BRU21 conference

Digital Tools for Offshore Energy Systems

Trondheim, May 31 – June 1, 2023

NTNU

NTNU

BRU21
Better Resource Utilization in the 21st century

BRU21: Research and Innovation Program in Digital and Automation Solutions for Offshore Energy Industry

Prof. Alexey Pavlov – BRU21 program manager

NTNU TechnipFMC equinor AkerBP OKEA wintershall dea GASSCO NEPTUNE ENERGY OLJEDIREKTORATET PETROBRAS

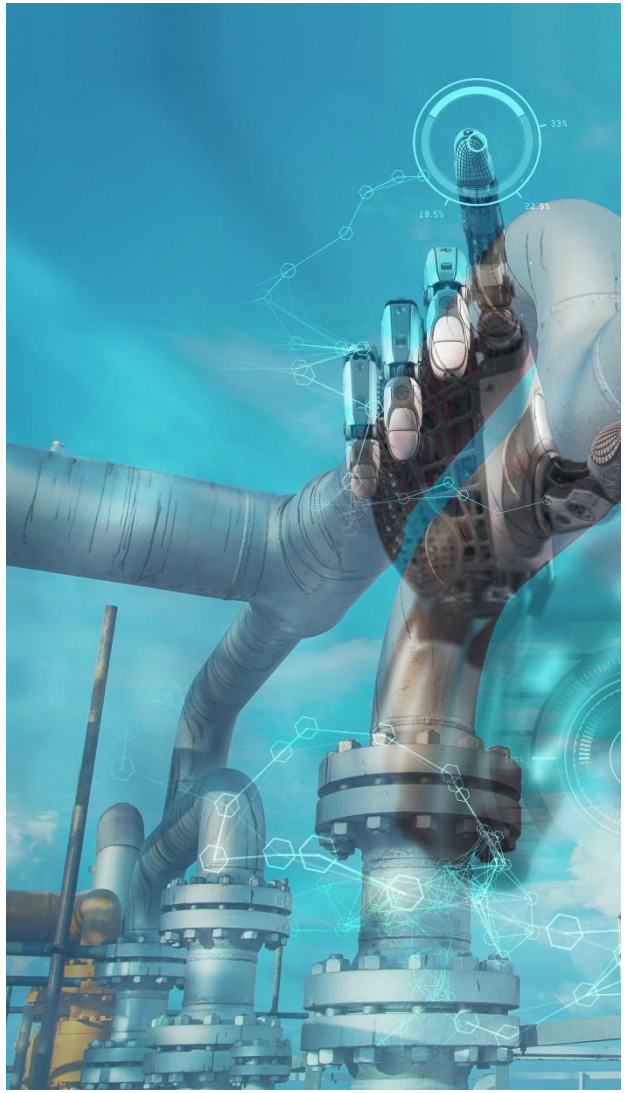
BRU21 vision, mission and goal

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 Offshore Energy industry and for the Norwegian society



