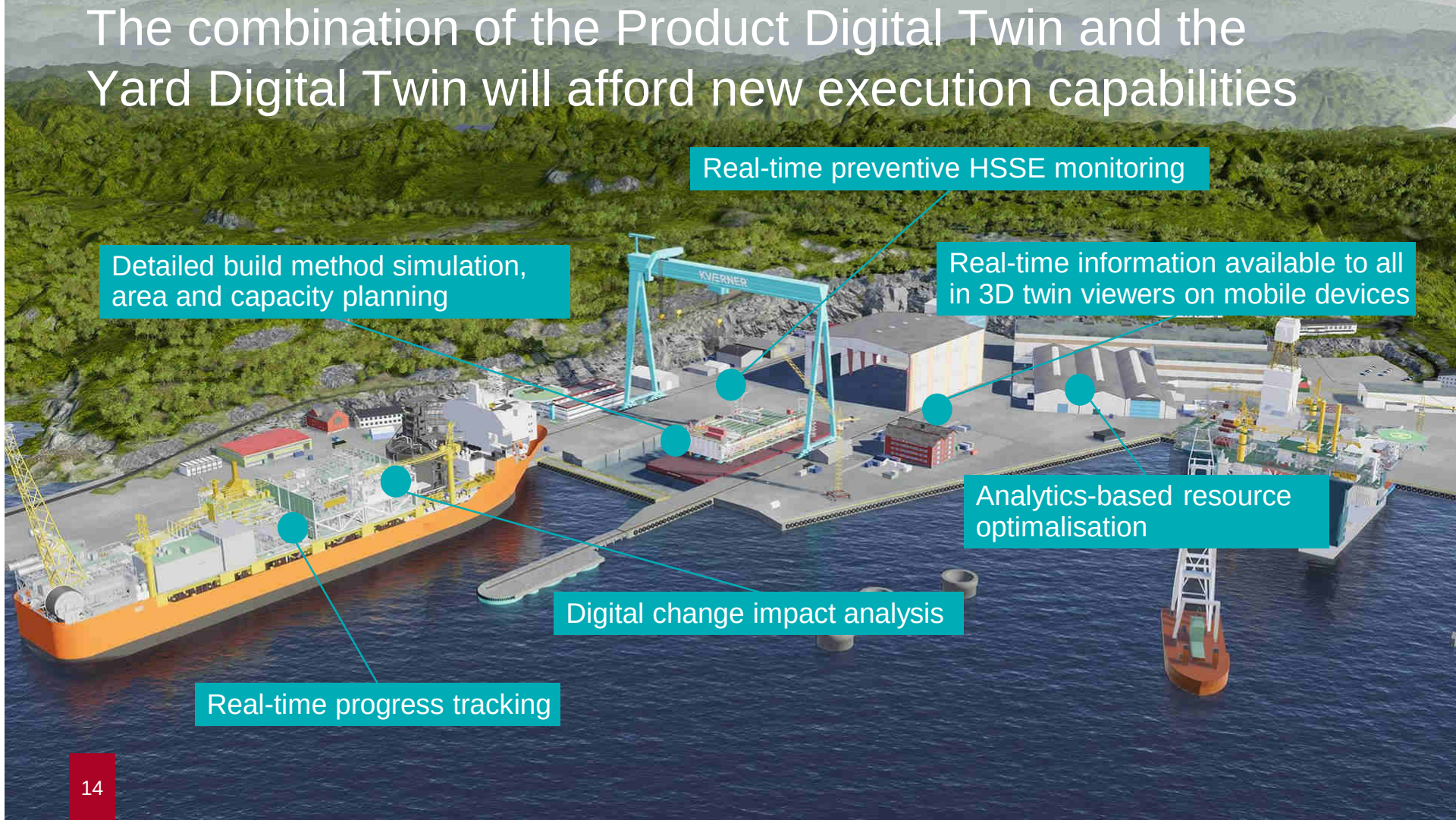


…with Kvaerner using the twin during the EPC phase

..which will also interact with the Yard Digital Twin

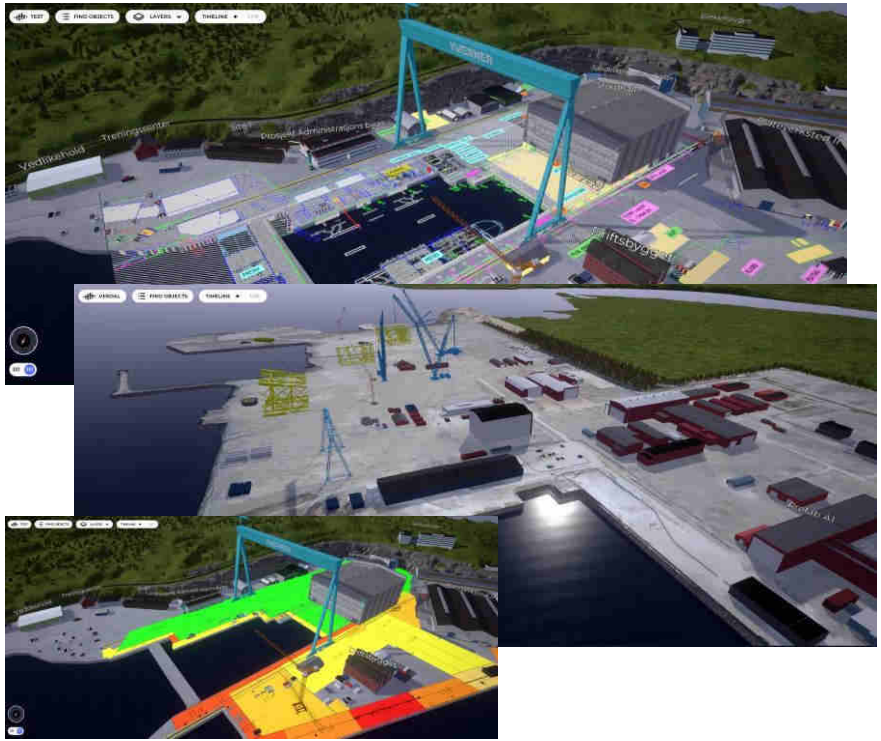


The combination of the Product Digital Twin and the Yard Digital Twin will afford new execution capabilities



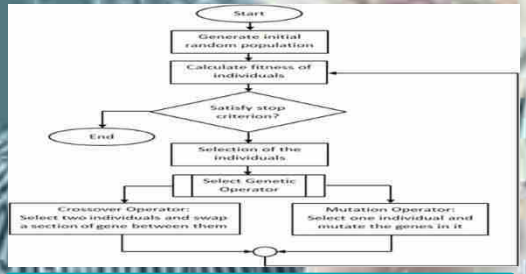
Yard Digital Twin viewer

- Available for Stord and Verdal yards
- Detailed 3D models of assets, with clickable objects with operational documentation and certificates
- Layers
  - Area plans, coupled to schedule
  - Ground pressure limits
  - Bollards
- Live sensor data
  - Position data for assets
  - Power and gas consumption
  - Temperatures



The EPC Information Worker – a new capability

Massive computing power



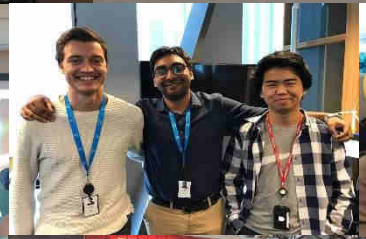
Algorithms

Very large data sets

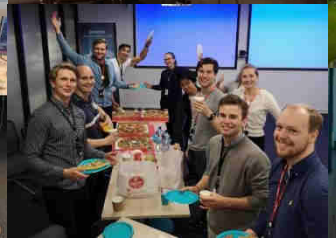








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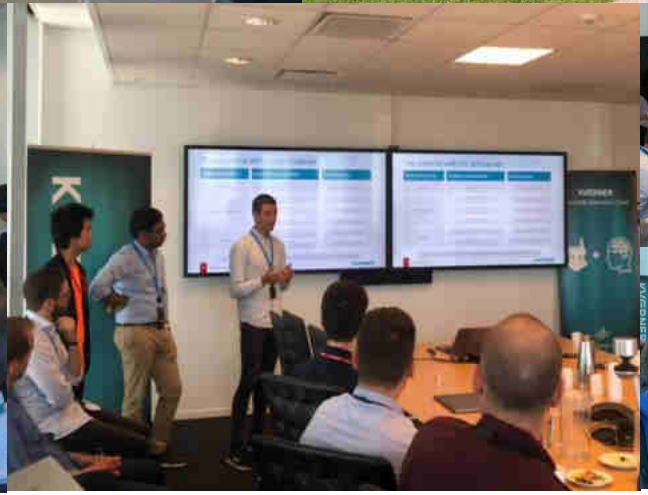


Cognite

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The process of digitalisation

Getting the process going

- Responsible EVP
- Steering group with executive mgmt

- Landscape overview
- Identify initiatives
- Cost/benefit analysis
- Sensitivity to project pipeline

- Programme manager
- Business owners
- IT organisation
- Reference groups

- DevOps development process
- Frequent releases
- Monthly steering group meetings
- Annual funding cycle
- Project funding when appropriate

Digitalisation roadmap, version 1.8

Automated Project Setup

- 1.1 Automated project setup

Automated Engineering

- 2.1 Jackets auto report generation
- 2.2 Jackets model integration
- R3 2.3 Automated jackets design
- 2.4 Auto fabrication engineering
- R3 2.6 Auto scaffolding design
- R3 2.7 Constructability

Digital Lifecycle Information

- 3.1 B2B collaboration platform
- R1 3.2 Project execution control
- 3.3 Next-generation MIPS

Digital Procurement

- 4.2 Supplier portal
- 4.3 Remote inspections

Digital Yard

- R4 5.1 Mobile construction workforce
- R2 5.2 HSSEQ app / Synergi
- R1 5.3 Connected yard (IoT)
- R2 5.4 Yard digital twin
- 5.5 Visual construction planning
- 5.6 Work force management

Robotics

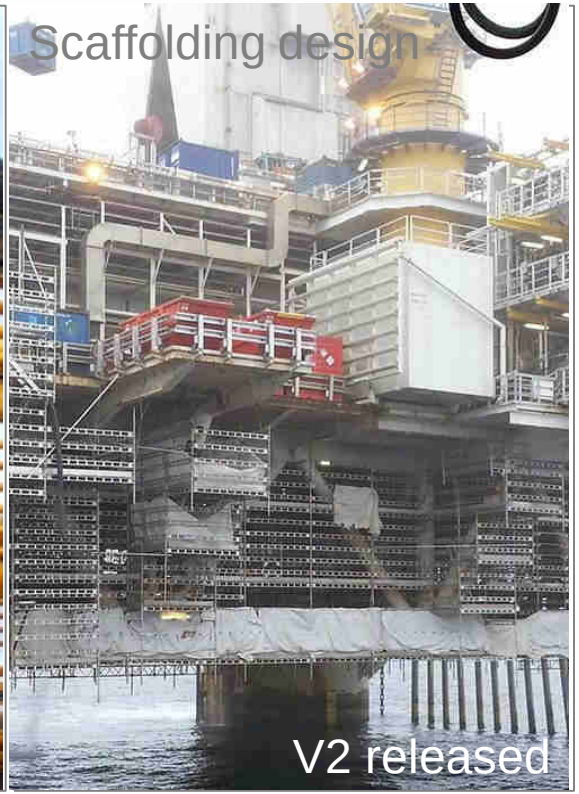
- 6.1 Yard robotisation team
- 6.2 High-priority robotics investments

Digital Project Management

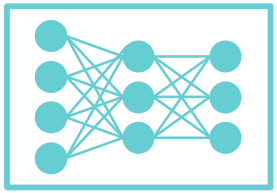
- R 2 7.1 Data warehouse platform
- R 2 7.2 EPC Dashboards
- 7.3 Analytics for decision support
- 7.4 Management system

Machine learning applications for EPC

Three machine learning applications

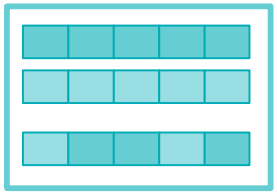


Bits and pieces from the toolbox



Neural networks

Using a set of training inputs and their known desired outputs, adjust the coefficients in a network of equations to maximise hit rate, and then apply the network on new data sets.



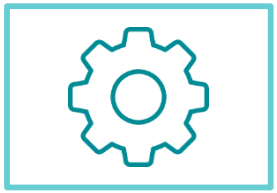
Genetic algorithms

Model the problem as a vector of values, and create a population of individs with semi-random parameter values. Create new generation of individs with better parameter values through cross-breding and mutation

$$\min \sum Wx$$
$$under\ Ax \leq b$$

Linear optimalisation

Define a quantity to be minimised or maximised, modelled as a sum of linear equations with constraints. For non-linear contraints, apply allowable transformations

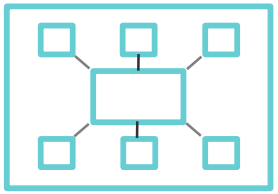


Rules engine

Define how to extract relevant information from the data to be processes. Define rules using an appropriate syntax, and use rules engine to apply rules to identify if and how to change the data.

