

BRU21: Research and Innovation Program in Digital and Automation Solutions for Oil and Gas Industry

Prof. Alexey Pavlov – BRU21 program manager

BRU21 origin

41 Fact finding meetings with the industry & authorities: 2016-2017

- ❑ What are the major challenges for the O&G industry?
- ❑ What are “break-through technologies” for oil prices at 30 \$?
- ❑ How can NTNU contribute to deliver future technologies & education in O&G?



BRU21 Report – NTNU Strategy for Oil & Gas www.ntnu.edu/bru21

BRU21

Better Resource Utilization in the 21st century



NTNU Strategy for Oil and Gas

What are the major challenges for the O&G industry on the Norwegian Continental Shelf in the future and the contribution from academia for solutions

BRU21 vision, mission and goal

BRU21 vision

Enable higher efficiency, safety and reduced environmental footprint of oil and gas production through digital and automation technologies

+ support the industry transition to sustainable energy future

BRU21 mission

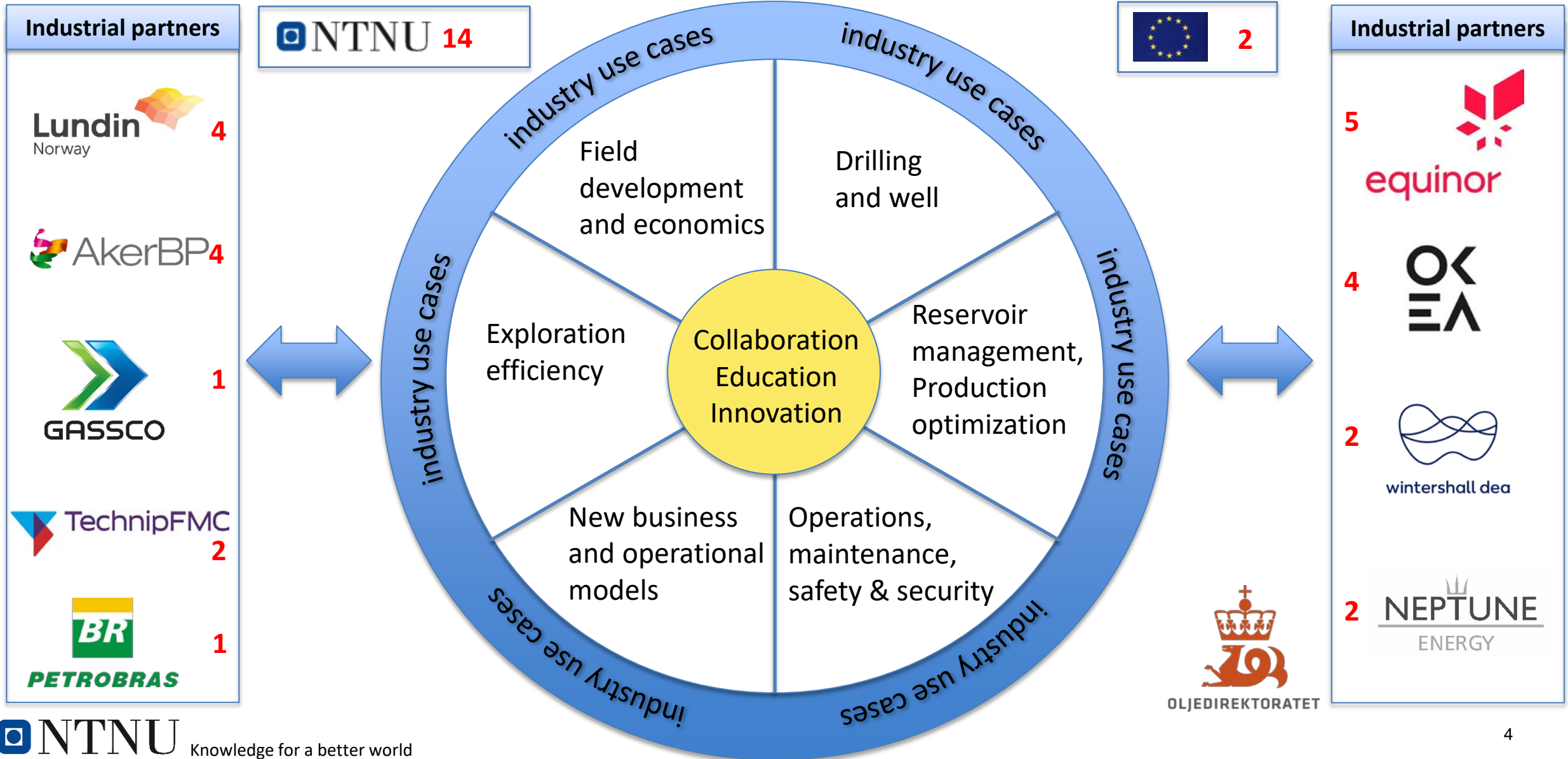
Mobilize multidisciplinary expertise across NTNU and, in cooperation with industrial partners, produce research results for novel technological and organizational solutions

