BRU21

2021
—
2022

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

interesting
important
innovative inspiring

i4

18.5%
22.9%

NTNU

DISCOVERIES
FOR THE INDUSTRY

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 Norwegian society.

"Through the BRU21 program, AkerBP is able to support and leverage world class interdisciplinary research at NTNU aligned with company strategic priorities"

– Kristin Moe Elgsaas, AkerBP

"BRU21 network and creative atmosphere help me to address industrial challenges and support me in developing solutions that are useful in the real world"

– Rialda Spahic, 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.

CONTACT

Alexey Pavlov
alexey.pavlov@ntnu.no

BRU21 program
S.P. Andersens v. 15A,
7491 Trondheim, Norway

www.ntnu.edu/bru21

TechnipFMC   AkerBP   NORWEGIAN PETROLEUM DIRECTORATE   OKEA   NTNU   GASSCO

equinor   BR PETROBRAS   Lundin Energy Norway   wintershall dea   NEPTUNE ENERGY

Exploration efficiency

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

BRU21 innovation

PERMEAN:

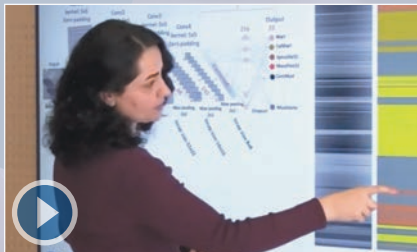Rapid downhole testing of permeability anisotropy

▶ p.**12**

Machine learning and seismic data analysis

Automated detection of geological unconformities

Machine learning and wellbore data analysis

Automated lithology classification employing whole core CT scans

Automatic depth matching of well log data

www.ntnu.edu/bru21/ee

Field development and economics

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

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

Operator-contractor risk and benefit sharing in oil exploration and production

Optimal field planning considering uncertainties and environmental performance

Improved planning method for more energy efficient and environmentally friendly field development

www.ntnu.edu/bru21/fde

Drilling and well

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

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

NTNU Drillbotics team

BRU21 innovation

MAC:

Acoustic look-ahead technology based on machine learning

▶ p.**12**

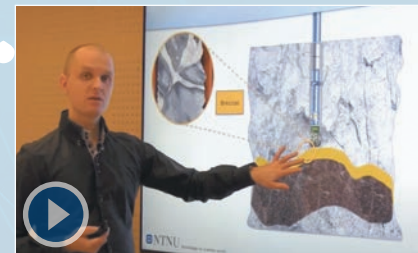Digitalization/automation of life-cycle well integrity

BRU21 innovation

ComputerWell:

Drillstring digital twin

▶ p.**12**

Intelligent data analytics for offshore well integrity and life cycle management

Safe drilling in karstified carbonates

www.ntnu.edu/bru21/dw

Reservoir management
and production optimization

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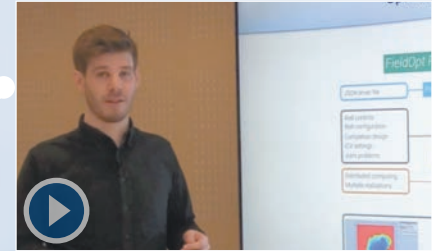

Numerical geo-steering using neural networks on a reservoir model

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

Virtual metering using hybrid modelling: predicting choke performance in Edvard Grieg wells
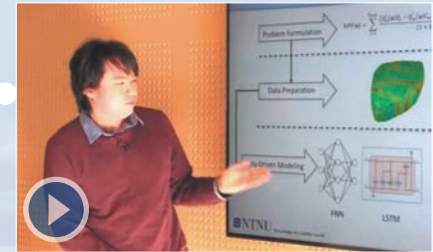
Data-driven reservoir modelling
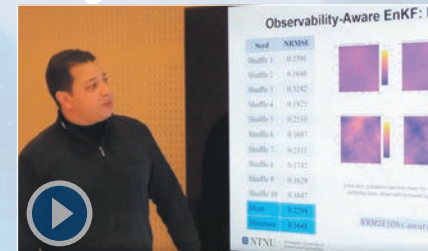