Cloud-based compute

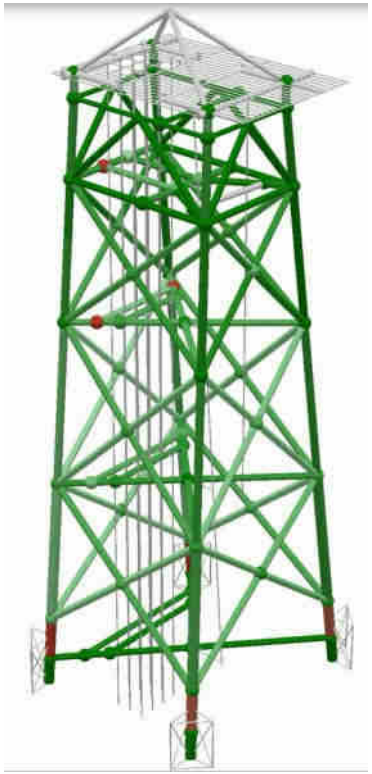
Azure Batch – based architecture for asynchrounous job execution, running appropriately sized VMs. Containerisation next.



Data warehouse

Contains data from Kvaerner's ERP system, currently at ~10^8 lines

Jackets design optimalisation



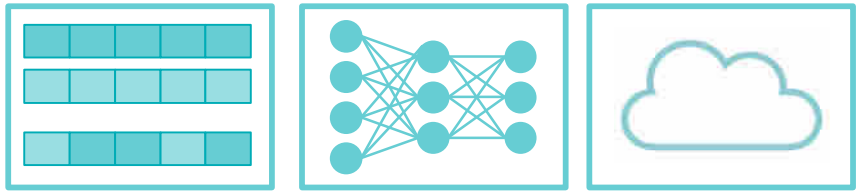
Capabilities

- Static and dynamic analyses
- Elevation and section optimalisation
- Brace addition and deletion
- Constructability rules taken into account
- User-tunable optimisation criteria
- Input parameter validation, report generation

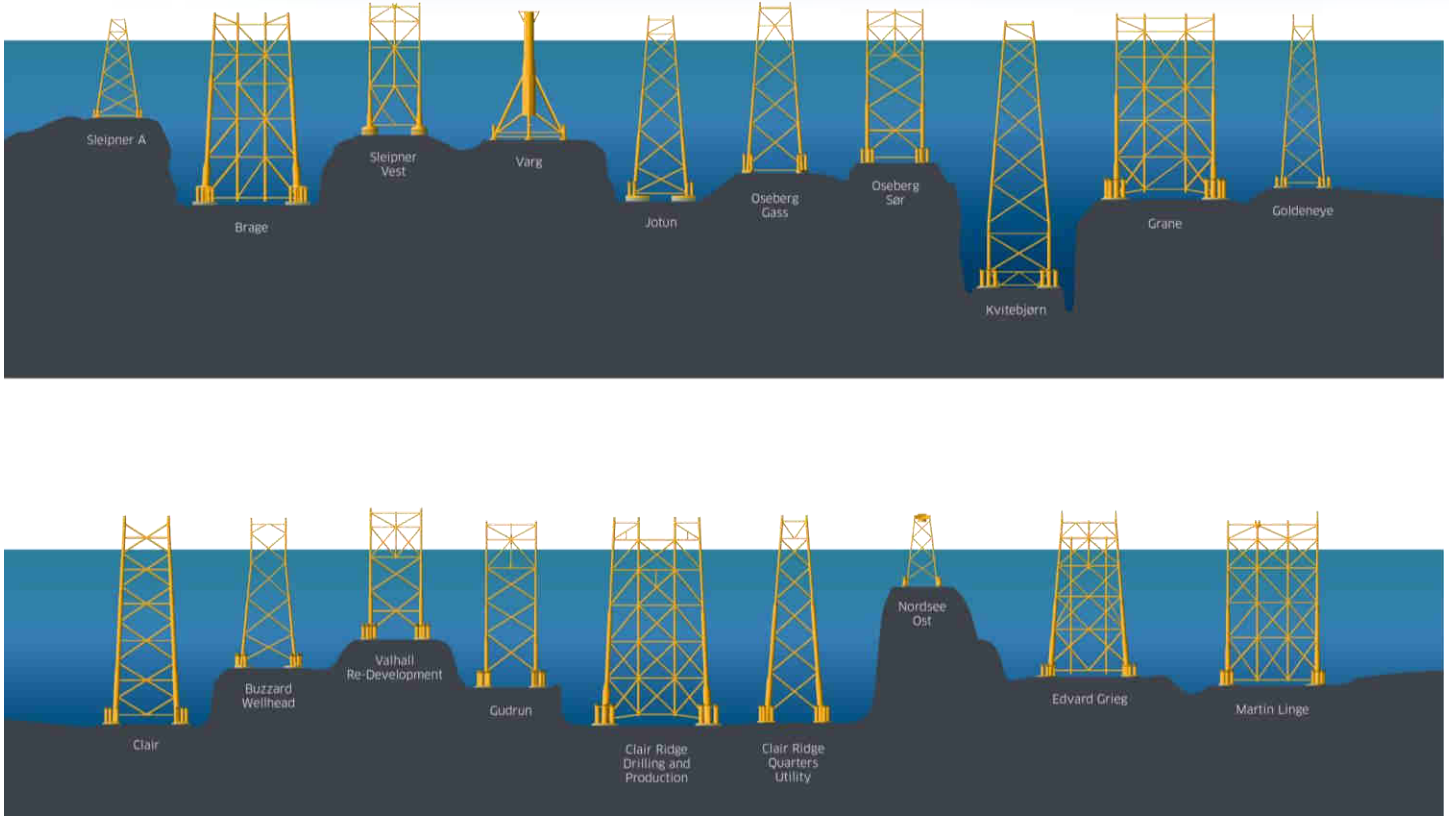
Benefits

- Rapid concept development
- Weight and construction optimisation

Technologies



Designs vary, but have patterns



How to design and build a Jacket

Input

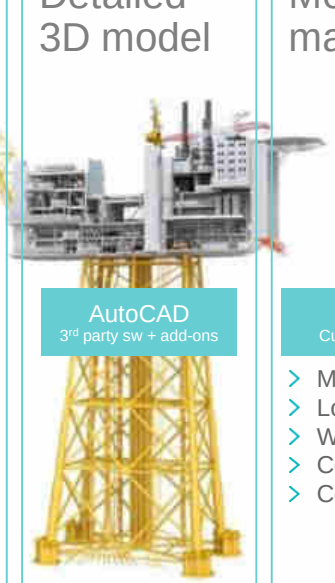
- Water depth
- Soil conditions
- Wave model
- Topsides weight & CG envelope
- Topsides interface
- Seabed interface
- Standards & regulations

Analysis

Sesam
3rd party software

- In-place
- Fatigue
- Seabed
- Ship collision
- Transport
- Launch/lift

Detailed 3D model



AutoCAD
3rd party sw + add-ons

Method and materials

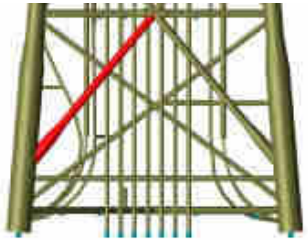
MIPS
Custom application

- Materials
- Logistics
- Work packages
- Completion
- Commissioning

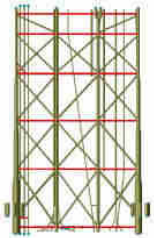
Output

- Analyses results
- Reports & docs
- Detailed 3D model
- CNC files
- Material lists
- Work packages
- Build method

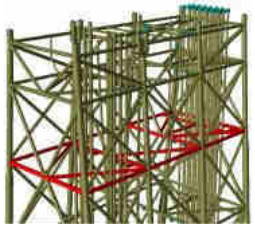
Jacket design topics



Brace placement



Elevation location



Elevation brace pattern

Joint optimalisation

Row bracing patterns

Global optimalisation

The claim

Use Algorithms and Massive Computing Power

to

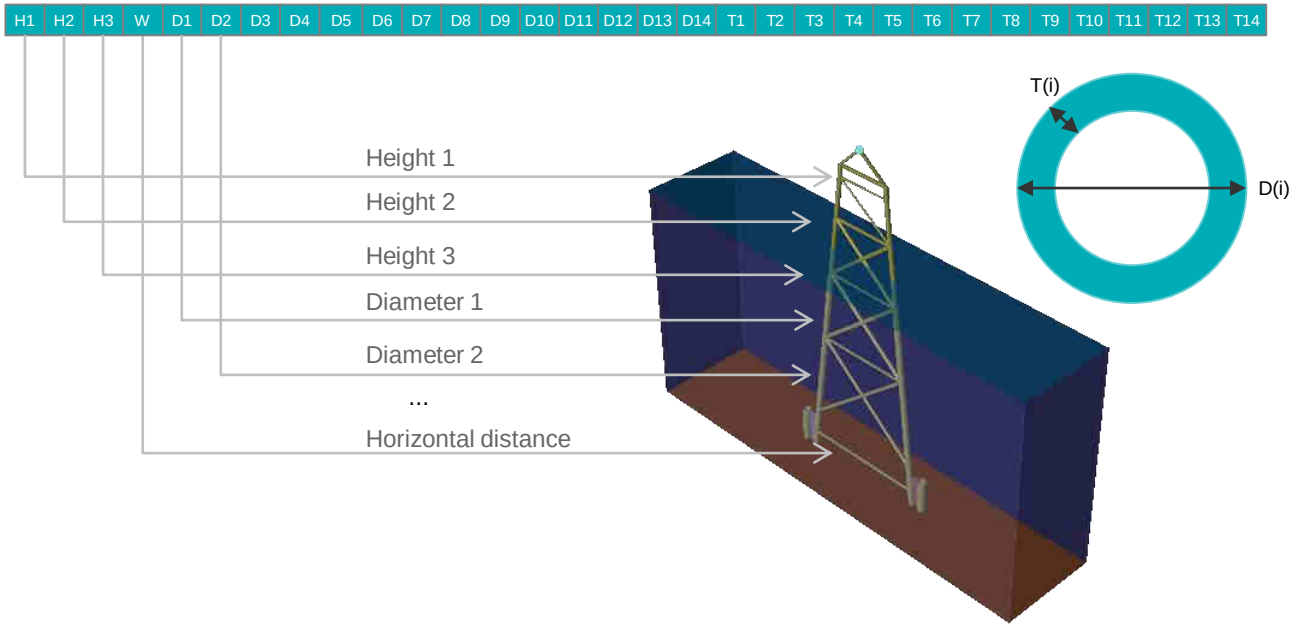
Generate and Analyse various Designs,

to

arrive at a Viable Solution quickly,

optimised for Weight and/or Cost and/or Build time

Model the problem



The complete model will have several thousand parameters

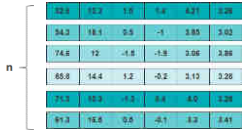
Add constraints and rules

- All utilisation factors must be < 1, and ideally around 0.85
- All angles must be > 40 degrees
- Force on piles must lie between 35 and 80 MN
- Member diameter must be > 16 * wall thickness
- Brace diameter must be < 0.95 * leg diameter
- Braces coming into a leg should be separated by 100 mm
- Leg diameters increase in 100mm steps
- Bracing diameters increase in 10 mm steps
- Wal thickness increase in 5 mm steps
- Cones must be placed beneath elevations
- Leg can diameter must equal diameter of leg above
- Inside diameter for cans on braces must match inside diameter of braces
- Bottom leg sections must widen to increase buoyancy
- Legs should be splayed to allow pile insertion

