NTNU
Norwegian University of
Science and Technology

Innovation, Equity & The Future of Prosperity
Workshop 12-13. November 2021

'Innovation and sustainable transition from oil and gas to renewables. Changes in Skills, automation and quality of work, a Scandinavian perspective'

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Who is Vidar Hepsø?

- Adjunct Professor in Digitalisation NTNU (2010->)
- Academic training (PhD NTNU 2002)
  - Anthropology of Science and Technology
  - [25 years of publications in this field]
- Informatics
- R&D Equinor
  - Multifield control rooms (offshore wind and O&G)
  - Digitalization

Drivers of change

DEMOGRAPHY
Increasing age dependency ratios, urbanization, and reinforced competition to attract migrant European labour will bring more shortages of labour and skills and heighten pressures for third-country labour import.

CLIMATE CHANGE
Efforts to counter and adapt to climate change require renewal of infrastructure, energy systems and patterns of production, work, and communication, demanding new skills and more shifts of jobs, occupations, and residence

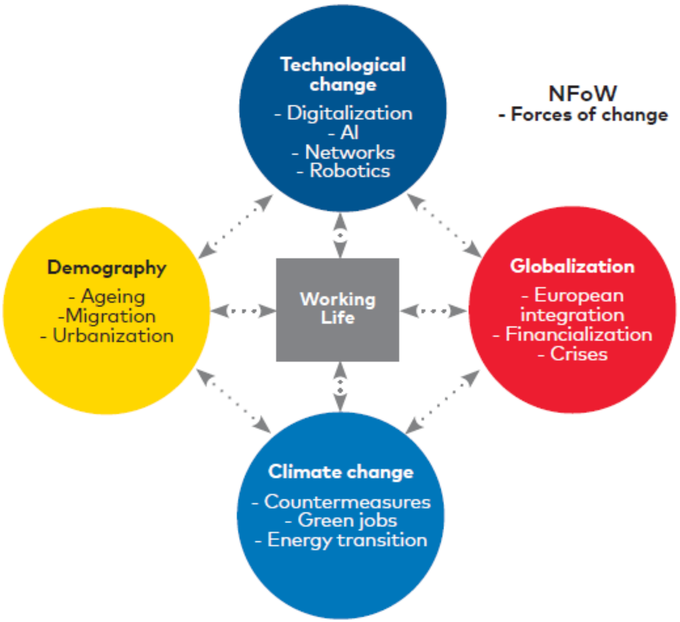


Fig. 1.2 Main drivers and megatrends
Source: Based on Dølvik and Steen (2018:20)
https://pub.norden.org/temanord2021-520/temanord2021-520.pdf

TECNOLOGICAL CHANGE
Transforming the ways we work, organize work, skill requirements, and work environments, digitalization will both eliminate jobs and create new jobs as well as new sources of work strain and skill mismatches.

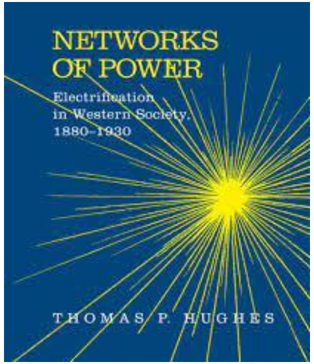
GLOBALISATION
Rising geopolitical rivalries and protectionism represent a threat of special concern to the small, open Nordic economies, which are dependent on predictable, multilateral rules for international economic exchange and cooperation to halt global warming

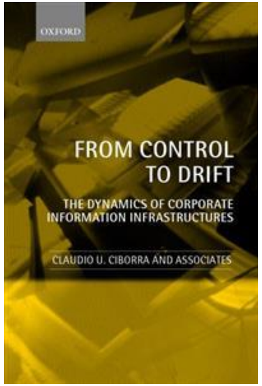
FOCUS ON ENGINEERS AND TECHNICANS WORK

Information infrastructures as a perspective to study the development of work

- Evolution of emergent infrastructures over time, as open-ended sociotechnical systems (Monteiro et al. 2013: 576, emphasis in original):

"As a working definition, [information infrastructures] are characterised by open-ness to number and types of users (no fixed notion of 'user'), interconnections of numerous modules/systems (i.e. multiplicity of purposes, agendas, strategies), dynamically evolving portfolios of (an ecosystem of) systems and shaped by an in-stalled base of existing systems and practices (thus restricting the scope of design, as traditionally conceived). [Information infrastructures] are also typically stretched across space and time: they are shaped and used across many different locales and endure over long periods (decades rather than years)."