Improving the management of produced water in the Draugen field

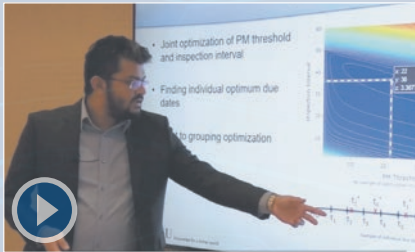Non-disturbing well testing for optimal gas-lifted production

Reservoir history matching using observability-based ensemble Kalman filter
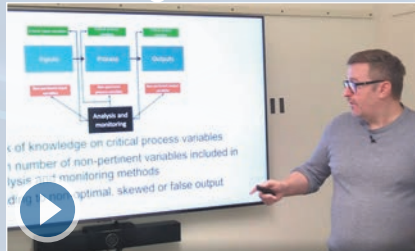
Operations, maintenance, safety and security

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

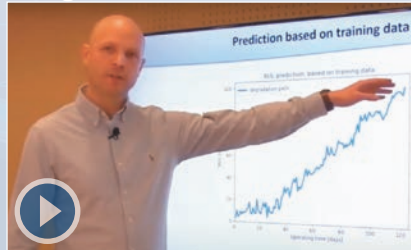Maintenance decision support in remote operations

Life extension and smart maintenance in existing Norwegian oil installations
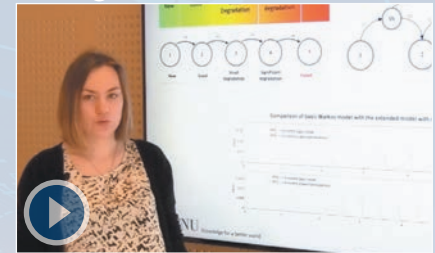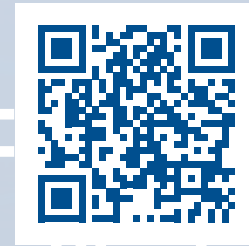

Underwater authentication using acoustic communication and the JANUS standard

Risk-based maintenance

Predictive maintenance on centrifugal pumps

Predictive maintenance: Optimization of testing strategy for Emergency Shutdown Valves

Subsea leak detection and localization

New business and operational models

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

FIELD DEVELOPMENT
AND ECONOMICS

RESERVOIR MANAGEMENT
AND PRODUCTION OPTIMIZATION

NEW BUSINESS
AND OPERATIONAL MODELS

Ensuring reliability of unmanned autonomous systems

Optimal operation, maintenance and investment strategies for offshore energy hubs

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

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

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

Artificial Intelligence in safety-critical remote operations

www.ntnu.edu/bru21/nbom

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i4 innovation
BRU21

Research-based innovation projects on the way to the industry

Prodecs: Better investment decisions

Permean: Rapid downhole testing of permeability anisotropy

ADF: Drilling data analytics tool

ComputerWell: Drillstring digital twin

MAC: Acoustic look-ahead technology based on machine learning

inspiring • interesting • innovative • important

BRU21 Academy

Courses on recent advances in digitalization and automation for the Oil and Gas industry

IT6207 – Remote operations

PK6029 – Digital solutions for planning and optimization of maintenance

PK6031 – Digital twins for managing safety and reliability of systems

PG6210 – Petroleum cybernetics for engineers and managers

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

"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

"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

Statements from BRU21 graduates

"During my PhD project, I developed workflows to automate the tasks of lithology classification and transport properties estimation using machine learning. The BRU21 program gave me – a petroleum geologist with background in the oil industry – an opportunity to explore a completely new area: data science and artificial intelligence. The multidisciplinary aspect of this program makes it very special as it connects researchers with various academic and industrial backgrounds. This way the BRU21 program can leave its footprints across the oil and gas value chain from exploration all the way to production and abandonment."