BRU21 goal

Deliver new knowledge, technologies, innovations and multidisciplinary specialists for the digital transformation of the Oil and Gas industry and for the Norwegian society



BRU21: Industry – NTNU collaboration: 39 (+2) projects





BRU21

Better Resource Utilization in the 21st century

BRU21 project matrix: 39(+2) projects

6	11	7	4 (+2)	5	6
<p>Drilling and Well</p> <p>Safe drilling in karstified carbonates</p> <p>Lundin Norway</p> <p>Intelligent data analytics for offshore well integrity and life cycle management</p> <p>BR PETROBRAS</p> <p>Automatic real-time surveillance of drill-string vibrations</p> <p>NTNU</p> <p>Digitalization/automation of life-cycle well integrity</p> <p>NTNU</p> <p>Drilling data analytics</p> <p>NTNU</p> <p>Real time fault and symptoms detection in drilling operation with wired pipe</p> <p>NTNU</p>	<p>Reservoir management and Production optimization</p> <p>A hybrid data-driven and mechanistic model for production optimization in the oil and gas industry</p> <p>Lundin Norway</p> <p>Production optimization strategies for offshore production systems with water processing constraints</p> <p>OK EA</p> <p>Improved technology for production optimization, with focus on gas lift allocation</p> <p>wintershall dea</p> <p>Assisted history matching for petroleum reservoirs</p> <p>equinor</p> <p>Assisted history matching, reservoir model update and optimization</p> <p>equinor</p> <p>Optimization of production, reservoir and field development</p> <p>NTNU</p> <p>Optimization across time-scales in oil- and gas production</p> <p>NTNU</p> <p>Data-driven reservoir modelling</p> <p>NTNU</p> <p>Integrated Reservoir Tool/FieldOpt</p> <p>NTNU</p> <p>Machine learning-based production optimization</p> <p>NTNU</p> <p>NTNU</p>	<p>Operations, Maintenance, Safety and Security</p> <p>Maintenance in remote operations</p> <p>AkerBP</p> <p>Predictive maintenance</p> <p>Lundin Norway</p> <p>Predictive Maintenance and Remaining Useful Lifetime</p> <p>OK EA</p> <p>Risk-based maintenance</p> <p>equinor</p> <p>Industry 4.0 and smart predictive maintenance</p> <p>NTNU</p> <p>Safety and security in design and operation of ICS systems</p> <p>NTNU</p> <p>Detection and localization of subsea leakages</p> <p>NTNU</p>	<p>New business and operational models</p> <p>Digital relations and new business models</p> <p>TechnipFMC</p> <p>Collaboration and digital tools in early stage design of offshore facilities</p> <p>TechnipFMC</p> <p>From idea to discovery: information sharing and cooperation in the exploration value chain</p> <p>NEPTUNE ENERGY</p> <p>Remote operations and future operating models</p> <p>equinor</p> <p>Design, operation and maintenance of offshore energy hubs</p> <p>EU</p> <p>AI for safety-critical remote operations</p> <p>EU</p>	<p>Exploration efficiency</p> <p>Does well data quality affect machine learning performance?</p> <p>AkerBP</p> <p>Automated Seismic Reconstruction of Missing Section</p> <p>NEPTUNE ENERGY</p> <p>Automated facies classification through applying machine-learning to pre-stack seismic data</p> <p>wintershall dea</p> <p>Automated lithology classification of whole core CT scans</p> <p>equinor</p> <p>Machine learning-based generic well log depth matching</p> <p>AkerBP</p>	<p>Field development and economics</p> <p>Improved planning methods for more energy efficient and environmentally friendly fields in the Barents Sea</p> <p>AkerBP</p> <p>Cost effective development of (small) discoveries on the NCS</p> <p>OK EA</p> <p>Automated methodologies for decision support in field development</p> <p>Lundin Norway</p> <p>Optimizing the operation of natural gas infrastructure</p> <p>GASSCO</p> <p>PoDecs: valuation under uncertainty</p> <p>OK EA</p> <p>Real options-based valuation for environmentally friendly O&G production</p> <p>NTNU</p> <p>NORWEGIAN PETROLEUM ASSOCIATION</p>