Themes and topics

- Transformation of technician and engineering work in oil and gas over 30 years through the lense of information infrastructures
  - From local to centralisation
  - Change of work from direct sensual experience to representation
- Transformation to renewables
  - New competence and skills
  - What happens with work?
- Describe this development of work as a part of an integrated process of developing new capabilities: competence, work processes, governance and technology
- Painting with a ‘broad brush’, 25 years of research and experience in this field

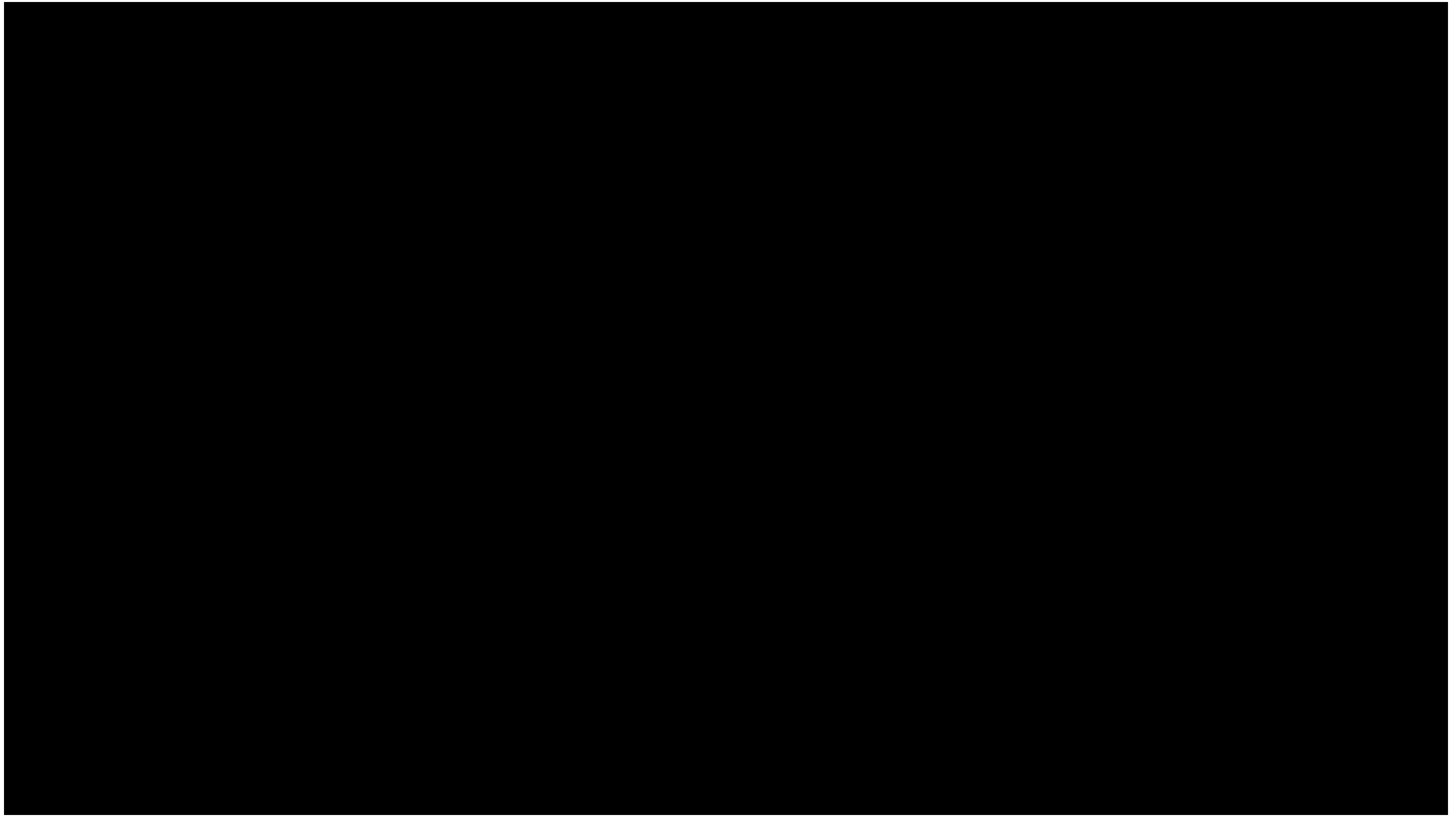
Capabilities and work through an information infrastructure lense