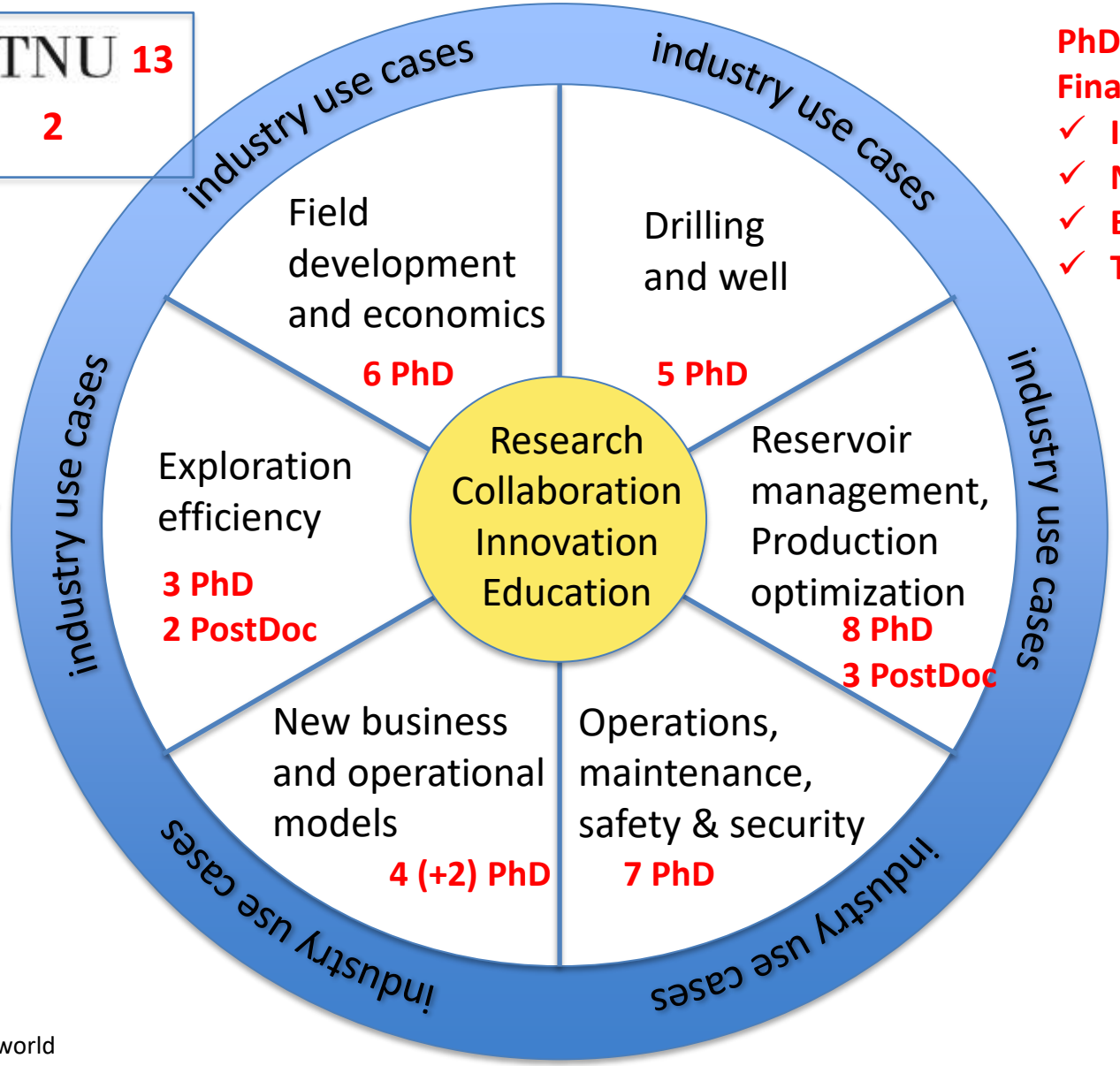
BRU21: Industry – NTNU collaboration

Industrial partners

- AkerBP 9
- GASSCO 1
- TechnipFMC 2
- OLJEDIREKTORATET
- PETROBRAS 1

NTNU 13

2



PhD/PostDoc Financed by:

- ✓ Industry: 26
- ✓ NTNU: 13
- ✓ EU: 2
- ✓ Total: 41

Industrial partners

- 5 equinor
- 4 OKEA
- 2 wintershall dea
- 2 NEPTUNE ENERGY

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BRU21 Research: 41 PhD/PostDoc projects

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

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New measurement solutions:
How to get new/more/faster measurements?
(e.g. from existing or new sensors)

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Automated data preparation:
Automated data preprocessing for advanced analytics tools (ML, AI)

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	– NTNU				

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Automated extraction of information from data
Events, trends, anomalies, properties

6

Drilling and Well

- Safe drilling in karstified carbonates — Lundin Norway
- Intelligent data analytics for offshore well integrity and life cycle management — PETROBRAS
- Real time fault and symptoms detection in drilling operation with wired pipe — NTNU
- Digitalization/automation of life-cycle well integrity — NTNU
- Drilling data analytics — NTNU
- Hard stringers prediction with acoustic look-ahead — AkerBP

Reserv… Produ…

- A hybrid da… model for … the oil and …
- Production … offshore pr… water proc…
- Improved technology for production optimization, with focus on gas lift allocation — wintershall dea
- Assisted history matching for petroleum reservoirs — equinor
- Assisted history matching, reservoir model update and optimization — equinor
- Optimization of production, reservoir and field development — NTNU
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- Machine learning-based production optimization — NTNU
- — NTNU

- Predictive Maintenance and Remaining Useful Lifetime — OKEA
- Risk-based maintenance — equinor
- Industry 4.0 and smart predictive maintenance — NTNU
- Safety and security in design and operation of ICS systems — NTNU
- …etection and localization of …ubsea leakages — NTNU

- From idea to discovery: information sharing and cooperation in the exploration value chain — NEPTUNE ENERGY
- Remote operations and future operating models — equinor
- Offshore energy hubs: investment, operation and maintenance
- AI for safety-critical remote operations

5

Exploration efficiency

- Does well data quality affect machine learning performance? — AkerBP
- Automated Seismic Reconstruction of Missing Section — NEPTUNE ENERGY
- — wintershall dea
- Automated lithology classification of whole core CT scans — equinor
- …Machine learning-based generic well log depth matching — AkerBP
- Rapid Downhole Testing of Permeability Anisotropy — NTNU, Lundin Norway

6

Field development and economics

- Improved planning methods for more energy efficient and environmentally friendly fields in the Barents Sea — AkerBP
- Cost effective development of (small) discoveries on the NCS — OKEA
- Automated methodologies for decision support in field development — Lundin Norway
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- Real options-based valuation for environmentally friendly O&G production — NTNU

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Fast and accurate
fit-for purpose models

- Physics-based, data-driven, hybrid
- Automated model updates
- Digital twins

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Optimization in planning and operation

- offline and real-time
- small- & large scale
- model-based, data-driven, hybrid

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Digital tools for efficient decision-making

- uncertainty
- flexibility
- avoid information loss
- multiple objectives

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Organizational solutions for the digital transformation

- Collaboration
- Data sharing strategies
- New operational models

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Transition to sustainable & decarbonized energy

- Electrification / Remote operations
- New energy projects development

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	(NTNU)				

Reduction of environmental footprint

More than half of all BRU21 projects contribute to reduced environmental footprint and increased safety