Find a quantitative fitness measure of any given design

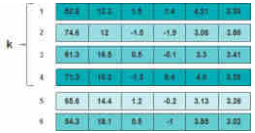
Run and tune a suitable algorithm

Establish the initial population

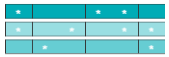


Run analysis and evaluate results

Rank the results and select winners



Adjust the parameters in a smart way



Breed the next generation

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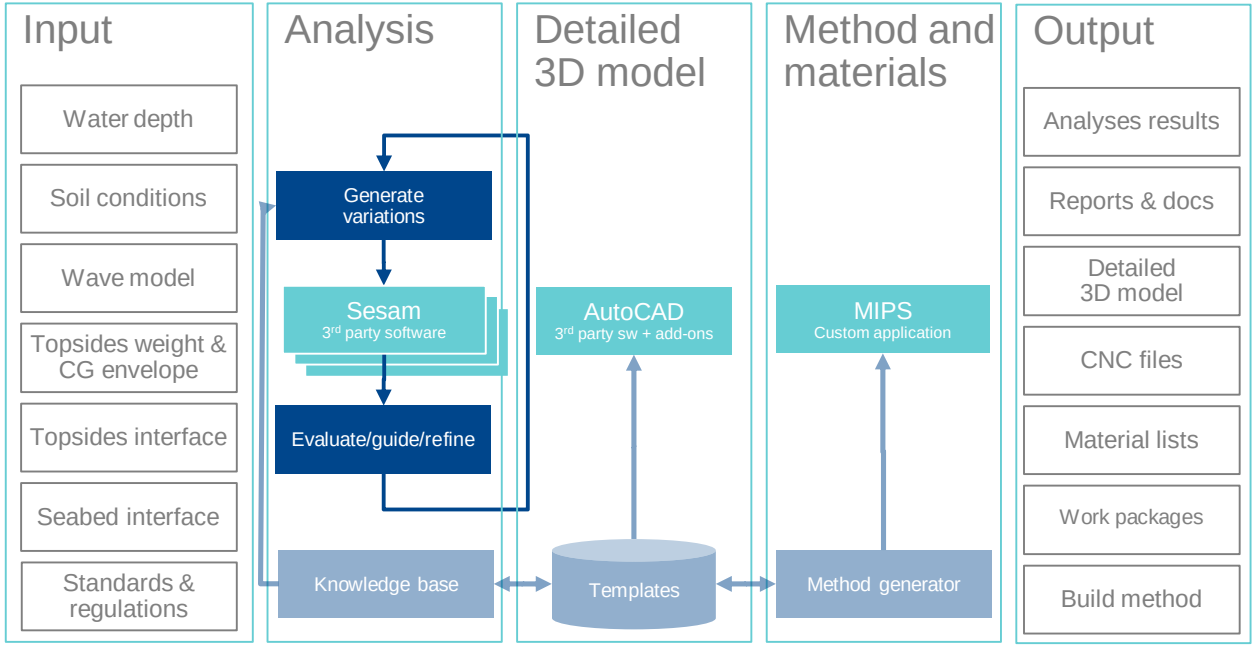
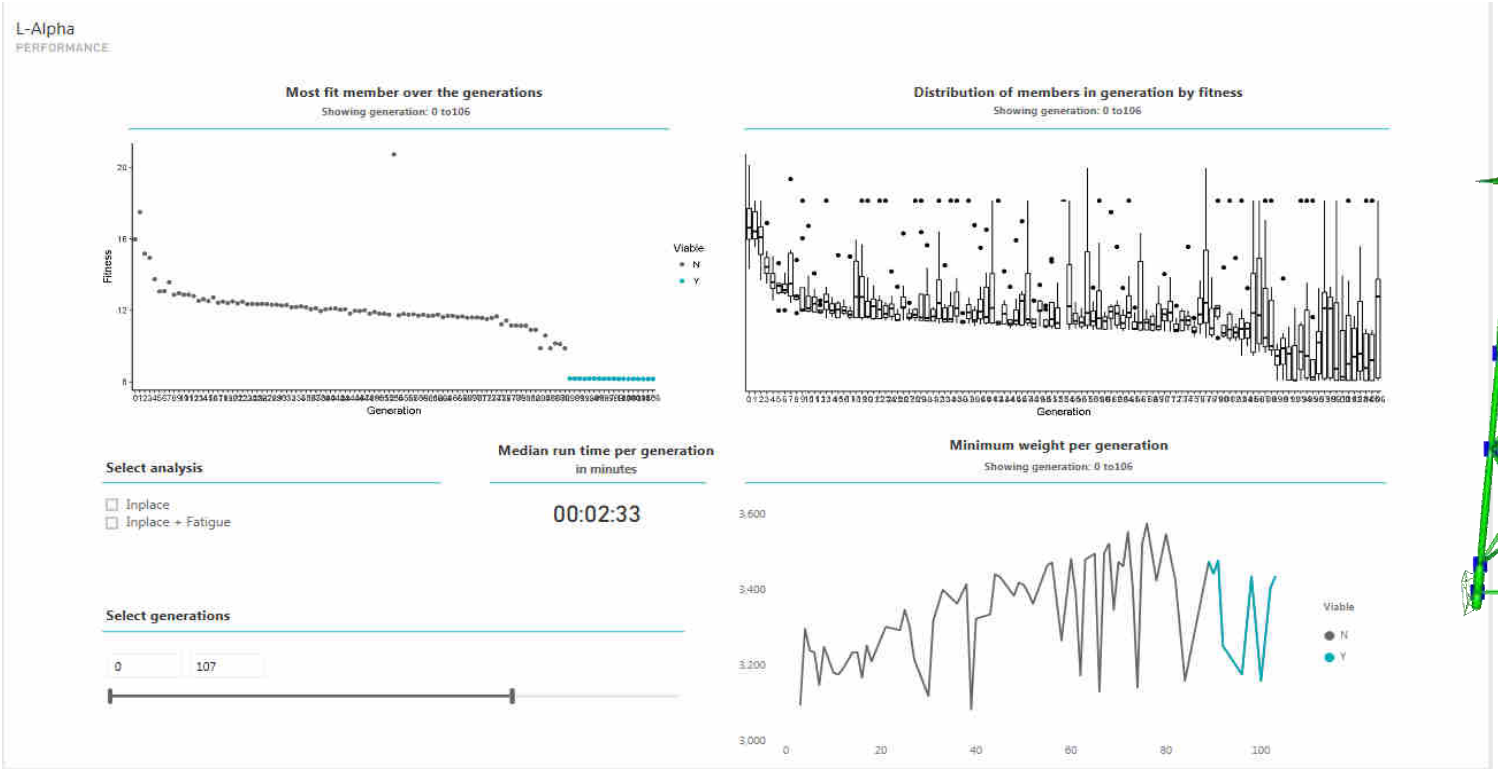
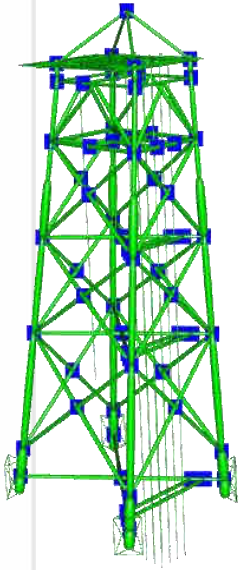
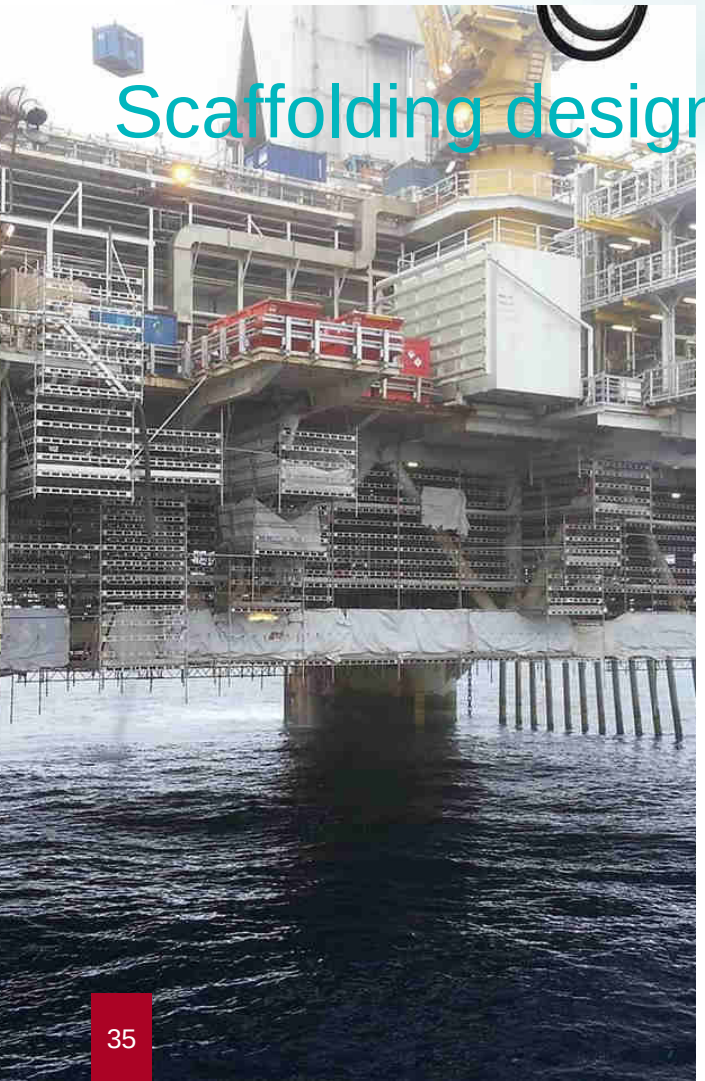
Target solution architecture



Does it work?







Scaffolding design optimalisation

Capabilities

- Provably optimal design
- Build around general exclusion volumes
- Reach specified work points
- Code compliant design
- Provides precise quantities and weights
- Integrated with 3D CAD application

Benefits

- Optimal design, with precise quantities
- Design permanent and dynamic portions
- Scaffolding as direct discipline

Technologies

$$\min \sum Wx \quad under\ Ax \leq b$$

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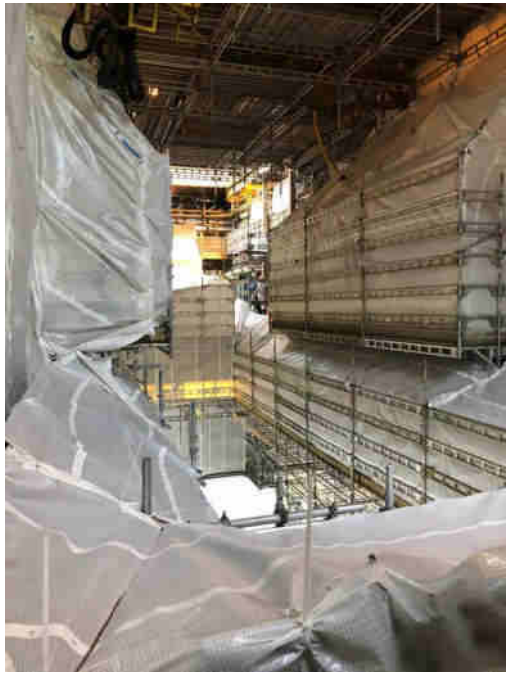
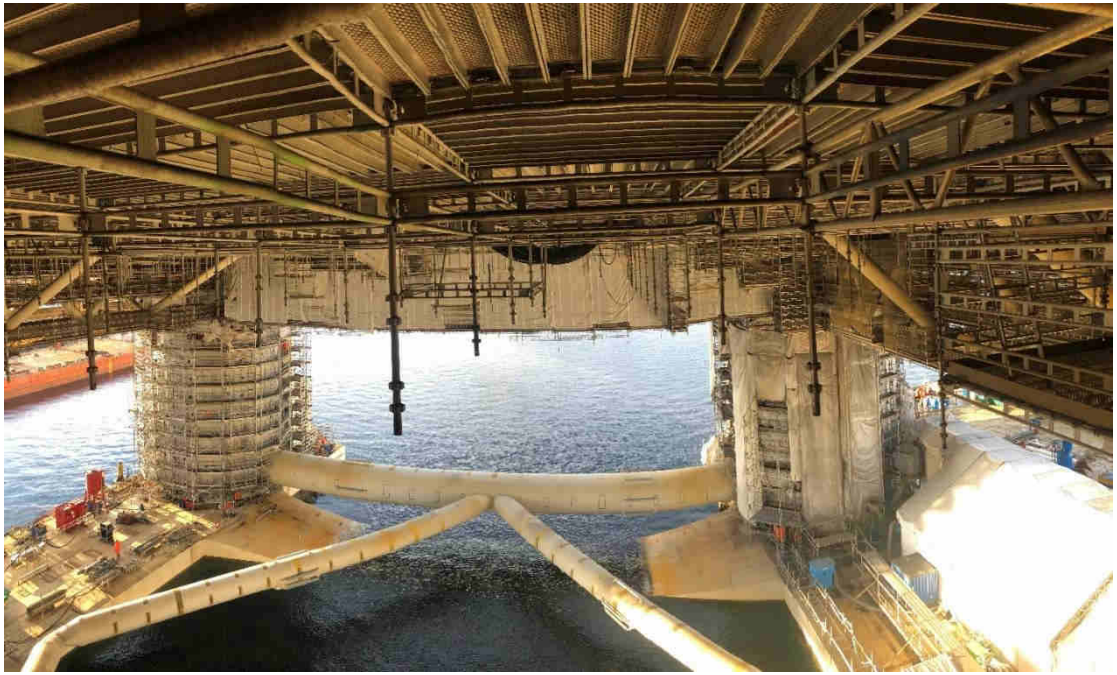
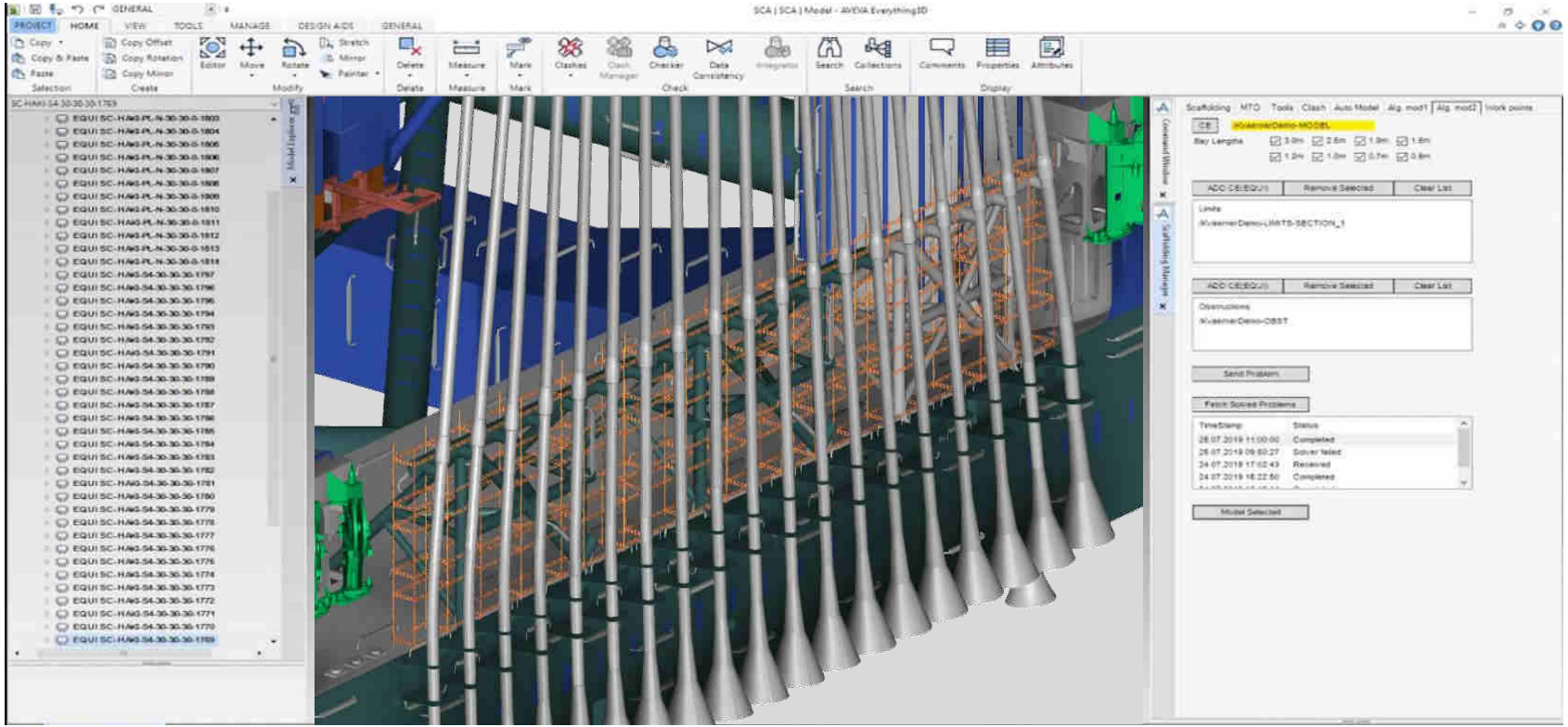
Njord scaffolding