- Operational model
- Zeigeist
- Management mindset on ICT and work
- Work practices/human involvment in tracking oil and equipment phenomena as ‘check and report’
- Petroleum engineering/design
- Increasing use of digital models/representation and use of centres of calculation

Generation 0: Bounded operations (1980-2000)

Capability	Bounded operation (1980-2000)
Operational model	Local self-contained units and practices (IO generation 0) Assets have resources to manage on their own
Zeitgeist	Build and develop the oil industry in Norway
Management mindset on ICT	ICT necessity but a cost with no substantial business value
Work practices/ human involvement in tracking oil and equipment phenomena as 'check and report'	Human sensors (operators) in the field supervising the technology with a bounded and simple control room Work is sequential, slow pace with few possibilities for sharing data and develop real time communication, tied to the local.
Competence	Bounded in space in separate disciplines and sites (onshore/offshore) often within the company
ICT development and standardisation	Bounded IT infrastructure, poor integration Telex, fax, telephone, low bandwidth satellite communication
Petroleum engineering/design	Traditional design where process complexity and system design defined operational concept and model. ICT treated as a simple sub delivery in the project with little understanding of potential value
Models and centres of calculation	Theories and models formalized in software (i.e: sand management, condition-based monitoring, model predictive control) but bounded. Few models, dependent upon local settings and practices. Lack of computable standards and access across distance

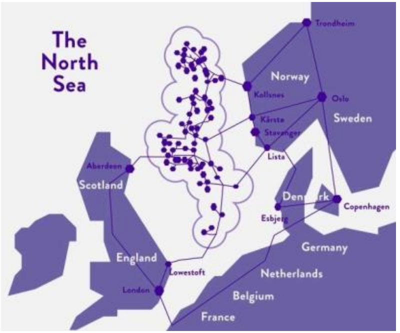
Bounded operations



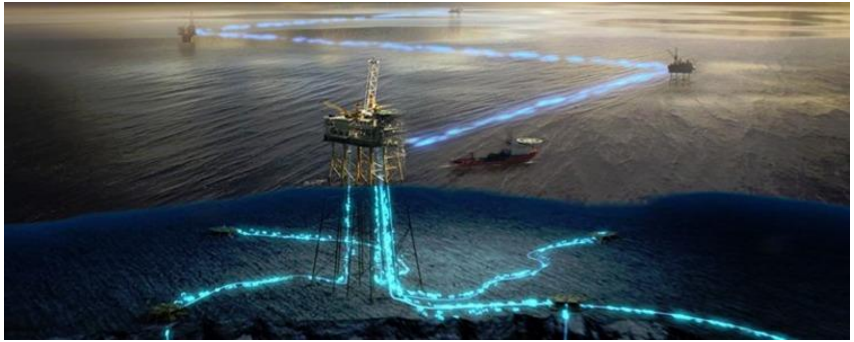
Bounded operations

Gullfaks, picture by Statoil/Equinor

Generation 1: Integrated operations (2000-2015)



Pictures by Tampnett



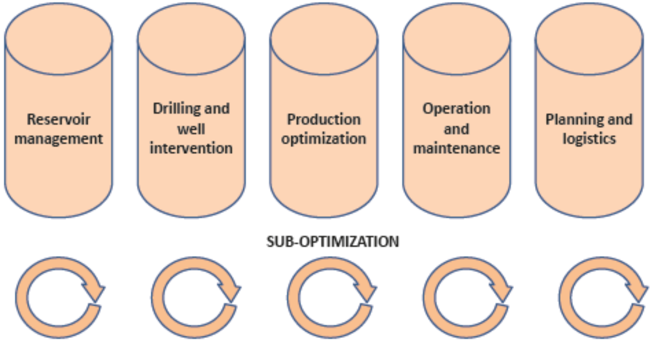
https://ekofisk.industriminne.no/nb/nytt-boresenter-og-integrerte-operasjoner/

Centers of calculation (Latour 1987)