Kurdistan Chawshin,
Chief Petroleum Data Scientist, Prores AS

"BRU21 program has given me an opportunity to develop new skills, especially in the computer science field. These skills have broadened my professional competence and increased my curiosity about how to find innovative ways of developing and implementing concepts and theories from different fields to tackle challenging problems. The program strongly focuses on solving engineering challenges faced by oil and gas companies. This is very beneficial since the new insights and knowledge I acquired during my PhD project can be easily applied in practice."

Veronica Alejandra Torres Caceres
Geophysicist - Data manager/Machine learning Scientist, Exploro Geoservices

"BRU21 was an integral part of my PhD studies. It provided an arena for collaboration and a place to discuss and exchange ideas with fellow colleagues. The special thing about BRU21 is that it gathers people with diverse competences and fosters collaboration and learning between these disciplines. The program has eased my transition from academia to industry by exposure to industrial partners. Participating in the program has also given me a wide social and professional network that I continue to utilize after finishing the program."

Andreas Teigland,
Engineer D&W Operations, Equinor

exploro geoservices

SINTEF

AkerBP

NOV

NTNU

equinor

Prores

AkerSolutions

Solution Seeker

aspentech

ROCKET LAB

NTNU Drillbotics Team 2022

International SPE Drillbotics Competition

BRU21 prepares future experts in drilling automation

NTNU drilling engineering and cybernetics students – Luis Carlos Alvarez Solis, Mikaela Solberg, Henrik Helgeland and Jarle Ness – develop and program a miniature robotic drilling rig for fully autonomous directional drilling. The team is coached by BRU21, and sponsored by NTNU, Equinor and Lyng Drilling. After being ranked as #1 in the pre-finals, the team intends to repeat the NTNU successes of previous years: 1st place in 2018, 2021 and 2nd place in 2017.

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
Arne Jacobsen, The Norwegian Petroleum Directorate
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
D. Varagnolo, Statistical Learning and Control
V.A.T. Caceres, BRU21 graduate
K. Chawshin, BRU21 graduate
L. Alberts, BRU21 graduate
P. Audhkhasi, PostDoc
PhD candidate to be hired

Operations, maintenance, safety and security

J. Vatn, Maintenance, Risk & Optimization
M.A. Lundteigen, Safety of Automation Systems
P. Schjølberg, 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 canidate
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, BRU21 graduate
D. Maksimov, BRU21 graduate
M. Nystad, BRU21 graduate
M. Gomar, PhD candidate
PhD candidate to be hired

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, PostDoc
S. Ki Moon, PhD candidate
O. Noshchenko, PhD candidate
S.S.U. Kumar, PhD candidate

Associated projects (EU funded)

R.A.A. Santos, PhD candidate (InnoCyPES)
PhD candidate to be hired (Perseus)

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
B. Strand Kristoffersen, BRU21 graduate
T. Lima Silva, BRU21 graduate
M. Hotvedt, PhD candidate
J. Rostrup Andersen, PhD candidate
T. Diaa-Eldeen, PhD candidate
C. Shang Wui Ng, PhD candidate
O. Fonseca, PhD candidate
K. Løvland, PhD candidate
2 PhD candidates to be hired

New business and operational models

E. Monteiro, Information Systems
P.M. Schiefloe, Sociology
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

BRU21 PROGRAM
– a success case in the OG21 strategy

BRU21

OG21

"The BRU21 initiative has been successful in attracting talent partly because it recruits already experienced people from the industry that want a career boost, partly because it recruits from a diverse set of academic backgrounds, and partly because it offers projects that combine digital and domain disciplines. Another success from the initiative is the close collaboration with the industry, where the students are engaged to solve concrete challenges (use cases). This is motivational for the students and it provides real value in return for the funding that the industry partners provide."

– OG21, Technology Strategy for the Petroleum Industry in Norway