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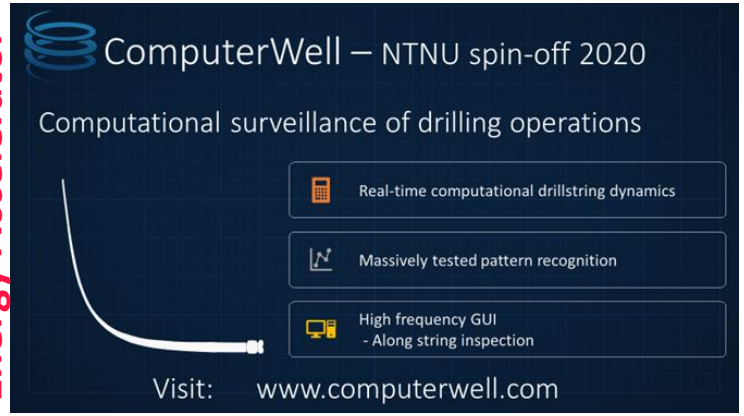
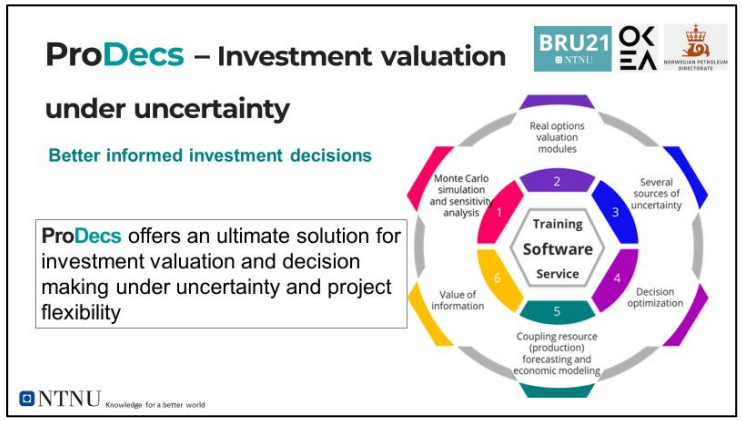
BRU21 Innovation