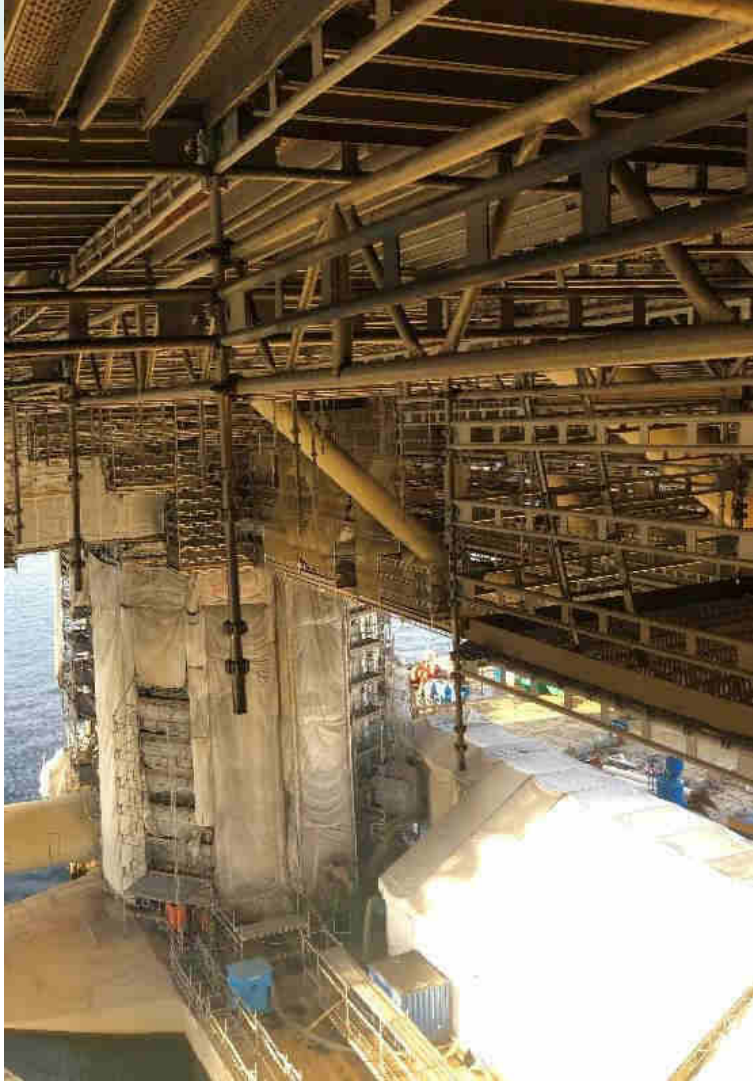


User interface integrated in 3D CAD application



Efficiency impact

- Significantly reduces the time required to model scaffolding
- Improved material management and resource planning
- Work process modified to include permanent scaffolding, reducing tear-down and rebuild effort
- Fewer modifications reduces risk



Spool delay prediction

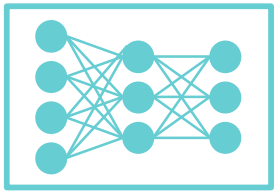
Capabilities

- Predict prefab delay for individual spools and pipe supports
- Timeline analysis
- Data available through dashboard

Benefits

- Prioritise effort to maximise flow
- Generate data for root-cause analysis
- Include impact in tendering & design

Technologies



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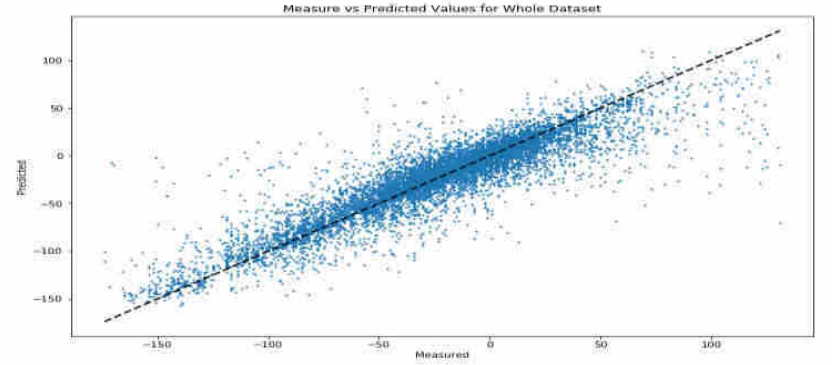
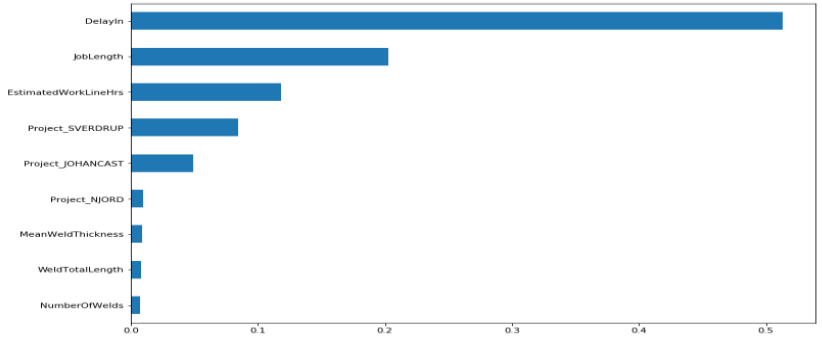
It’s about applied statistics

Actual vs. predicted delay



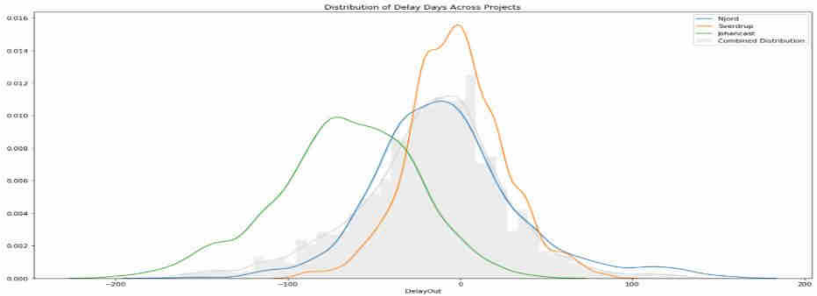
Underlying drivers



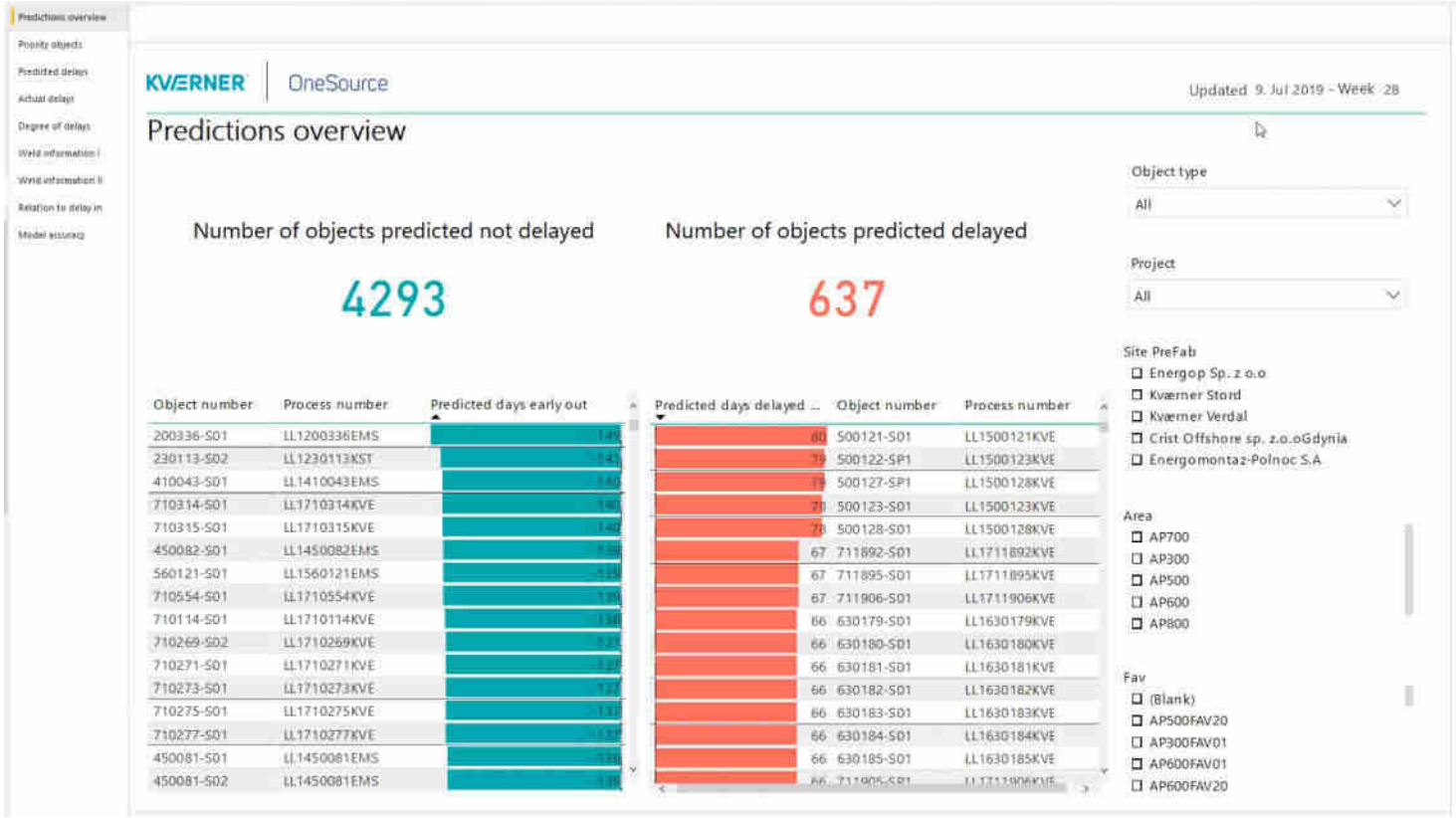
Regression measures

	Adjusted R2	R2	RMSE	Explained Variance
Random Forest Regressor	0.801375	0.801708	19.5382	0.801724
Extra Trees Regressor	0.792064	0.792412	19.991	0.792426
Bagging Regressor	0.781588	0.781954	20.4883	0.78197
Gradient Boosting Regressor	0.709931	0.710417	23.6113	0.710418
KN Regressor	0.705423	0.705917	23.794	0.706066
Decision Tree Regressor	0.672475	0.673024	25.0894	0.673024
Extra Tree Regressor	0.634357	0.63497	26.5092	0.634971
Linear Regression	0.598302	0.598976	27.7855	0.598976