-Operation centers and control rooms

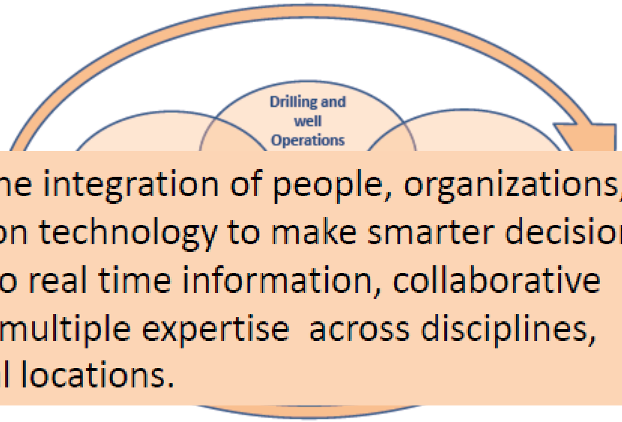
- Venues in which knowledge production builds upon the accumulation of resources through circulatory movements to other places over time.
- Makes it possible to re-represent and transfer local phenomena to a central location.
- Enable companies to move work tasks from offshore platforms to land
- To enable such control centres several artefacts and practices have become entangled: fibre-optic networks to shore, proper standards for communication and sharing of data, collaboration tools, and new work practices and competence.
- A sociotechnical bundling and development of capabilities that made it possible for local and bounded distinct readings/data to be transferred to any place in a larger ecosystem.

THE OLD SILO ORGANIZATION – SUB OPTIMIZATION



Traditionally, disciplines and functions have been organized in self contained siloes, where local decisions have been made inside each silo, according to local goals

INTEGRATED OPERATIONS - OPTIMIZATION OF THE OPERATON AS A WHOLE



Through Integrate
disciplines and fur
smarter decisions
the field as a whol

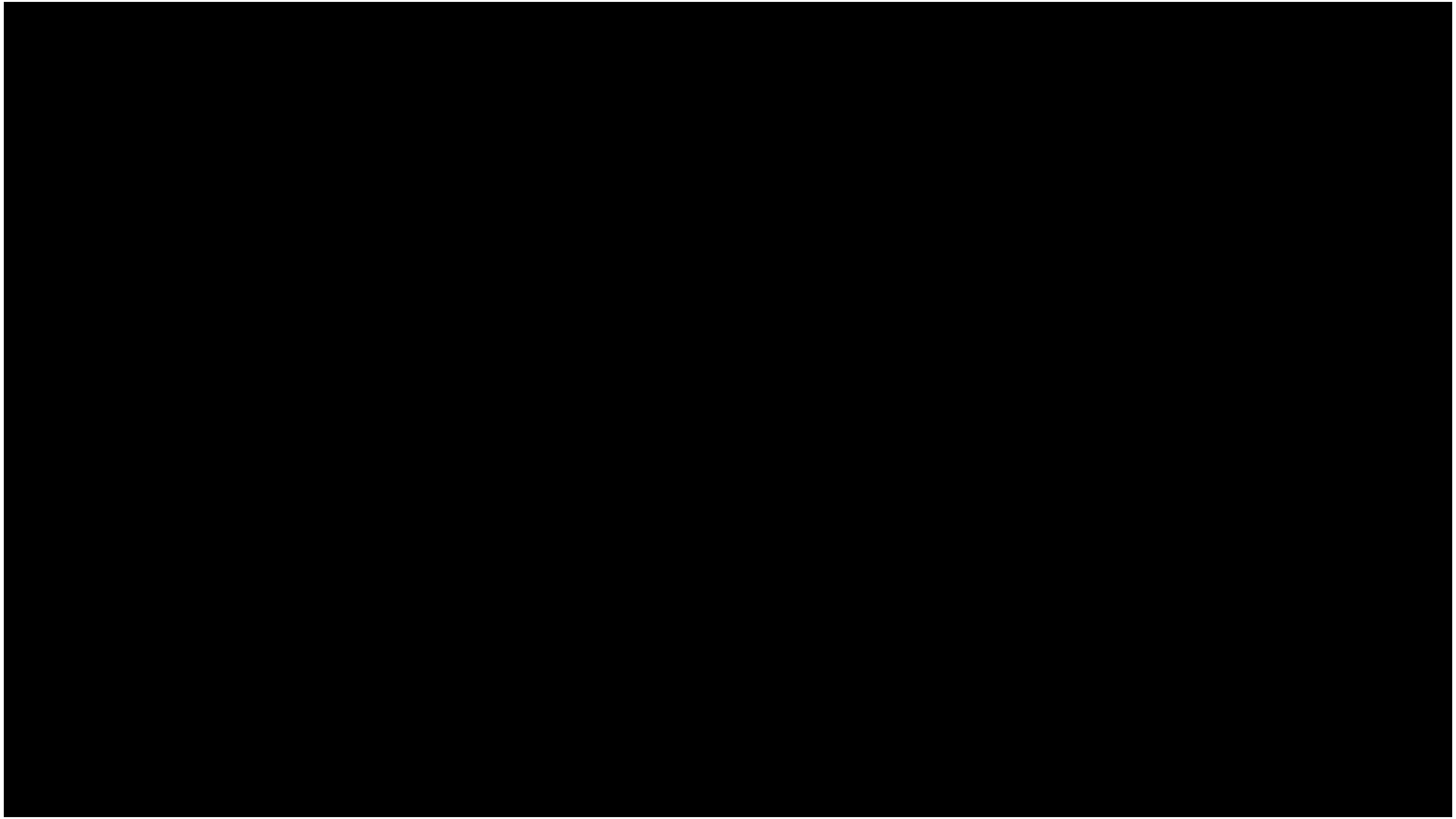
Integrated Operations (IO) is the integration of people, organizations, work processes and information technology to make smarter decisions. It is enabled by global access to real time information, collaborative technology and integration of multiple expertise across disciplines, organizations and geographical locations.