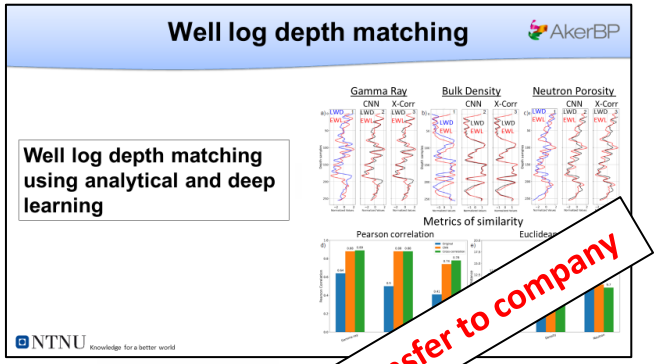
Equinor & Techstars Energy Accelerator



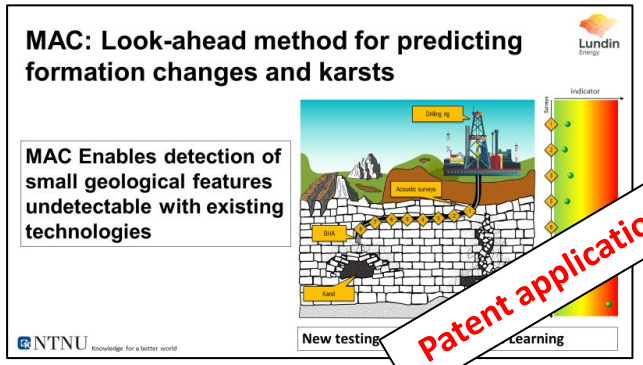
KONGSBERG HOW



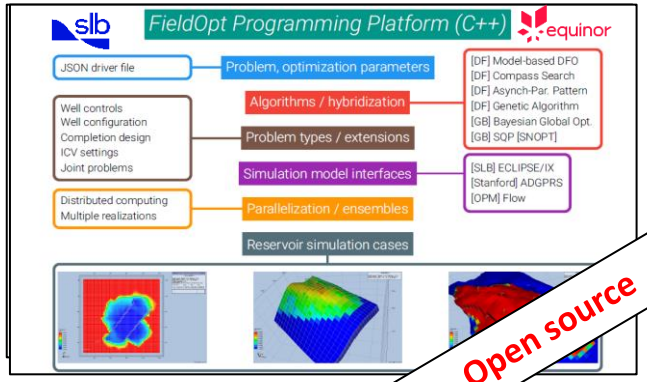
Innovation examples



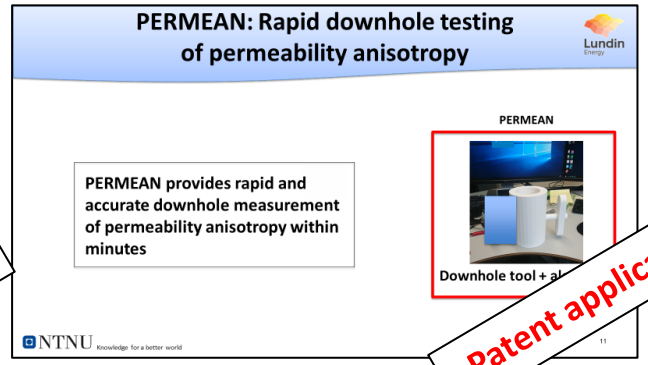
Transfer to company



Patent application



Open source



Patent application

AkerBP equinor OLJEDIREKTORATET

NTNU Technology Transfer as

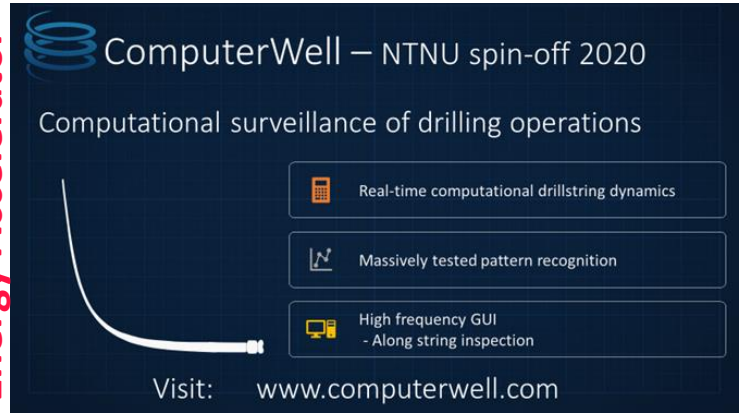
NTNU Discovery

Kongsberg Innovation

Forskningsrådet

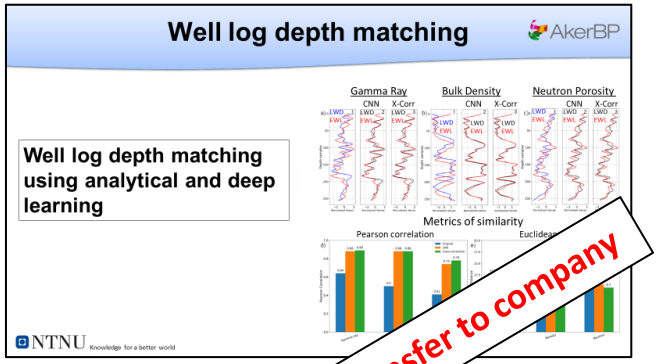
BRU21 Innovation

Equinor & Techstars Energy Accelerator

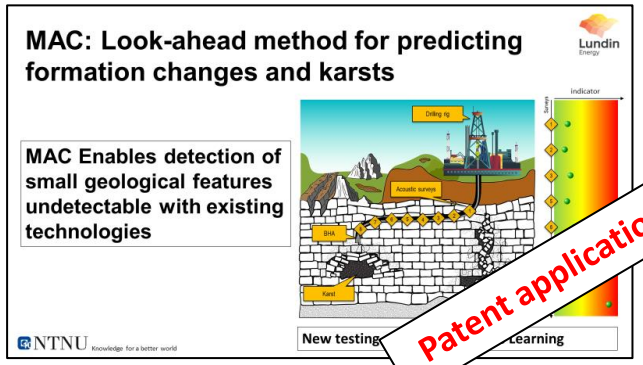


KONGSBERG HOW

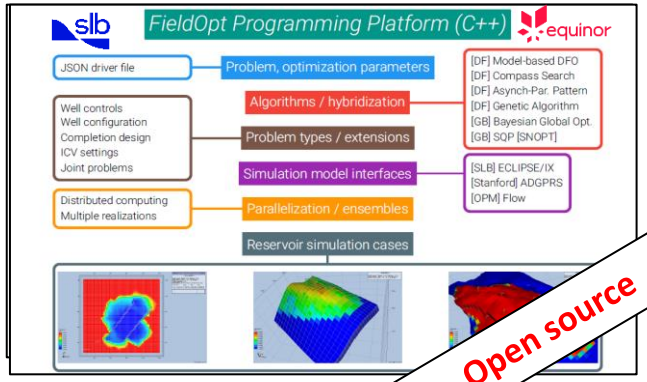
Innovation examples



Transfer to company



Patent application



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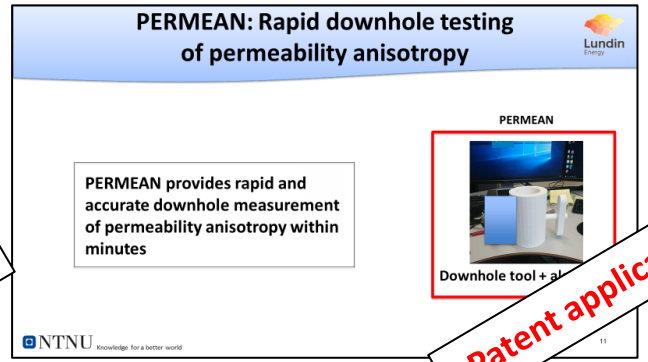