BRU21 project matrix: 39(+2) projects

6	11	7	4 (+2)	5	6
Drilling and Well Safe drilling in karstified carbonates 	Reservoir management and Production optimization A hybrid data-driven and mechanistic model for production optimization in the oil and gas industry 	Operations, Maintenance, Safety and Security Maintenance in remote operations 	New business and operational models Digital relations and new business models 	Exploration efficiency Does well data quality affect machine learning performance? 	Field development and economics Improved planning methods for more energy efficient and environmentally friendly fields in the Barents Sea
Intelligent data analytics for offshore well integrity and life cycle management 	Production optimization strategies for offshore production systems with water processing constraints 	Predictive maintenance 	Collaboration and digital tools in early stage design of offshore facilities 	Automated Seismic Reconstruction of Missing Section 	Cost effective development of (small) discoveries on the NCS
Automatic real-time surveillance of drill-string vibrations 	Improved technology for production optimization, with focus on gas lift allocation 	Predictive Maintenance and Remaining Useful Lifetime 	From idea to discovery: information sharing and cooperation in the exploration value chain 	Automated facies classification through applying machine-learning to pre-stack seismic data 	Automated methodologies for decision support in field development
Digitalization/automation of life-cycle well integrity 	Assisted history matching for petroleum reservoirs 	Risk-based maintenance 	Remote operations and future operating models 	Automated lithology classification of whole core CT scans 	Optimizing the operation of natural gas infrastructure
Drilling data analytics 	Assisted history matching, reservoir model update and optimization 	Industry 4.0 and smart predictive maintenance 	Design, operation and maintenance of offshore energy hubs 	Machine learning-based generic well log depth matching 	PODecs: valuation under uncertainty
Real time fault and symptoms detection in drilling operation with wired pipe 	Optimization of production, reservoir and field development 	Safety and security in design and operation of ICS systems 	AI for safety-critical remote operations 		Real options-based valuation for environmentally friendly O&G production
	Optimization across time-scales in oil- and gas production 	Detection and localization of subsea leakages 			
	Data-driven reservoir modelling 				
	Integrated Reservoir Tool/FieldOpt 				
	Machine learning-based production optimization 				

