

BRU21

2020
2021

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



DISCOVERIES
FOR THE INDUSTRY

BRU21 vision

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

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 Norwegian society.

“We regard BRU21 as an innovative and exciting model for collaboration between the industry and NTNU”



– Tor Ulleberg, Equinor

“The knowledge that my work may be utilized for something real is a great motivator in my everyday work”



– Mathilde Hotvedt, BRU21 PhD candidate

Foreword



Prof. Alexey Pavlov
BRU21 Program manager

BRU21 is NTNU's Research and Innovation Program in Digital and Automation Solutions for the Oil and Gas Industry. We combine digital and domain expertise to tackle tough challenges from our industrial partners and explore the possibilities within the digital transformation of the industry. It is very important for us to efficiently transfer the obtained knowledge to the industry. To communicate our research, we have made a series of short videos describing BRU21 projects, results and their potential value.

In this booklet you will find QR codes with links to videos from the BRU21 program areas:

Exploration Efficiency	New Business and Operational Models
Drilling and Well	Field Development and Economics
Reservoir Management and Production Optimization	Operations, Maintenance, Safety and Security

Feel free to contact us for more information or suggestions for further research.

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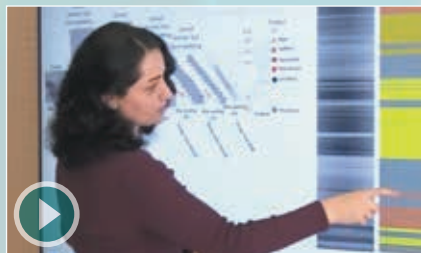
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7491 Trondheim, Norway

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Exploration efficiency

Prototyping future geoscience data organization and analytics tools for improved exploration workflows



Automated lithology classification
employing whole core CT scans



Automatic depth matching of well log data



Rapid downhole testing
of permeability anisotropy



Automated detection
of geological unconformities

Machine learning and seismic data analysis

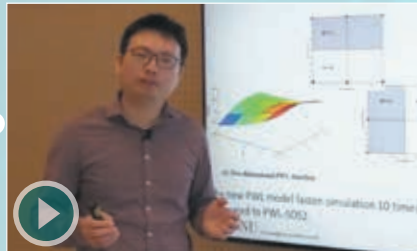
Machine learning and wellbore data analysis

Field development and economics

Developing smart methods for planning and development of offshore fields with high economic value and lower environmental footprint



Staged development enables getting more value out of small discoveries



Decision support in early field development using mathematical programming



Methods to plan environmentally friendly offshore fields

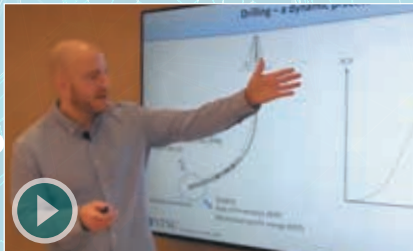
Short-term optimization under uncertainty in the Norwegian natural gas system

Drilling and well

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



Digitalization/automation of life-cycle well integrity



Real-time drilling optimization through continuous micro-testing



NTNU Drillbotics team



Safe drilling in karstified carbonates

Automatic real-time surveillance of drillstring vibrations

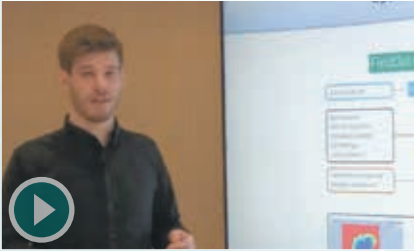
Intelligent data analytics for offshore well integrity and life cycle management



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

Reservoir management and production optimization

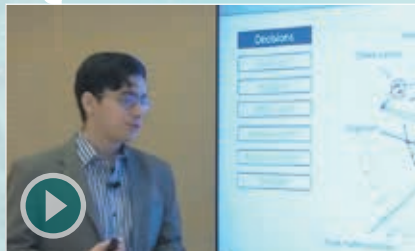
Modelling and optimization of reservoir and production systems – handling uncertainties and unlocking value with Big data and smart analytics