Joint probability distributions



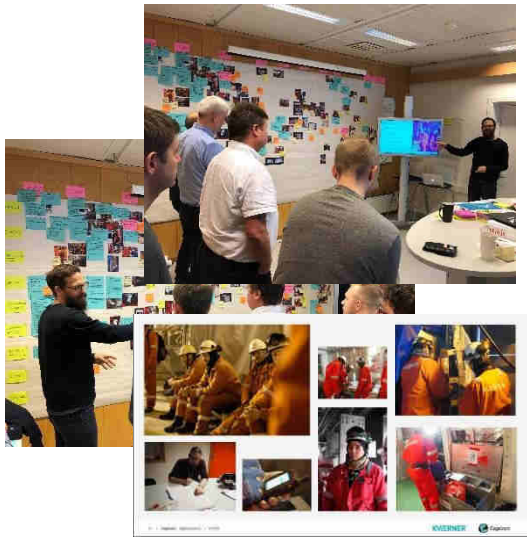
Demonstration



Mobile Construction Workforce

Mobile Construction Workforce – initial steps

- Initial design ideas established though global innovation contest in Cognizant
- Kvaerner awarded Cognizant 9 week study to develop a design concept for operators and foremen using mobile devices
- Initial yard walks and workshop conducted at Stord and Verdal Yards over a two week period
- Extensive involvement from selected foremen and operators from structural, piping and EIT disciplines

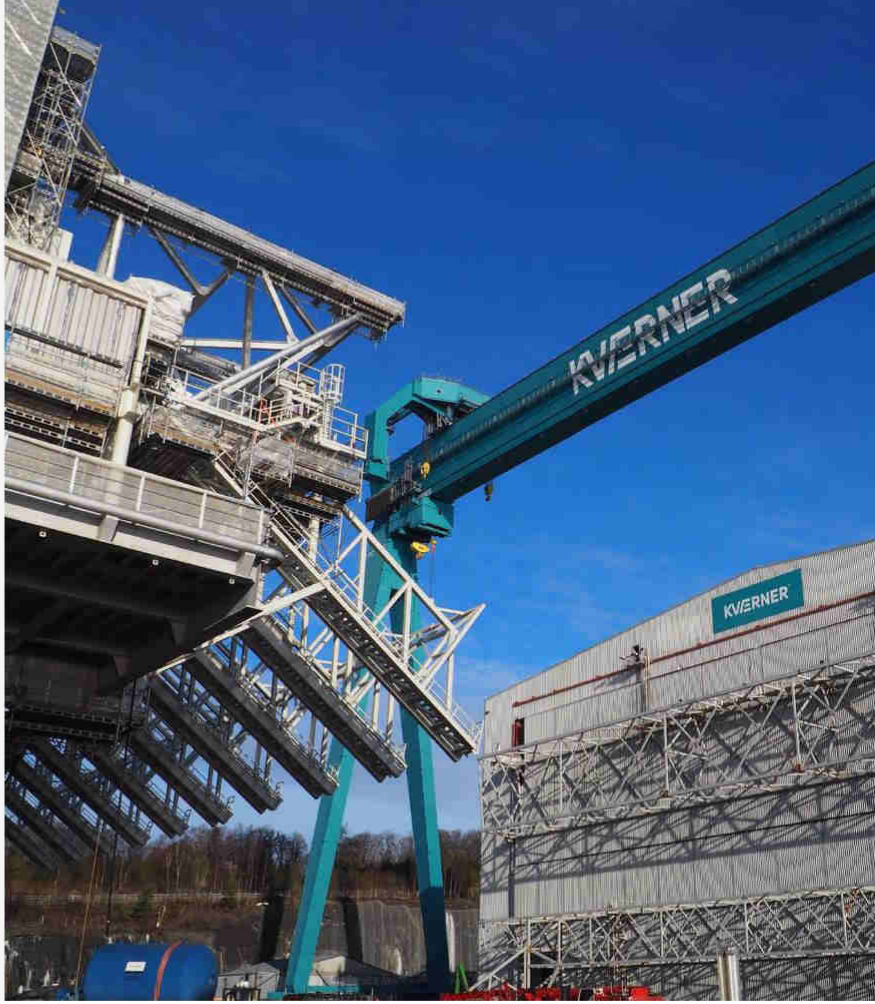


Setting the scene

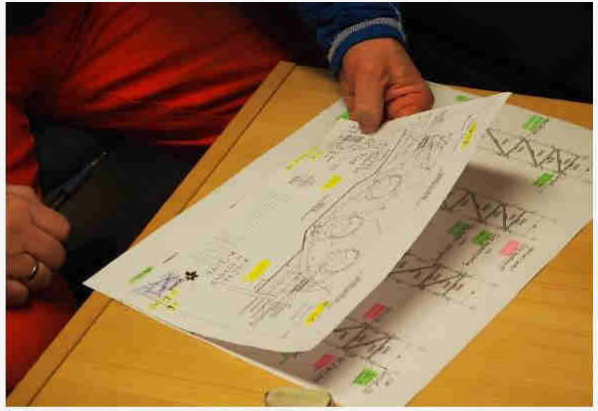
Focusing our research

Kværner is a huge industrialised operation; hundreds of worker across multiple sites specialising in many disciplines.

The power is in the people, the skills and knowledge they bring to the table exceeds all expectations. They are masters of their own environment, they hack the world around them to solve any situation.



KVÆRNER Cognizant



KVERNER Cognizant

KVERNER Cognizant

Morten

Foreman

Mid 40s

Morten has been an operator for 13 years, then he moved to being a foremen 4 years ago.
He has always worked in Kvaerner on multiple projects in the electrical discipline

Behaviours

He has multiple years of experience in the job.

Digital is not his main domain but he acknowledges the advantages of it.

He defined some small tweaks, who he is using with his team, to have a better workflow.

Motivations

He feels he is using a lot of time and energy to accomplish tasks that can be managed in a smarter way.

He sees how digitalisation made his private life easier and he would like to see the same improvement in his work life too.

Needs

Morten is looking for a solution to keep all his operators updated and to reduce the time he spends on location checks.

He also would like that all the repetitive and manual tasks he manages on top of his work on work packages could be automated or made easier.

KVAERNER Cognizant

Thorbjorn

Operator

Mid 20s

Thorbjorn started to work in Kvaerner 2 years ago, his first working experience.
He is learning a lot and consider his colleagues as a family helping him to become a better professional.

Behaviours

He has a strong problem-solving attitude and team spirit.

He trusts his foremen and team and knows that sometimes jobs can't be done, so it's not a big deal "another one is waiting for me"

He uses his mobile mostly for social networking and messages.

Motivations

When asked which is his main satisfaction he replies "When everything works!"

That's why his main frustration is when jobs get blocked or need to be reworked because of some miscommunication or misalignment in information.

Needs

He needs to have tools to enable him to do his job at his best, has all needed equipment available and tools to enable him to communicate in a smart way with his foreman and team.

Being so young he also need his voice to be heard so he can asks for help to improve his professionalism

KVAERNER Cognizant

Behaviours & insights

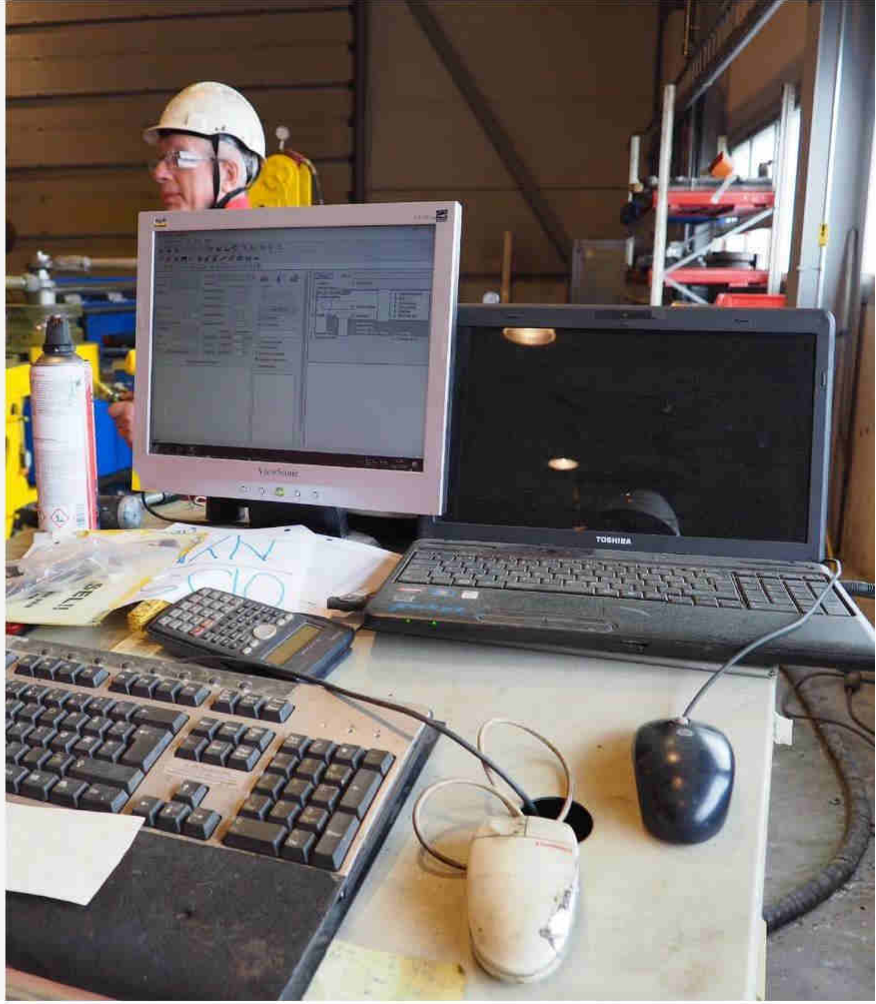
Motivation & solidarity

- Our operators and foremen are highly skilled, they constantly share their knowledge with one another.
- Always start their morning with a stand up it's part of their working culture
- They have a can-do mentality, they are used to working around problems
- They have acceptance towards broken processes
- They have a strong sense of camaraderie, they have each others back

Behaviours & insights

Interactions & interfaces

- Our operators and foremen are used to work with out-of-date technology
- They create there own mental model of interfaces
- They have an idea of how solutions should work
- They need concrete and real information displayed
- Digital communication channels are hard to use Because of out date tech (e.g PDA) and email



KVERNER Cognizant

Behaviours & insights

Core insights

- The foremen and operators interact as if there is no hierarchy, they behave as one team

Collaboration

Empowerment

KVERNER Cognizant

Behaviours & insights

Core insights

- They are very autonomous in starting a new task if the one they were working on is done or on hold