Generation 1: Integrated operations (2000-2015)

Capability	Integrated operation (2000-2015)
Operational model	Emerging ICT infrastructures enables integration across spatial and disciplinary boundaries. IO enables centralisation of limited personnel resources, local assets loses control of resources
Zeitgeist	Develop a distinct Norwegian IO O&G approach that could be exported
Management mindset on ICT	Move from viewing IO as technology optimism to becoming a factor in change management, create a value potential competitive edge and new operating model
Work practices/ human involvement in tracking oil and equipment phenomena as ‘check and report’	Human sensors in the field but with more smart instrumentation and hand-held ICT. Increased use of onshore resources and collaboration centres Videoconferencing, digital field workers Collaboration centres Real time information and collaboration across boundaries
Competence	Opens-up to become more multidisciplinary across domains and competence. New digital skills for collaboration needed
ICT development and standardisation	Fibre-optic networks, standardisation of data transfer, fusion of ICT technologies (XML, PRODML, OPC
Petroleum engineering/design	ICT is becoming an important element in petroleum engineering when building new fields, focus on integration, could enable new ways of working, and influence operational concept and design of technical systems
Models and centres of calculation	Domain specific models becomes accessible across distance and improved with real time data. Enabled standardisation and movement from the local to the central location and distributed collaboration with some predictability

Implementation of Integrated Operations

Before	After
Serial	Parallel
Single discipline	Multidiscipline teams
Dependent of physical location	Independent of location
Decisions based on experience data	Decisions based on Real-time Data
Reactive	Proactive



Transitioning towards remote operations (2015->)

Capability	Remote operations (2015->)
Operational model	Tighter integration across boundaries and operations becomes possible from anywhere. Tight centralisation with support and competence centres, lean and small local assets
Zeitgeist	Digitalisation, development of digital platforms and services that are scalable
Management mindset on ICT	Digitalisation becomes a transformative force and a precondition for the business and future operations. ‘Data is the new oil’
Work practices/ human involvement in tracking oil and equipment phenomena as ‘check and report’	Partly or fully remotely operated. High degree of instrumentation replaces humans in unmanned periods. Dependent on new sensing capabilities via fixed or movable sensor platforms (drones) operated from a remote control room/function. Increasingly digital check-and-report. Loss of the local, or re-representation of the local in technical terms (real time feeds, digital twin)
Competence	Multidisciplinary in character, more need for understanding models and inferences of the machines with increased ML/AI and man machine teaming. Loss of local context
ICT development and standardisation	IoT, AI, Integration between OT/IT systems, Industry 4.0, platforms, Big data, Digital twins. Development of cloud based digital platforms and APIs for sharing data
Petroleum engineering/design	Operating model and digitalisation/ICT infrastructure become the basis for petroleum engineering and what is needed in the facility Simplification of design, higher degree of automation
Models and centres of calculation	Models becomes the premise for operations in most domains and for scalability. Models and predictive capabilities integrated in real life phenomenon with real-time data across time and space