Numerical geo-steering using neural networks on a reservoir model



An improved method for optimal gas-lift allocation using automatic well testing



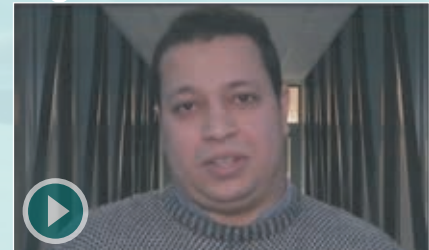
Improving the management of produced water in the Draugen field



Improved technology for production optimization, with focus on gas lift allocation



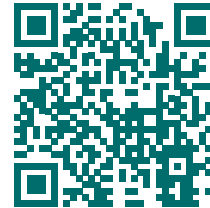
Data-driven reservoir modelling



Assisted history matching for petroleum reservoirs

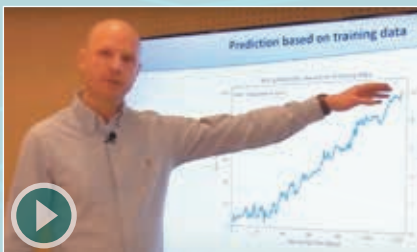


Virtual metering using hybrid modelling: predicting choke performance in Edvard Grieg wells



Operations, maintenance, safety and security

Digital and automation solutions for optimized maintenance, improved safety and reliability and higher security levels



Industry 4.0 and Smart Predictive Maintenance



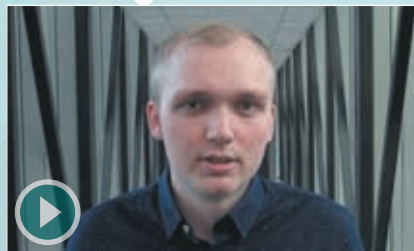
Maintenance optimization in remote operations



Predictive maintenance: Optimization of testing strategy for Emergency Shutdown Valves

Subsea leak detection and localization

Predictive maintenance and residual useful lifetime prediction



Risk-based maintenance



Extending the lifetime of Norwegian oil installations using predictive maintenance



Underwater authentication using acoustic communication and the JANUS standard

New business and operational models

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



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



Socio-technical aspects of collaboration with digital tools in early stage design of offshore facilities



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



An operational model for remote operations that improves safety and reliability

Statements from BRU21 industrial partners



Aker BP's ambition is to build the leading independent E&P company and digitalization is a key component in this strategy. Our digital vision is to digitize the value chain from exploration and abandonment. With strong commitment and support from owners and top management, Aker BP is transforming core end-to-end processes.

Through the BRU21 program, Aker BP is able to support and leverage world class interdisciplinary research at NTNU that is aligned with specific business needs and company strategic priorities. Topics being explored through the program include subsurface understanding, improved maintenance schemes and reduced emission. In addition, the BRU21 program offers an opportunity for Aker BP to contribute to the development of digital and interdisciplinary talent that will be needed to transform the O&G industry."

Kristin Moe Elgsaas, AkerBP, Technology Manager, Concept Development & Technology



OKEA has supported the BRU21 program at NTNU since it was initiated in 2018. The technical focus on digitalization and automation addresses important opportunities for the oil and gas industry. Our use cases were defined on the background of actual problems that we are facing in development projects and operations. The research work is carried out in close collaboration between us, the PhD candidates, and their supervisors at NTNU. The results from these projects are therefore expected to directly add value to our business. In addition to addressing highly relevant topics, the BRU21 program has a strong focus on education. This has allowed us to attract highly skilled young professionals, whom we are proud to support, inspire and collaborate with. We are pleased to announce that one of our use cases is likely to result in a commercial product that we eventually can integrate in our workflows."

Thomas Lerdahl, OKEA, VP Reservoir and Production Technology



We regard BRU21 as an innovative and exciting model for collaboration between the industry and NTNU. We participate in educating the next generation of petroleum technologists with digitalization «under their skin» on top of addressing critical challenges for the future.