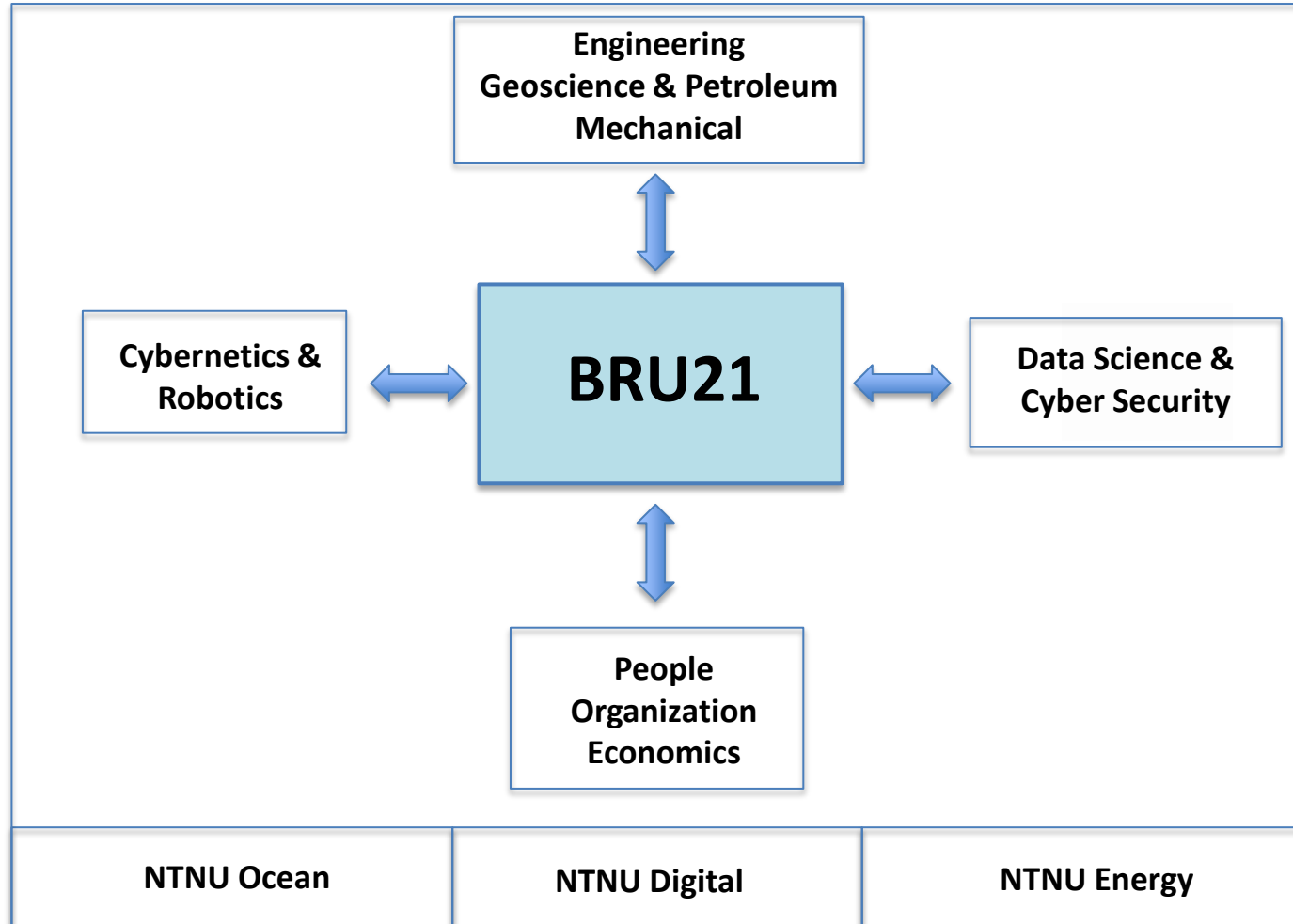
Contribution to reduced environmental footprint

BRU21 model:

Collaboration Research Education Innovation

BRU21 Multidisciplinary collaboration across NTNU

8 departments / 4 faculties at NTNU



BRU21 Research

Exploration efficiency

BRU21 innovation

Reservoir management and production optimization

FIELD DEVELOPMENT AND ECONOMICS

Field development and economics

FIELD DEVELOPMENT AND ECONOMICS

Operations, maintenance, safety and security

and automation solutions for optimized maintenance,

Drilling and well

Digital and automation solutions for reduced cost, environmental footprint and increased safety of Drilling and Well operations

BRU21 innovation

New business and operational models

Organizational and technological preconditions for the realization of the digitalization and Industry 4.0 potential

EXPLORATION EFFICIENCY

EXPLORATION EFFICIENCY

DRILLING AND WELL

OPERATIONS, MAINTENANCE, SAFETY AND SECURITY



Real-time fault and symptoms detection in drilling operations with wired pipe



NTNU Drillbotics team



Digitalization/automation of life-cycle integrity



Safe drilling in karstified carbonates

ComputerWell:

Drillstring digital twin

p.12

Intelligent data analytics for offshore well integrity and life cycle management

MAC:

Acoustic look-ahead technology based on machine learning

p.12



Optimal operation, maintenance and investment strategies for offshore energy hubs



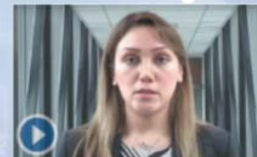
Ensuring reliability of unmanned autonomous systems



Preconditions, implementation and exploitation of knowledge collaboration in a complex organization



