BRU21

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. 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

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.
Machine learning and seismic data analysis

Machine learning and wellbore data analysis

PERMEAN:
Rapid downhole testing of permeability anisotropy

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

OPERATIONS, MAINTENANCE, SAFETY AND SECURITY
DRILLING AND WELL
EXPLORATION EFFICIENCY

Automated lithology classification employing whole core CT scans
Automated depth matching of well log data
Machine learning and wellbore data analysis
Machine learning and seismic data analysis

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
Drilling and well

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

ComputerWell: Drilling digital twin

Safe drilling in karstified carbonates

Digitalization/automation of life-cycle well integrity

Intelligent data analytics for offshore well integrity and life cycle management

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

MAC: Acoustic look-ahead technology based on machine learning
Reservoir management and production optimization

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

- Non-disturbing well testing for optimal gas-lifted production
- Improving the management of produced water in the Draugen field
- Virtual metering using hybrid modelling: predicting choke performance in Edvard Grieg wells
- Data-driven reservoir modelling
- Reservoir history matching using observability-based ensemble Kalman filter
- Improved technology for production optimization, with focus on gas lift allocation
- Numerical geo-steering using neural networks on a reservoir model
Operations, maintenance, safety and security

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

- Predictive maintenance on centrifugal pumps
- Optimization of testing strategy for Emergency Shutdown Valves
- Underwater authentication using acoustic communication and the JANUS standard
- Life extension and smart maintenance in existing Norwegian oil installations
- Risk-based maintenance
- 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

- 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
- Ensuring reliability of unmanned autonomous systems
- 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
BRU21 innovation

Research-based innovation projects on the way to the industry

Permean: Rapid downhole testing of permeability anisotropy

MAC: Acoustic look-ahead technology based on machine learning

Prodecs: Better investment decisions

ADF: Drilling data analytics tool

ComputerWell: Drillstring digital twin

important • innovative • interesting • inspiring
BRU21 Academy

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

- **IT6207** – Remote operations
- **PK6031** – Digital twins for managing safety and reliability of systems
- **PK6029** – Digital solutions for planning and optimization of maintenance
- **PG6210** – Petroleum cybernetics for engineers and managers

Photos courtesy of Siemens, NTNU Grafisk Senter, Thor Nielsen and Anne-Line Bakken
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
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 Elgsaaas, 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

**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  
M. 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

**Reservoir management and production optimization**

L. Imsland, Optimization and Control  
C.F. Berg, Reservoir Engineering  
A. Jahanbani Ghaftarokhi, 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. Levland, PhD candidate  
2 PhD candidates 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. Sølvberg, PhD candidate  
M. Bratland Kvammen, PhD candidate  
G. Tabella, PhD candidate  
B. Zoltan Teglas, PhD candidate  
T.I. Pedersen, PhD candidate  
A. Md Ariful Islam, PhD candidate  
E.M. Laskowska, 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, PostDoc  
S. Ki Moon, PhD candidate  
O. Noshchenko, PhD candidate  
S.S.U. Kumar, PhD candidate

**New business and operational models**

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

**Associated projects (EU funded)**

R.A.A. Santos, PhD candidate (InnoCyPES)  
PhD candidate to be hired (Perseus)
BRU21 PROGRAM

– a success case in the OG21 strategy

"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