Patent application

AkerBP equinor OKEA OLJEDIREKTORATET

NTNU Technology Transfer as

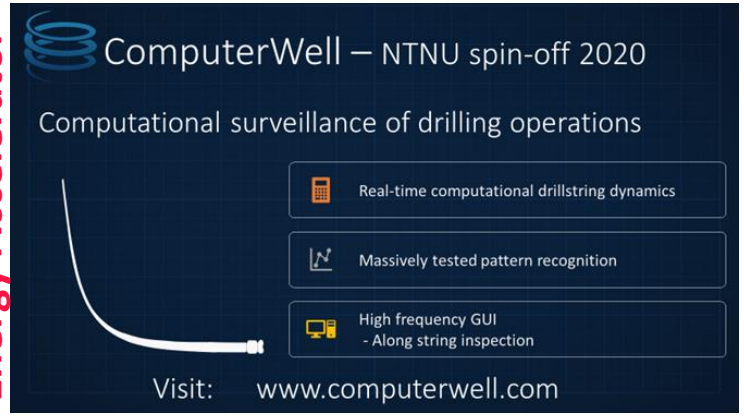
NTNU Discovery

Kongsberg Innovation

Forskningsrådet

BRU21 Innovation

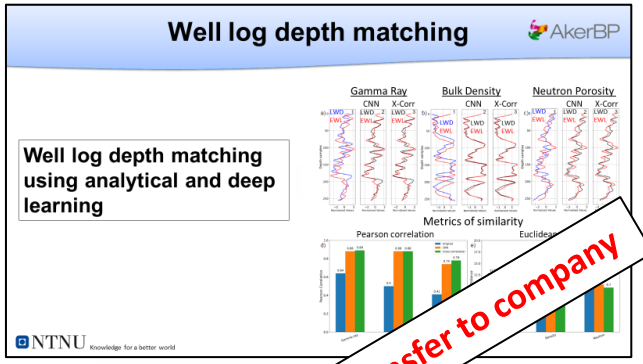
Equinor & Techstars Energy Accelerator



KONGSBERG HOW

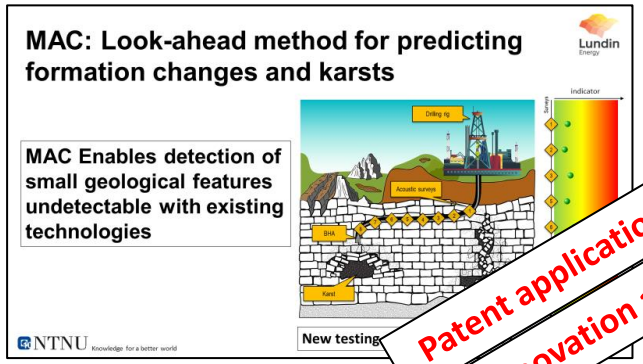
Innovation examples

Further development



Transfer to company

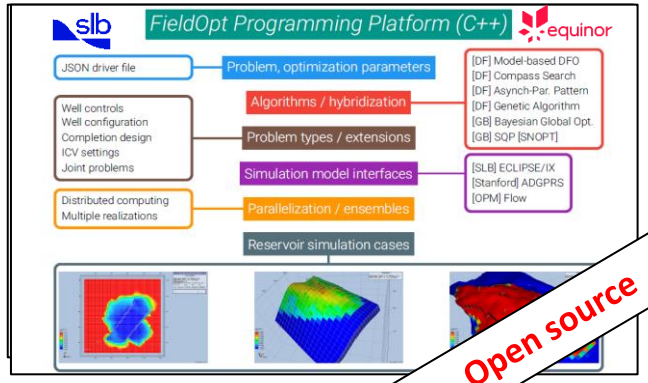
Further development



Patent application

IV Innovation award

Further development



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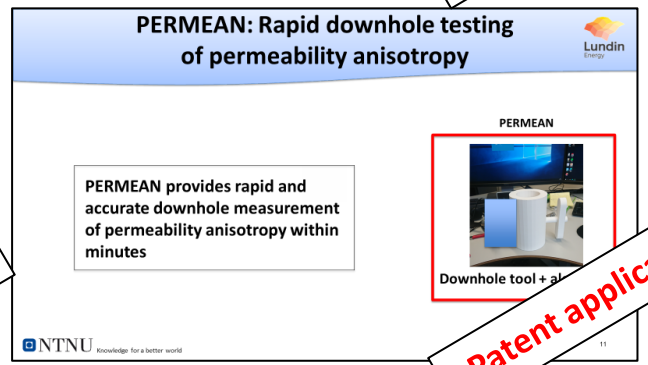

Patent application

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NTNU Technology Transfer as

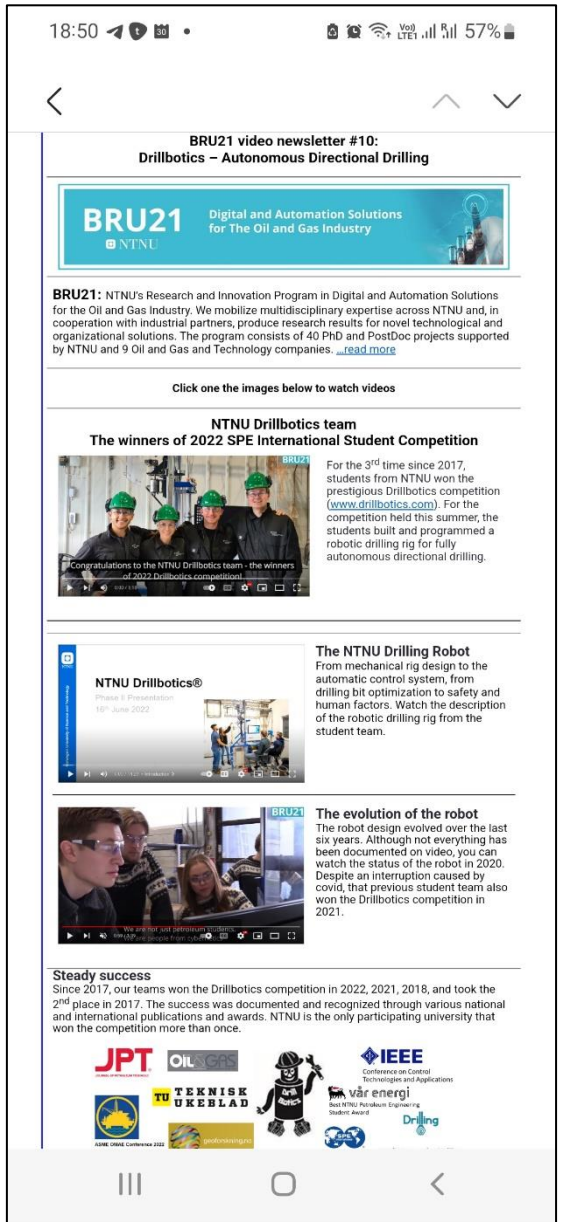
NTNU Discovery

Kongsberg Innovation

Forskningsrådet

Innovative Dissemination

Video Newsletters



BRU21 video newsletter #10:
Drillbotics – Autonomous Directional Drilling

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 40 PhD and PostDoc projects supported by NTNU and 9 Oil and Gas and Technology companies. ...read more