Digitalization is a necessary enabler inherent in most future value creation. Our fields of interest range from subsurface technology to risk-based maintenance, remote operations, future operation models and cyber security. Through our participation in BRU21 we contribute to competence development and innovation and thus high value creation in the future."

Tor Ulleberg, Equinor, Senior Advisor Innovation and Collaboration

BRU21 Team

BRU21 Program Steering Committee

Elisabeth Nøst, TechnipFMC
Kim Alexander Jørgensen, Lundin Energy Norway
Danilo Colombo, Petrobras
Therese Rannem, Neptune Energy

Tor Ulleberg, Equinor
Kristin Moe Elgsaas, AkerBP
Thomas Lerdahl, OKEA
Torgeir Norstad, Wintershall DEA

Elisabeth Alne Hendriks, Gassco
Ute Mann, BRU21 program owner, NTNU
Alexey Pavlov, BRU21 program manager, NTNU

Program area teams

Exploration efficiency

K. Duffaut, Geophysics
C.F. Berg, Reservoir Engineering
F.O. Westad, Big Data Cybernetics
I. Tyukin, Artificial Intelligence, Machine Learning
D. Varagnolo, Statistical Learning and Control
A. Yazidi, Machine Learning
V.A.T. Caceres, PhD candidate
K. Chawshin, PhD candidate
L. Alberts, PostDoc

Operations, maintenance, safety and security

J. Vatn, Maintenance, Risk & Optimization
M.A. Lundteigen, Safety of Automation Systems
P. Schjøberg, Maintenance Management and Industry 4.0
P. Salvo Rossi, Machine Learning for Signal Processing
S. Katsikas, Cyber Security
S. Wolthusen, Cyber Security
E. Sølvsberg, PhD candidate
M. Bratland Kvammen, PhD candidate
G. Tabella, PhD candidate
B. Zoltán Téglásy, PhD candidate
T.I. Pedersen, PhD candidate
A. Md Ariful Islam, PhD candidate
E.M. Laskowska, PhD candidate

Drilling and well

S. Sangesland, Petroleum Engineering
A. Pavlov, Petroleum Cybernetics
S. Hovda, Drilling Engineering
T.B. Gjersvik, Subsea Engineering
B. Elahifar, Drilling Engineering
B. Aadnøy, Drilling Engineering
A. Teigland, PhD candidate
D. Maksimov, PhD candidate
I. Pirir, PhD candidate
M. Nystad, PhD candidate
M. Gomar, PhD candidate

Field development and economics

M. Stanko, Petroleum Engineering
V. Hagspiel, Investment and Finance
M. Lavrutich, Industrial Economics
L. Imsland, Automatic Control and Optimization
A. Tomasgard, Industrial Economics & Technology Management
G. Lei, PhD candidate
S. Fedorov, PhD candidate
S. Ki Moon, PhD candidate

Reservoir management and production optimization

L. Imsland, Optimization and Control
C.F. Berg, Reservoir Engineering
A. Jahanbani Ghahfarokhi, Reservoir Engineering
A. Pavlov, Petroleum Cybernetics
M. Hovd, Optimization-based Control
D. Varagnolo, Statistical Learning and Control
J. Kleppe, Reservoir Engineering
M. Bellout, Reservoir Optimization
M. Hotvedt, PhD candidate
J. Rostrup Andersen, PhD candidate
T. Daa-Eldeen, PhD candidate
C. Shang Wui Ng, PhD candidate
B. Strand Kristoffersen, PhD candidate
O. Fonseca, PhD candidate
M. Mirzayev, PostDoc
T. Lima Silva, PostDoc

New business and operational models

P.M. Schiefloe, Sociology
E. Monteiro, Information Systems
M.A. Lundteigen, Safety of Automation Systems
K. Duffaut, Geophysics
V. Hepsø, Digitalization
I. Mohallick, PhD candidate
N. Korotkova, PhD candidate
M. Moradi, PhD candidate
R. Spahic, PhD candidate

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.