The role of shared understanding in collaborative work: A case study of early-stage design in the Oil and Gas industry



Digital transformation in oil and gas exploration: organizational pre-conditions and implementation roadmap

Artificial Intelligence in safety-critical remote operations

www.ntnu.edu/bru21/fde

www.ntnu.edu/bru21/nbom

Research dissemination

Video Newsletters

BRU21 Digital and Automation Solutions for The Oil and Gas Industry

BRU21: NTNU's Research and Innovation Program in Digital and Automation Solutions for the Oil and Gas Industry. We mobilize multidisciplinary expertise across NTNU and, in cooperation with industrial partners, produce research results for novel technological and organizational solutions. The program consists of over 30 PhD and PostDoc projects supported by NTNU and 9 Oil and Gas and Technology companies. [read more](#)

Video newsletters: In this series of newsletters we present BRU21 projects and selected results in the form of short videos covering each of the [6 program areas](#).

BRU21 program area: Exploration Efficiency
Prototyping future geoscience data organization and analytics tools for improved exploration workflows

BRU21 aims at developing novel automated tools to increase data analysis efficiency in the exploration workflows through modern computational methods, e.g. machine learning and artificial intelligence, combined with cross-disciplinary subsurface expertise...[read more](#)

BRU21 project: Automated lithology classification employing whole core CT scans
Lithology classification enabled by whole core Computerized Tomography images and advanced analytics algorithms

Project result: Workflows to classify lithology using 2D and 3D CT images
Convolutional Neural Network-based workflows for high-resolution classification of lithology and porosity

BRU21 Project: The impact of well data quality on machine learning performance
Structuring and preprocessing of petrophysical data for efficient use with machine learning algorithms

LinkedIn

Nataliaia Korotkova · 1st
PHD Candidate hos Norges teknisk-naturvitenskapelige universitet (NTNU)
5mo · 🌐

A brief video presentation about my PhD project. [#phd](#) [#project](#) [#BRU21](#)

Department of Geoscience and Petroleum
5,998 followers
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Efficient cross-boundary collaboration and information sharing are still among the greatest challenges for many organizations. In this project, [#BRU21](#) PhD Candidate [Nataliaia Korotkova](#) at [Norwegian University of Science and Technology \(NTNU\)](#) is working on digitalization of knowledge collaboration in the Front-End stage of the oil and gas value chain. The research focus is on preconditions, implementation, and exploitation of digital technologies for knowledge collaboration in different parts of complex organizations. Nataliaia scrutinizes social systems by analyzing knowledge networking, trust-building, knowledge reuse, and adoption of emerging technological concepts, such as digital twins. [TechnipFMC](#) sponsors this project. [Egil TjålandAlexey PavlovMilan StankoJon Are NilsenRialda SpahicMahdis MoradilTishree MohallickVidar HepsøKenneth DuffautPer Morten SchiefloeEric MonteiroMary Ann LundteigenJon Are NilsenSigve HovdaJon KleppeAshkan Jahanbani](#)

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Video reports

BRU21 2020 2021
NTNU Research and Innovation Program in Digital and Automation Solutions for the Oil and Gas Industry

efficiency

data organization and analytics tools workflows

Rapid downhole testing of permeability anisotropy

Automated detection of geological unconformities

Machine learning and seismic data analysis

Machine learning and wellbore data analysis

Automatic depth matching of well log data

www.ntnu.edu/bructi/ee

Innovative dissemination strategy

- 55+ videos on projects and project results
- In total 2+ hours of videos
- Training in business communication

BRU21 Innovation

Equinor & Techstars
Energy Accelerator


ComputerWell – NTNU spin-off 2020

Computational surveillance of drilling operations

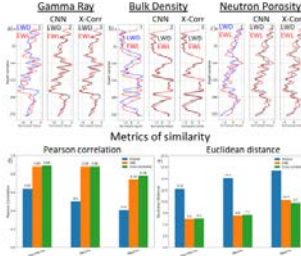
- Real-time computational drillstring dynamics
- Massively tested pattern recognition
- High frequency GUI - Along string inspection