Click one the images below to watch videos

NTNU Drillbotics team
The winners of 2022 SPE International Student Competition

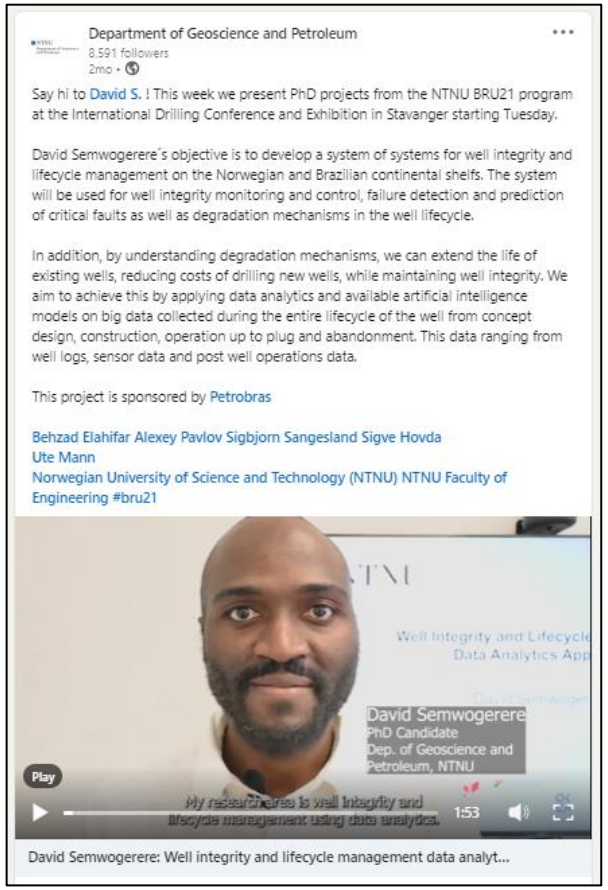
For the 3rd time since 2017, students from NTNU won the prestigious Drillbotics competition (www.drillbotics.com). For the competition held this summer, the students built and programmed a robotic drilling rig for fully autonomous directional drilling.

The NTNU Drilling Robot
From mechanical rig design to the automatic control system, from drilling bit optimization to safety and human factors. Watch the description of the robotic drilling rig from the student team.

The evolution of the robot
The robot design evolved over the last six years. Although not everything has been documented on video, you can watch the status of the robot in 2020. Despite an interruption caused by covid, that previous student team also won the Drillbotics competition in 2021.

Steady success
Since 2017, our teams won the Drillbotics competition in 2022, 2021, 2018, and took the 2nd place in 2017. The success was documented and recognized through various national and international publications and awards. NTNU is the only participating university that won the competition more than once.

LinkedIn



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Say hi to David S. ! This week we present PhD projects from the NTNU BRU21 program at the International Drilling Conference and Exhibition in Stavanger starting Tuesday.

David Semwogerere´s objective is to develop a system of systems for well integrity and lifecycle management on the Norwegian and Brazilian continental shelfs. The system will be used for well integrity monitoring and control, failure detection and prediction of critical faults as well as degradation mechanisms in the well lifecycle.

In addition, by understanding degradation mechanisms, we can extend the life of existing wells, reducing costs of drilling new wells, while maintaining well integrity. We aim to achieve this by applying data analytics and available artificial intelligence models on big data collected during the entire lifecycle of the well from concept design, construction, operation up to plug and abandonment. This data ranging from well logs, sensor data and post well operations data.

This project is sponsored by Petrobras

Behzad Elahifar Alexey Pavlov Sigbjorn Sangesland Sigve Hovda
Ute Mann
Norwegian University of Science and Technology (NTNU) NTNU Faculty of Engineering #bru21

David Semwogerere: Well integrity and lifecycle management data analyt...

Video reports

800+ copies

Discoveries for the Industry

- 77+ videos on projects and project results
- Video proceedings of BRU21 conference 2022
- Training in efficient business communication

BRU21 Collaboration

IX Oil and Gas Production Optimization Workshop
Digital Transformation for Sustainable Production

NTNU – Trondheim
Norwegian University of Science and Technology

UNIVERSIDADE FEDERAL DE SANTA CATARINA

PETROBRAS

The Research Council of Norway

Rio de Janeiro, March 2-3, 2023

OSDU Workshop

NTNU

equinor

CEGAL

slb

NTNU, April 28, 2023

2nd Training School on Innovative Tools for Cyber-Physical Energy Systems

InnoCyPES
Innovative Tools for Cyber-Physical Energy Systems

NTNU

DTU Technical University of Denmark

equinor

Universiteit Utrecht

EDF

SIEMENS Gamesa RENEWABLE ENERGY

UNIVERSITÀ DEL SALENTO

TU Delft

ETH zürich

Typhoon HIL

Imperial College London

AIT AUSTRIAN INSTITUTE OF TECHNOLOGY

Trondheim, January 23 – February 1, 2023

BRU21 Collaboration

BRU21 Conference

Trondheim, June 2, 2022

Trondheim, May 31-June 1, 2023

PETROBRAS

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AkerBP

Offshore energy projects are becoming increasingly complex. New technologies; technical, market, and regulatory uncertainties, as well as rapid changes, must be addressed to reduce CO2 emissions ar ...see more