Empowerment

Proactivity

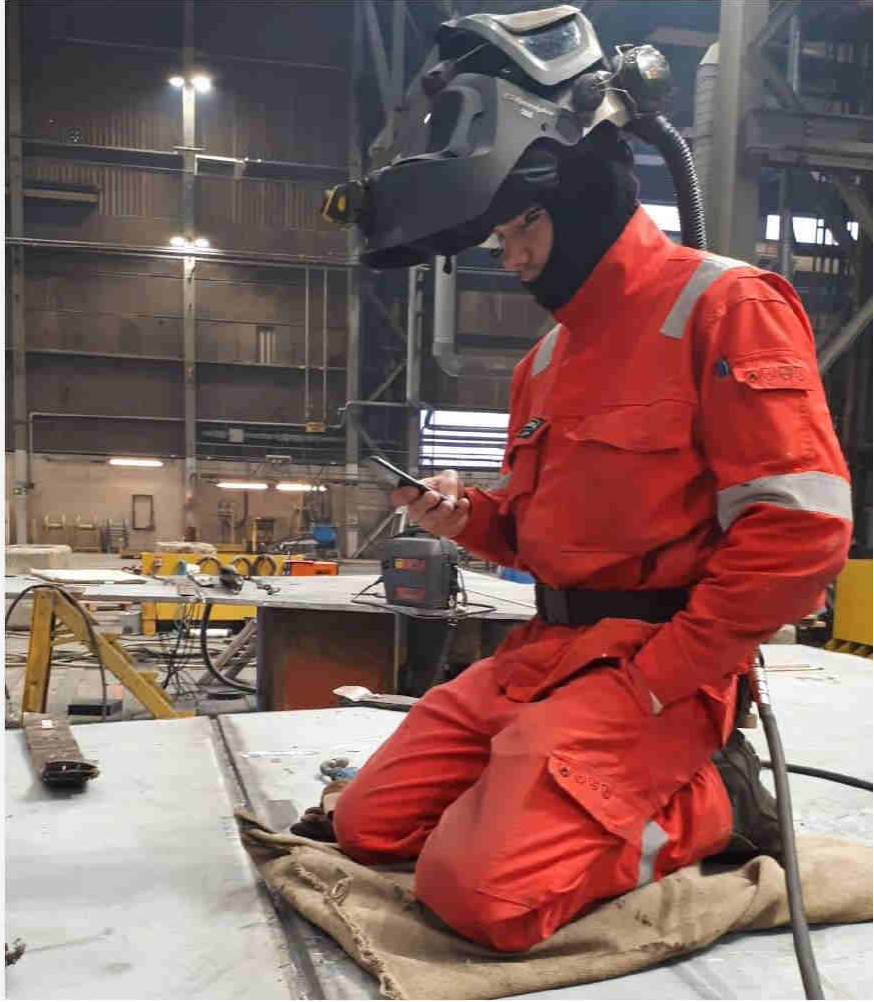
KVERNER Cognizant

Behaviours & insights

Core insights

- They are very serious about safety protocols. They give feedback to each other when needed

Collaboration



KVERNER Cognizant

Behaviours & insights

Core insights

- They reinvent the process themselves

Empowerment

Mobility

KVERNER Cognizant

Behaviours & insights

Core insights

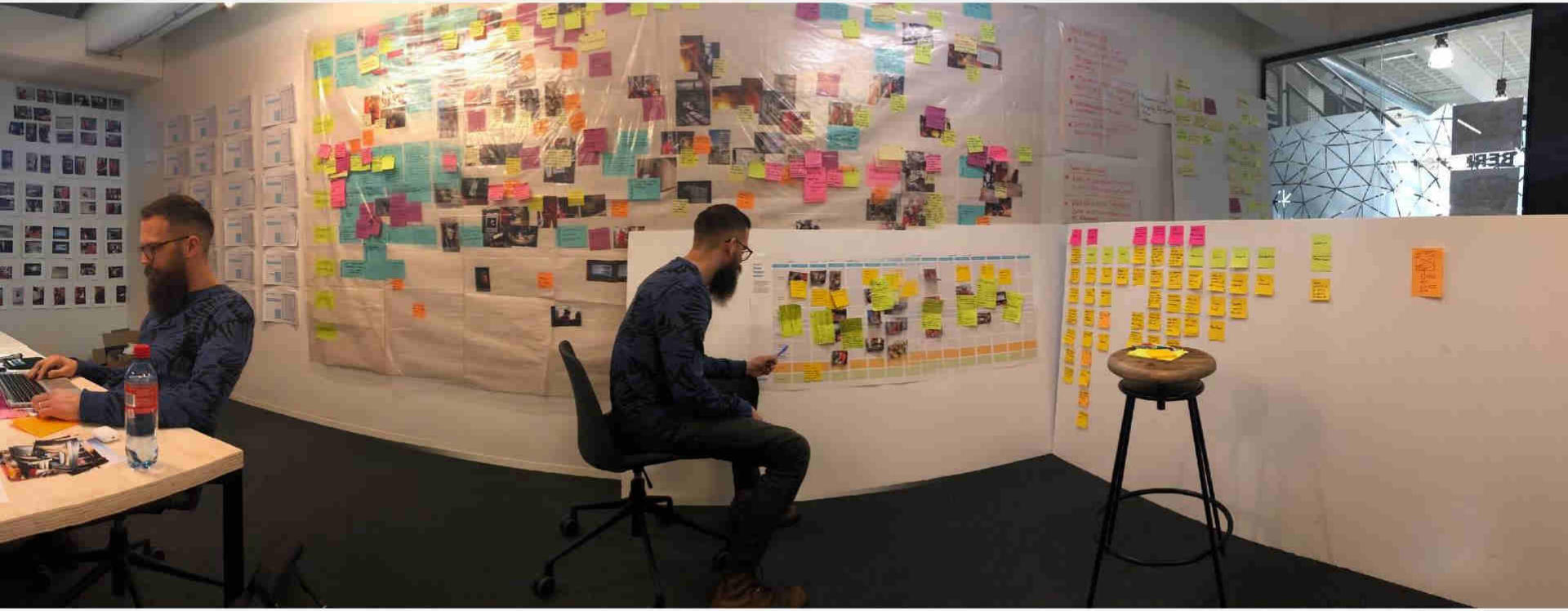
- They show frustration when WP or other information is incomplete or out of date

Empowerment

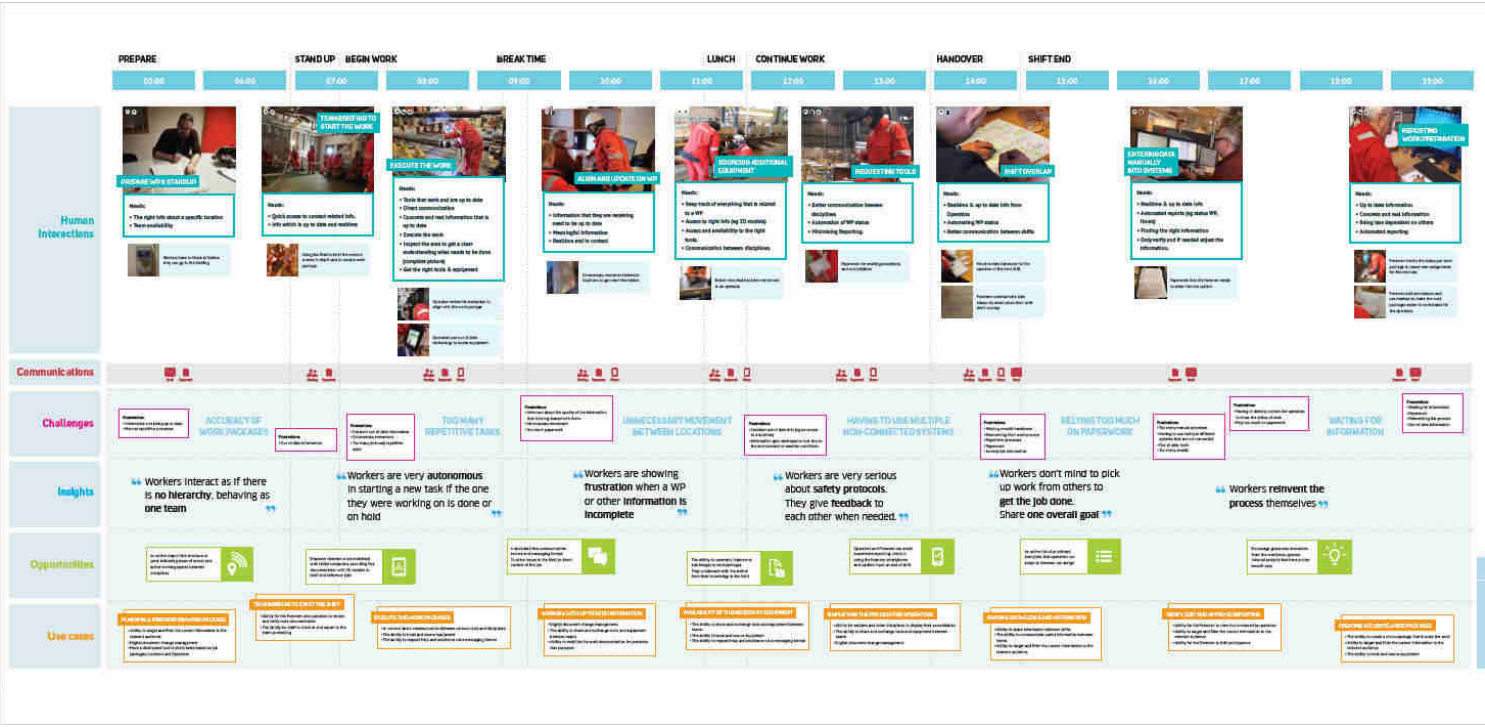
Control

KVERNER Cognizant

Mapping the data



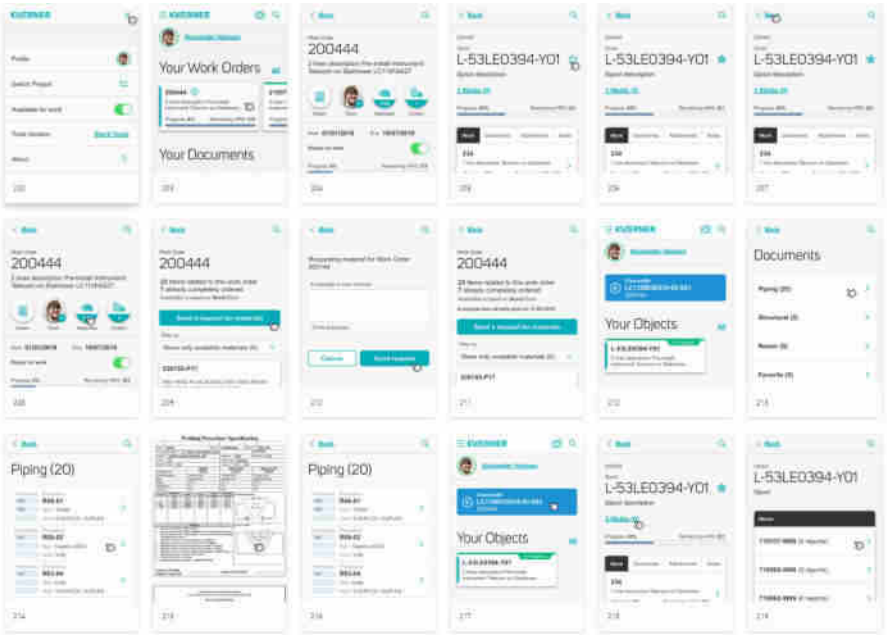
Experience map created through analysis



KVÆRNER

Clickable wireframe prototype

- Wireframes for 20 use cases approved by Kvaerner stakeholders, including foremen & operators at Stord and Verdal
- Shown extensively throughout organisation
- Deliverables for 14 use cases selected for initial implementation

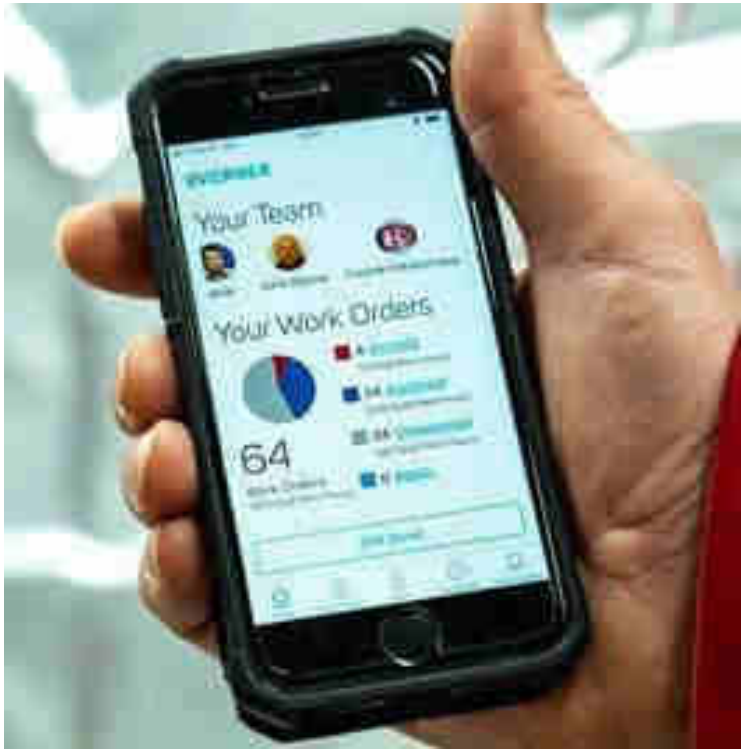


Implementation effort

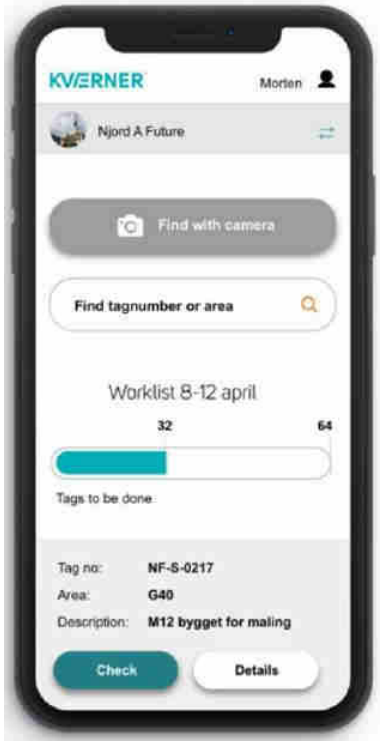
- 9 week analysis effort
- 27 week implementation for 14 use cases
- Multi-location implementation team
  - On-site team for product development, requirements definition and user interaction
  - Near-shore software factory