Visit: www.computerwell.com


Innovation projects towards implementation/licensing

Well log depth matching 

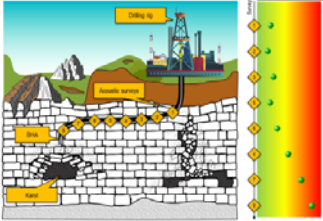
Well log depth matching using analytical and deep learning



NTNU Knowledge for a better world

MAC: Look-ahead method for predicting formation changes and karsts 


MAC Enables detection of small geological features undetectable with existing technologies



New testing concept + Machine Learning


NTNU Knowledge for a better world

KONGSBERG
HOW


ProDecs – Investment valuation under uncertainty 

Better informed investment decisions

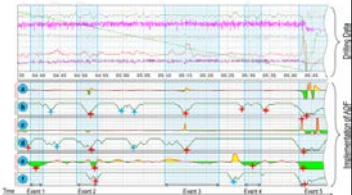
ProDecs offers an ultimate solution for investment valuation and decision making under uncertainty and project flexibility



NTNU Knowledge for a better world


ADF: Drilling data processing 

ADF enables detection of small events in logged drilling data




Detection of karstification objects in carbonates

NTNU Knowledge for a better world

PERMEAN: Rapid downhole testing of permeability anisotropy 

PERMEAN provides rapid and accurate downhole measurement of permeability anisotropy within minutes



Downhole tool + algorithm

NTNU Knowledge for a better world

BRU21 Education

NTNU Drillbotics Team 2021

Winners of International SPE Drillbotics Competition

Preparing future industry specialists with both digital and petroleum expertise is one of the BRU21 goals.

NTNU team of drilling engineering and cybernetics students – Benedicte Gjersdal, Gaute Hånsnar, Mikal Viga Skretting and Magnus Steinstø – developed a miniature robotic drilling rig for autonomous directional drilling and won the 2021 SPE Drillbotics competition in drilling automation. Coached and sponsored by BRU21, NTNU teams won the competition also in 2018 and took 2nd place in 2017.



Concept: Alexey Pavlov, Video and communications: Jon Are Nilsen, Graphic design and print: Skipnes Kommunikasjon AS

2018



The NTNU team members and what they are doing since graduating: (from left) Alexander Handeland, software developer at Sopra Steria; Per Øystein Turøy, field engineer at Allus Intervention; Sebastian Knopg, field engineer at Allus Intervention; Mikkel Lette Arne, working on a PhD in drilling automation at NTNU; and Andreas Thuve, completion engineer at Equinor. Source: DSATS/Fred Florence.

1. NTNU
2. OU
3. A&M

2017



1. Texas A&M
2. NTNU
3. UiS

BRU21 Academy: courses for the industry



Petroleum Cybernetics for Engineers and Managers

(A. Pavlov, M. Stanko)



Digital solutions for planning and optimization of maintenance

(J. Vatn)



Digital Twins for Managing Safety and Reliability of Systems

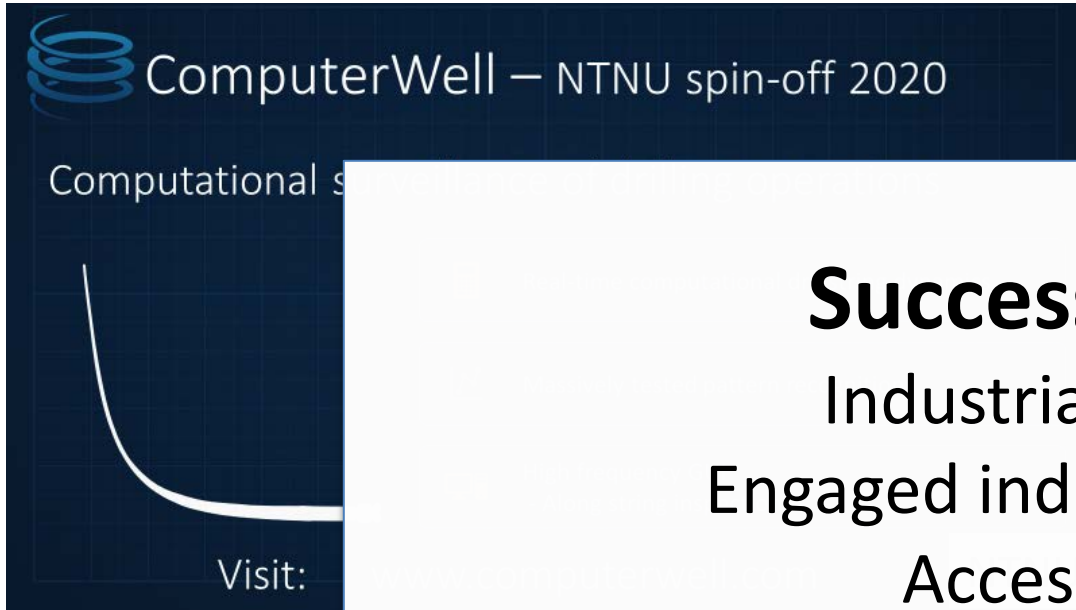
(J. Vatn)