Knut Sandvik, Aker BP on NTNU collaboration and BRU21

AkerBP

AkerBP

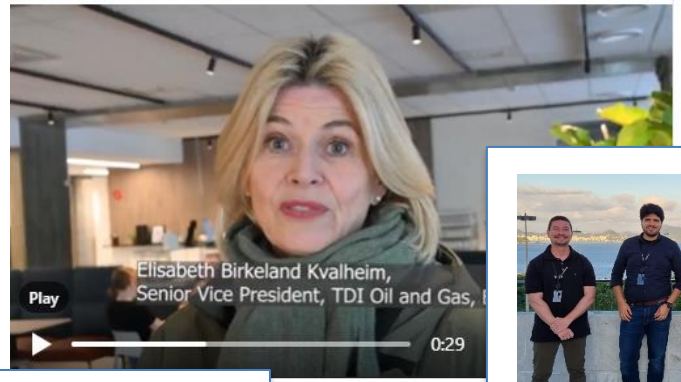
AkerBP

NTNU

equinor

Yesterday Elisabeth Birkeland Kvalheim, Equinor's Senior Vic
and Gas in Technology Digital and Innovation brought her lea
to Norwegian University of Science and Technology (NTNU) to ...see more

equinor



equinor **Technology Executive Program**

equinor **Brazil**

International Energy Agency

slb

HALLIBURTON

Trondheim, January 23 – February 1, 2023

BRU21 Academy: Knowledge transfer to the industry

Petroleum Cybernetics for Engineers and Managers
(A. Pavlov, M. Stanko)

Digital solutions for planning and optimization of maintenance
(J. Vatn)

Launching in 2023

Digital Twins for Managing Safety and Reliability of Systems
(J. Vatn)

Remote operations
(V. Hepsø)