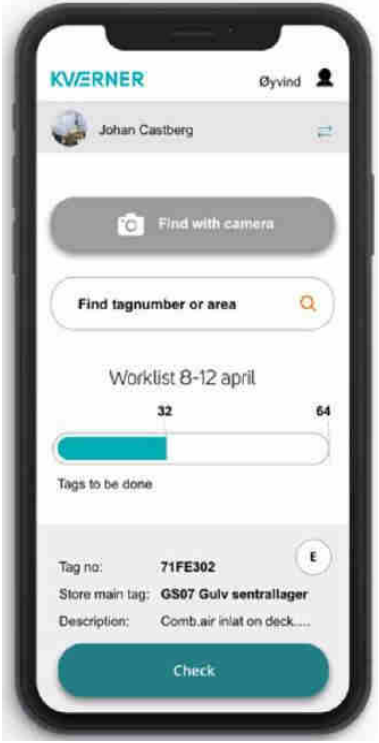
The result – the WeBuild app

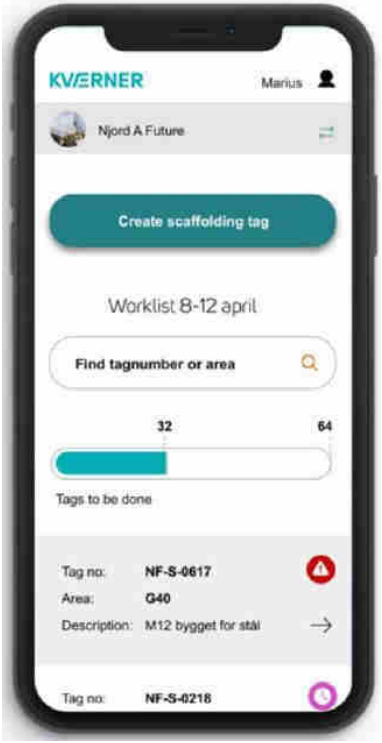
- App in production for 300+ users, to be rolled out to entire blue-collar work force
  - Includes support for hired-ins
  - Multi-language support
- Foreman role: Work order management, material management, team management and collaboration
- Operator role: Presence, fully fledged object/operations lists, procedures, weld reporting, time capture, collaboration features

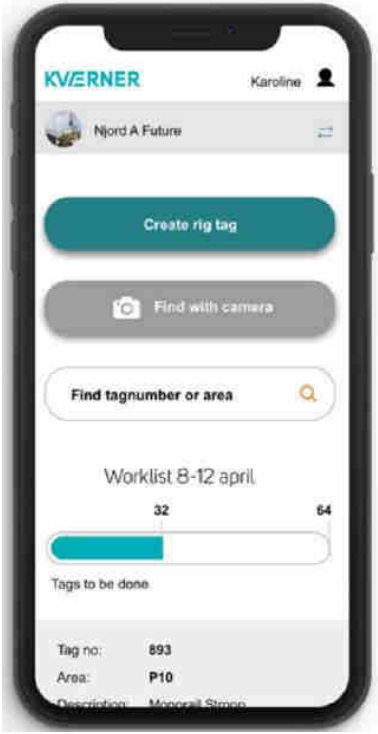


First spin-off: The WeCheck app

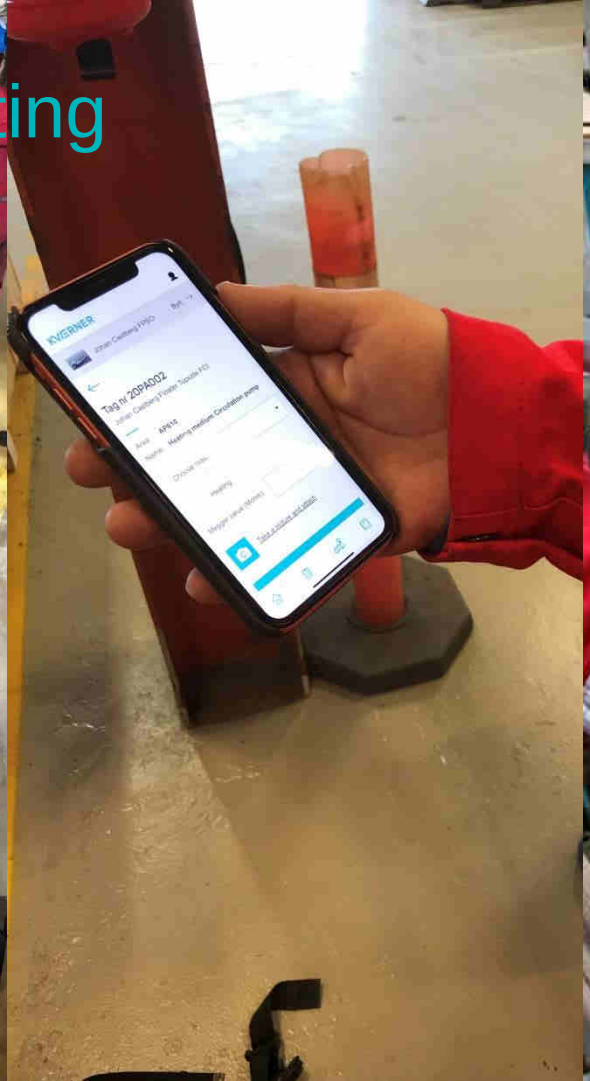








WeCheck user testing



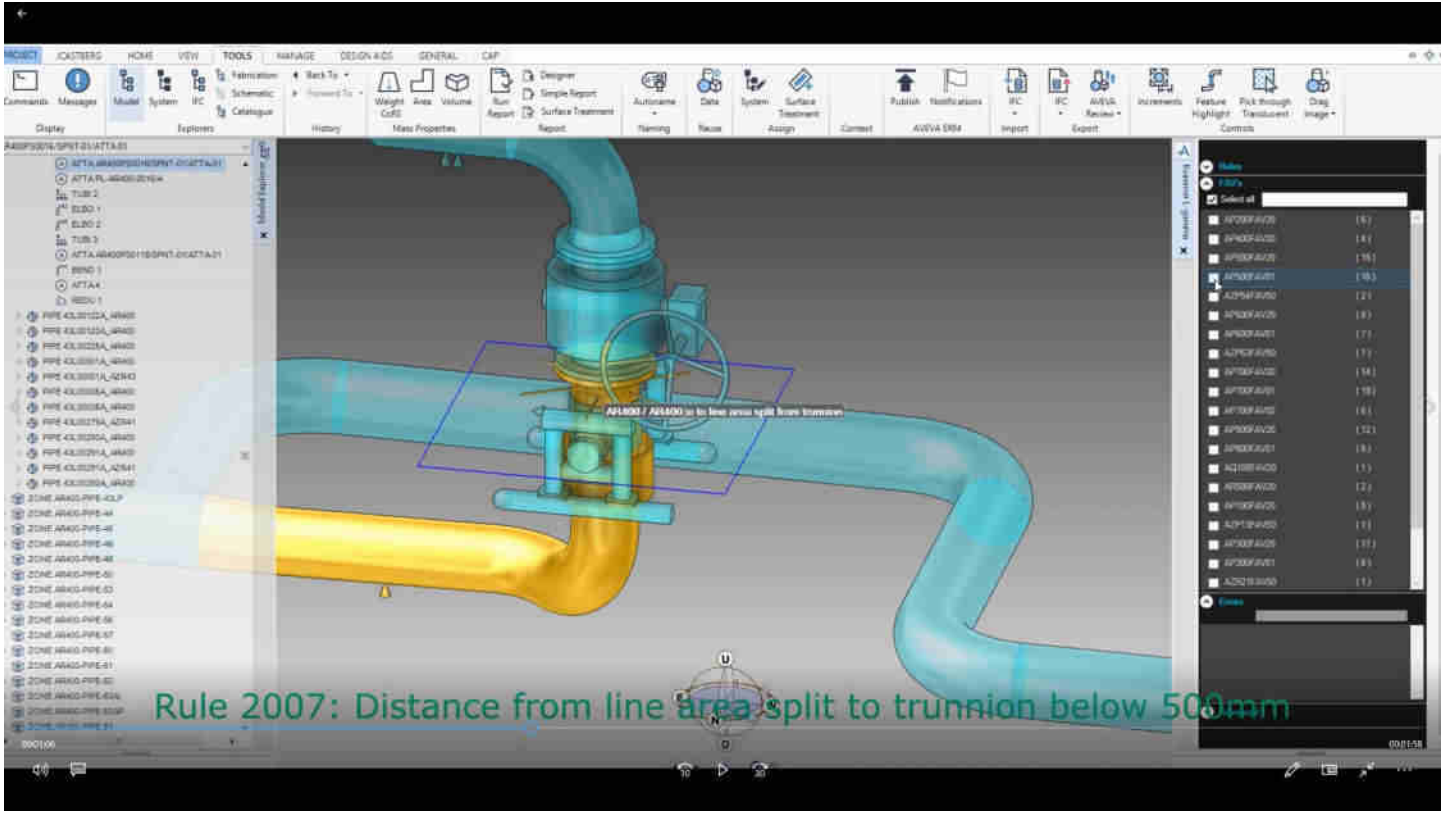
Constructability engine

The transition from design to fabrication is key

- Turn system design into physical design
- Determine overall geometry
- Ensure compliance to operational and safety requirements
- Specify materials, welds, etc.

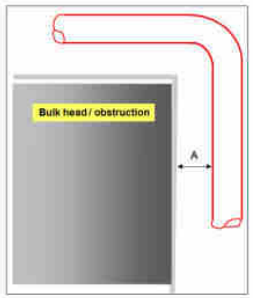
- Verify completeness and data quality
- Add objects and data needed for construction
- Check constructability
- Prepare fabrication data
- Create job cards

Constructability engine available in 3D CAD tool



Minimum distance from weld to obstruction

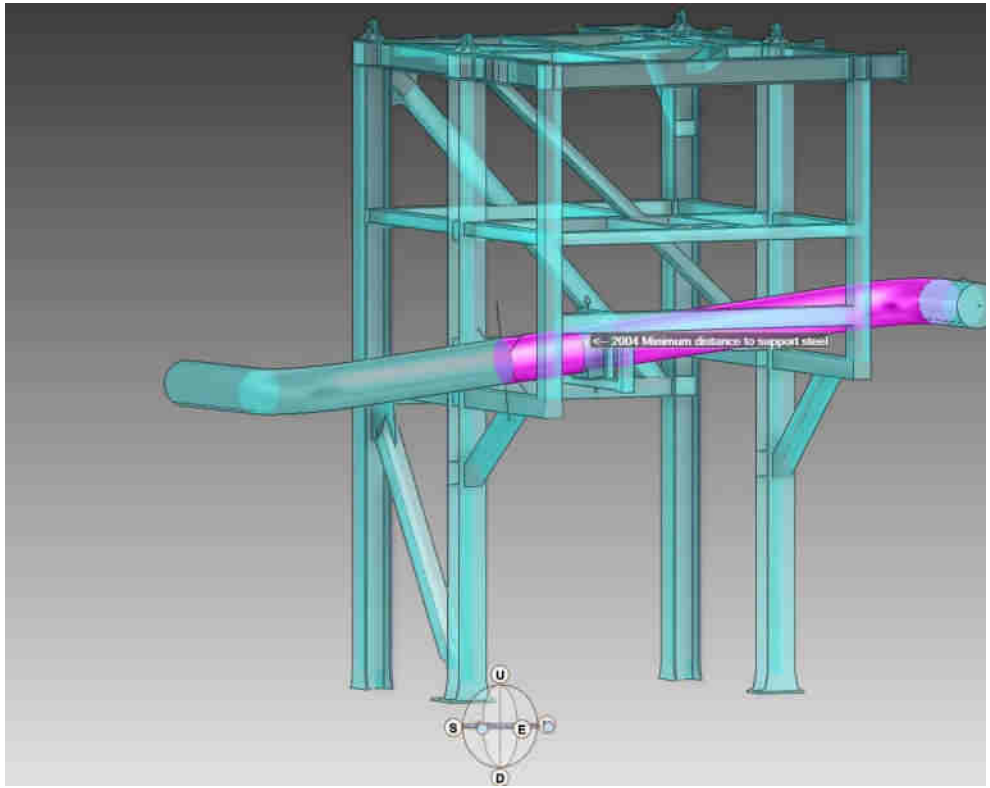
- Minimum distance from weld to obstruction is 300mm