Remote operations

(V. Hepsø)

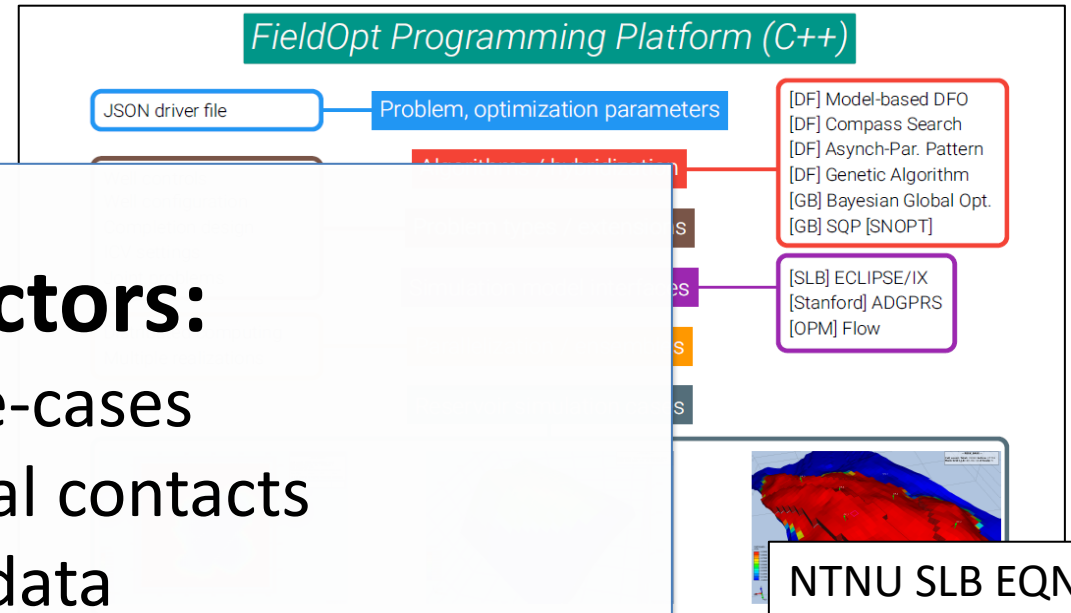
BRU21 success factors



ComputerWell – NTNU spin-off 2020

Computational s

Visit:

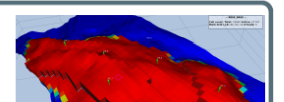


FieldOpt Programming Platform (C++)

JSON driver file — Problem, optimization parameters

- [DF] Model-based DFO
- [DF] Compass Search
- [DF] Asynch-Par. Pattern
- [DF] Genetic Algorithm
- [GB] Bayesian Global Opt.
- [GB] SQP [SNOPT]

[SLB] ECLIPSE/IX
[Stanford] ADGPRS
[OPM] Flow



NTNU SLB EQN

Success factors:

- Industrial use-cases
- Engaged industrial contacts
- Access to data
- Access to industrial expertise
- Capable & experienced PhDs/PostDocs
- NTNU expertise + supervision
- Focus on Innovation



Thiago Lima Silva
PostDoc

Across 5 BRU21 projects

NTNU

whole testing of
ity anisotropy

scholarship from

Faculty of Engineering

Lundin

BRU21

2021

2022

NTNU Research and Innovation Program
in Digital and Automation Solutions
for the Oil and Gas Industry

 NTNU

DISCOVERIES
FOR THE INDUSTRY



22.9%