KOMPETANSE NORGE

BRU21 graduates

Defended PhD projects


Brage Strand Kristoffersen


Kurdistan Chawshin


Magnus Nystad


Andreas Teigland


Danil Maksimov


Veronica Alejandra Torres Caceres


Semyon Fedorov


Mathilde Hotvedt


Guowen Lei


Tom Ivar Pedersen


Joakim Rostrup Andersen


Cuthbert Shang Wui Ng

Completed PostDoc projects


Luc Alberts


Thiago Lima Silva


Mammad Mirzayev

BRU21 Education: Drillbotics

BRU21

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Schlumberger

SPE International
Drilling Systems Automation Technical Section

ALTUS Intervention

DNV

OLIASOFT

equinor

Capgemini

bouvet

moreld apply

ConocoPhillips

MACQUARIE

wintershall dea

AkerBP

WEBSTEP

slb

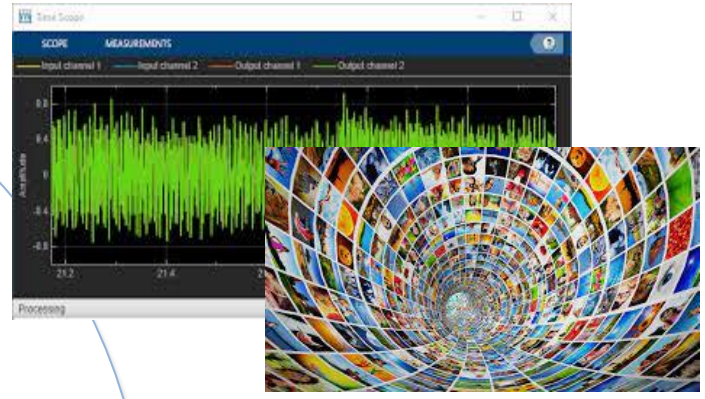
CCB SUBSEA AS

HALLIBURTON

BRU21: Fun place to work

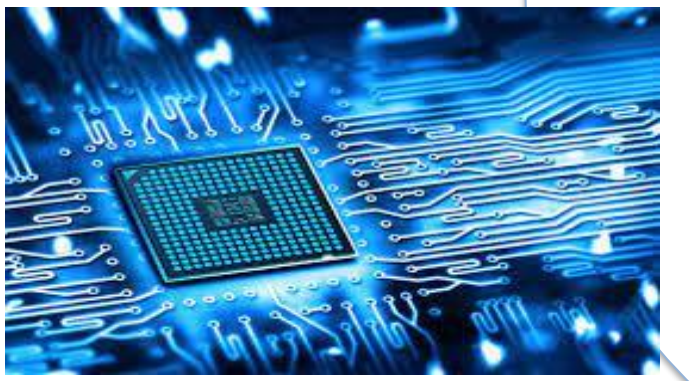
Gaming

Offshore energy industry



Audio/video processing

BRU21



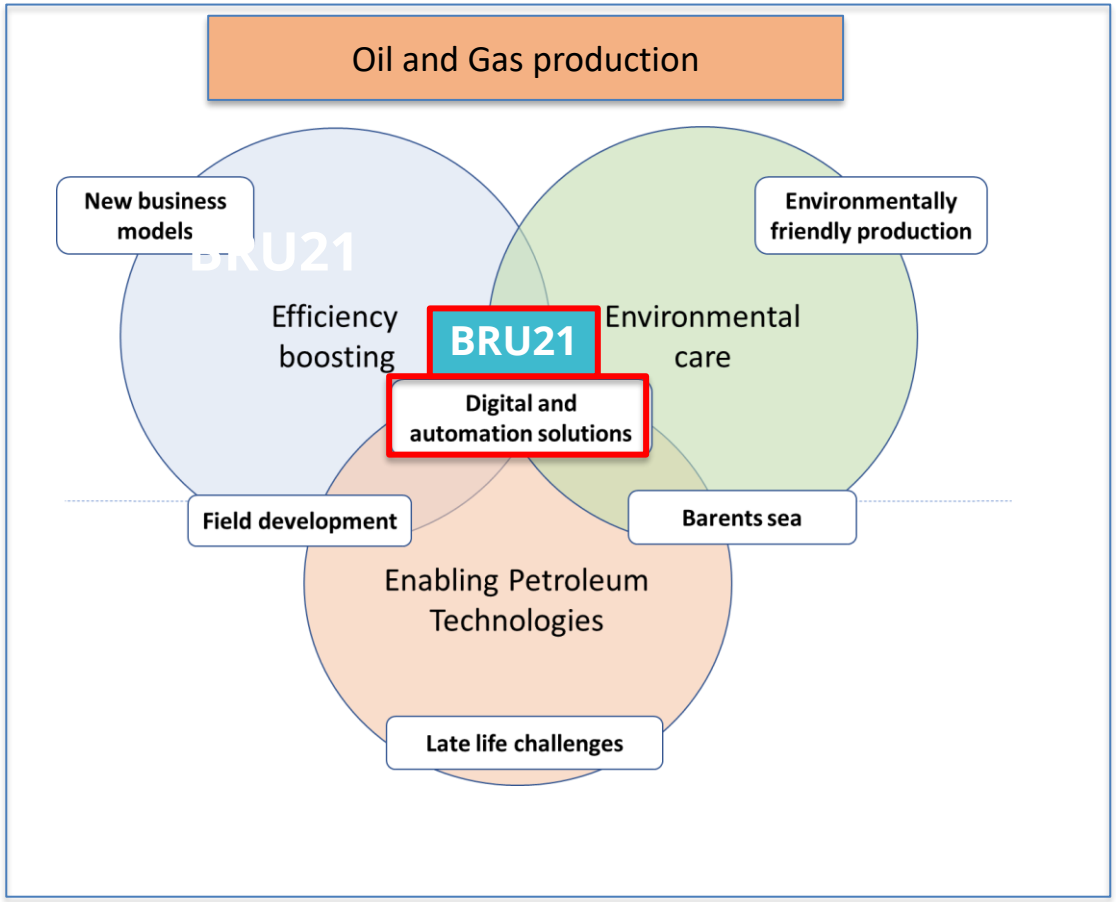
Semiconductor industry

Pharmaceutical industry

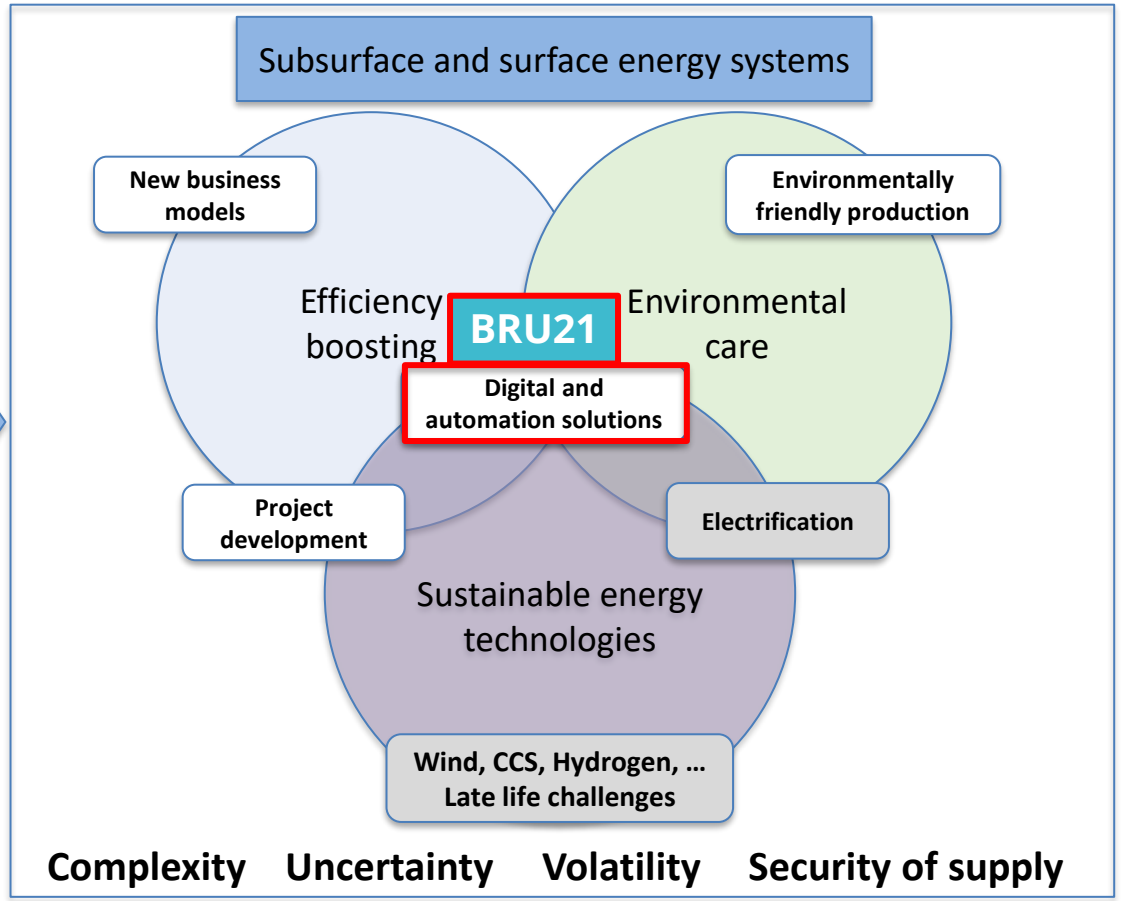
Finance industry

BRU21: outlook into the future

Industry perspective in 2017



… and in 2023



BRU21 program

Alexey Pavlov
BRU21 program manager
alexey.pavlov@ntnu.no

NTNU