Minimum welding distance:	
2" – 6"	A = 150mm
8" – 16"	A = 200mm
=>18"	A = 300mm

welding, between pipe, bulkhead / obstructions

- Model shows DN700mm pipe with 188mm distance from weld to pipe support

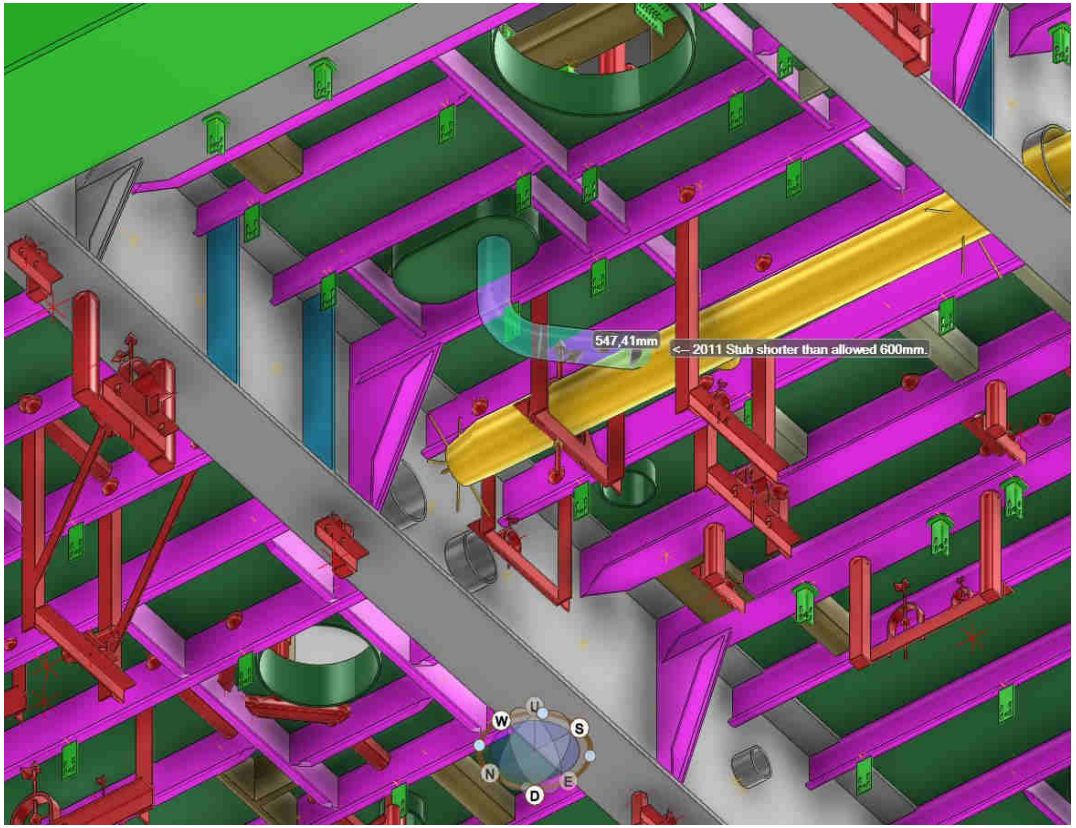


Minimum stub lengths

- Stubs must have a minimum length as a function of pipe diamter

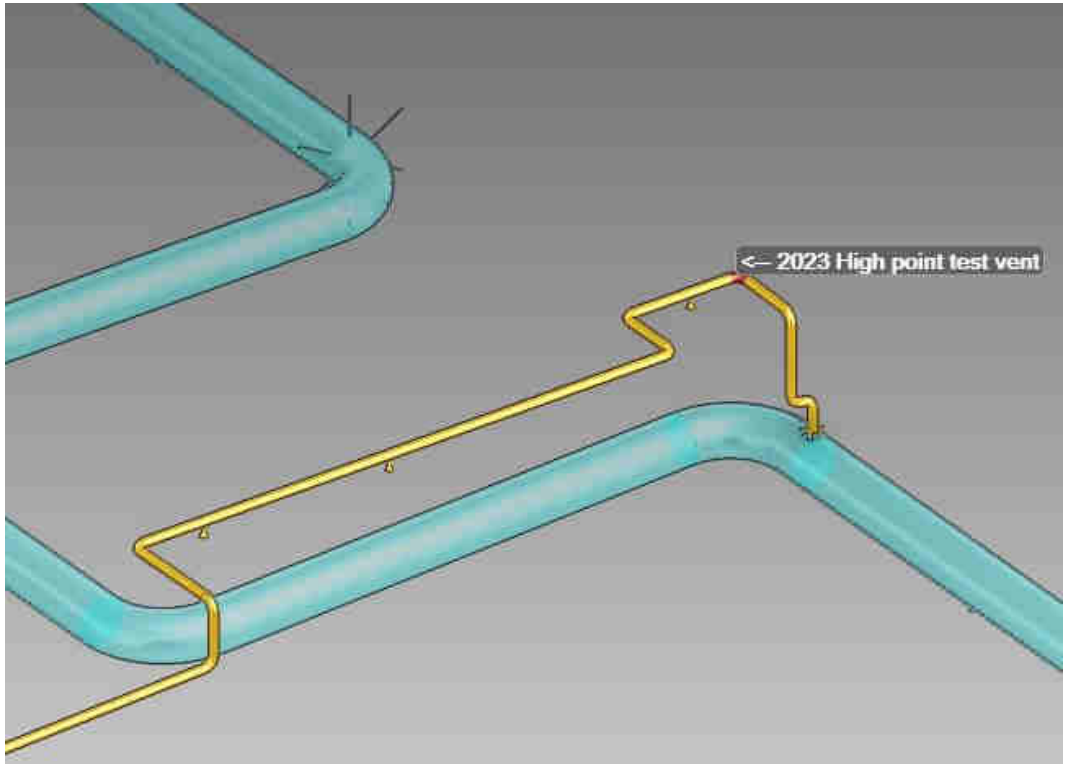
Branch to header (L)	length min.
2" to 4"	350 mm
2" to 6"	350 mm
4" to 4"	400 mm
4" to 6"	450 mm
4" to 8"	500 mm
6" to 6"	550 mm
6" to 8"	550 mm
6" to 10"	600 mm

- Model shows a drain box stub which is shorter than prescribed



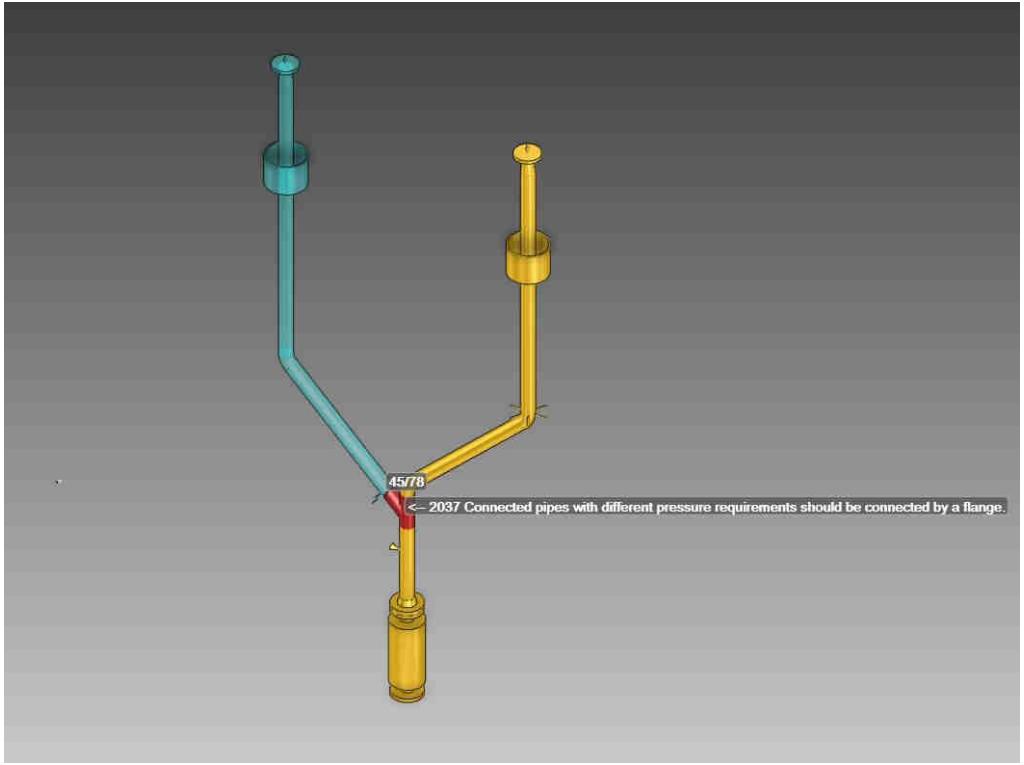
Venting of high points, drain for low points

- All line high points must have venting, to enable gas escape for testing
- Similarly, all low points must have drains
- Model shows line with no venting at high point



Equal test pressure for welded lines

- Lines welded together must have equal test pressures
- Model shows to lines with 45 bar and 78 bar test pressures, respectively



Additional slides

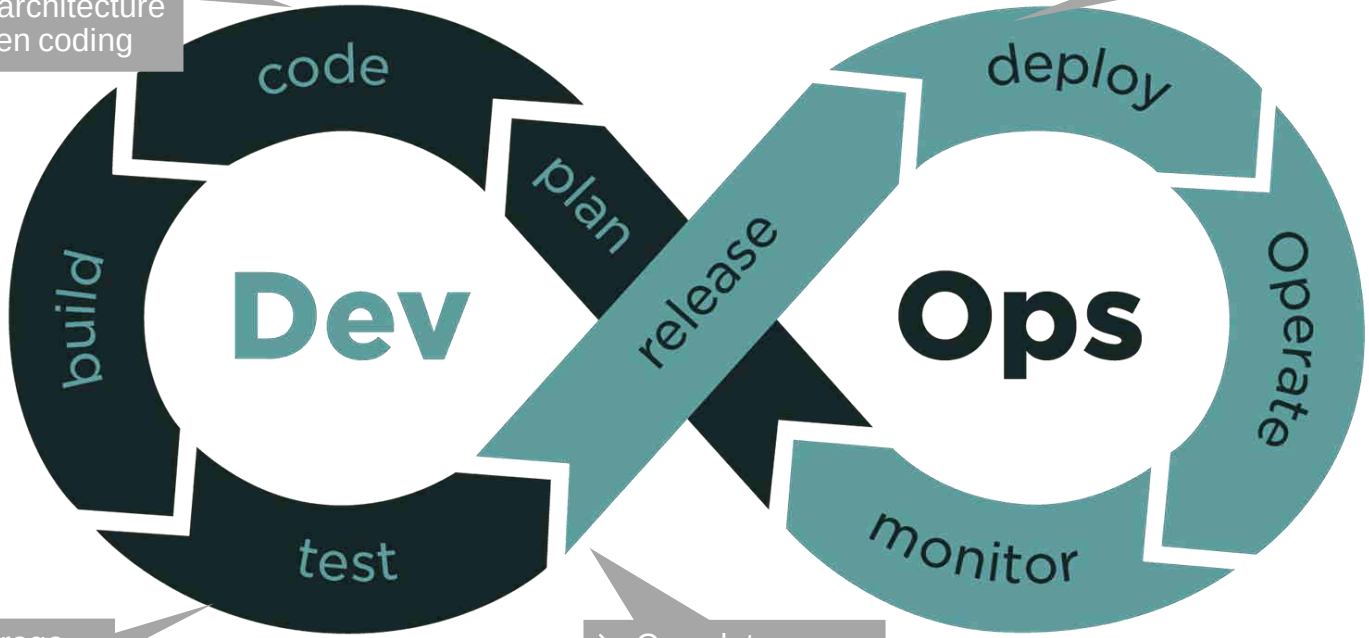
Required platform capabilities in the digital landscape

Landscape characteristica	Implications for Kvaerner
1 The set of business partners, i.e. digital actors will vary across projects, markets, and over time	Implement required cloud-based security features, directory services and publicly exposed APIs to enable collaboration with a changing set of actors
2 All market-leading cloud platforms will be represented in the landscape	Base architecture on loosely coupled (micro)services, with common authentication and authorisation architecture
3 The technical standards for information exchange will vary across actors, and evolve over time	Architect multi-channel information exchange capability, supporting industry-standard technologies
4 The information models for information exchange will evolve over time	Use versioned schemas for information exchange
5 The application portfolios will evolve over time, moving to cloud-based delivery, both in-tenant and SaaS	SaaS where appropriate, buy-before-build, cloud-first, micro-services architecture, cloud migration of on-premise portfolio based on lifecycle considerations
6 The digital landscape will create new roles and business opportunities	Use third-party SaaS to build capabilities, and identify digital business opportunities based on own strengths

Some notes on DevOps

- Code quality
- Solution architecture
- Test-driven coding

- App distribution
- Communication



- Test coverage
- Test data

- Completeness
- Documentation

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