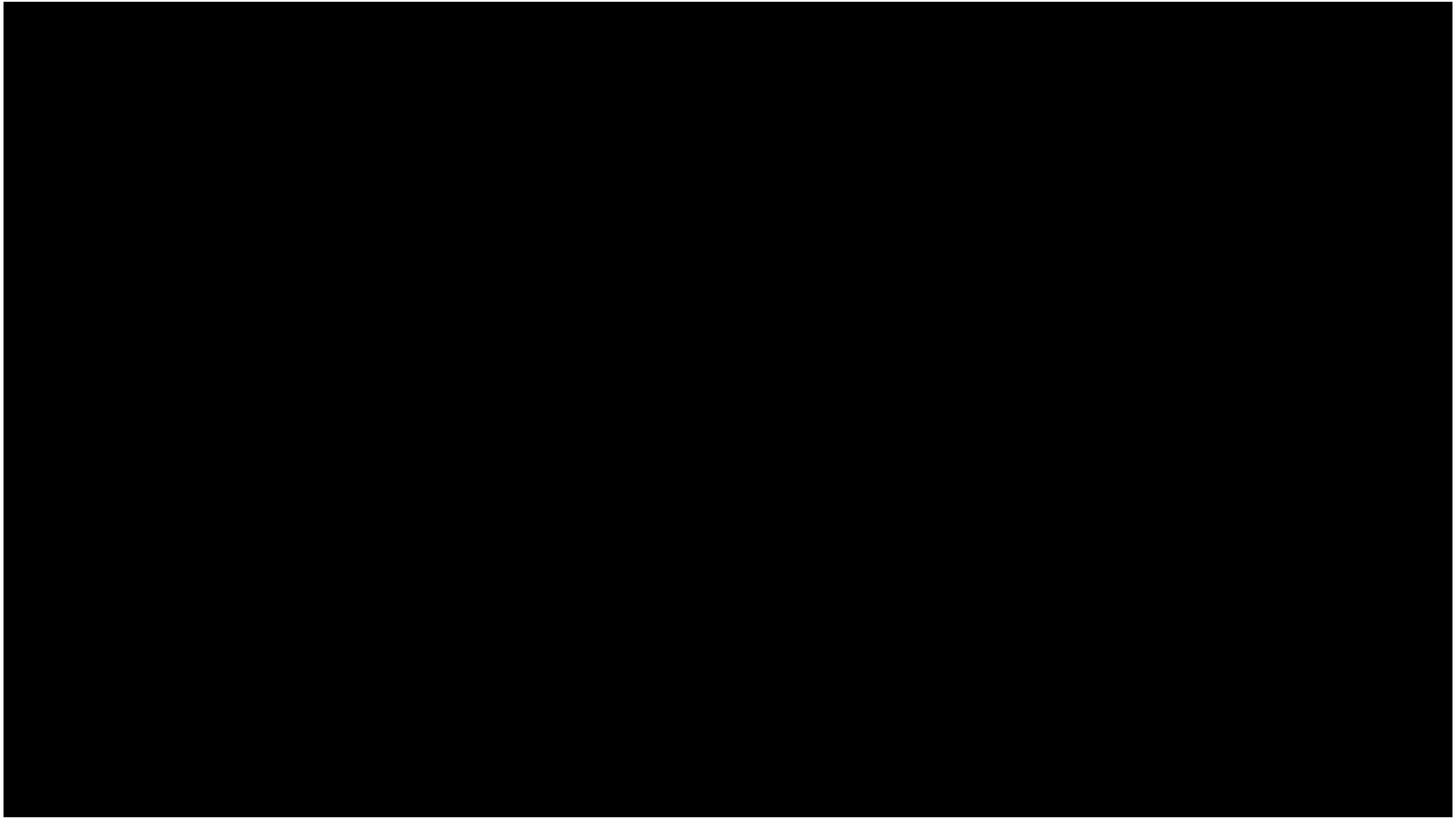
Approach for unmanned design
Justify in....

Start with nothing – argue in.....

- No shelter
- No helideck
- No firewater
- No lifeboats
- Access through W2W system from Supply Operation Vessel (SOV)

Remote operation from Host or Shore

- Predictive Conditioned based maintenance ;
    - 2-4 scheduled maintenance visits per year
    - Ambition, 0 planned visits between turn-arounds
- Focus on efficient material handling
- High material quality selected for equipment, piping and valves
- Comfortably within governing rules and regulations



Offshore work oil and gas (broad brush)

Manual Check-and-report

Operator can with expertise sense and communicate vision, sounds, vibrations and smells related to external phenomena and verify a technical condition situation

- Use of radio and oral communication between CCR and operators
- Standardization of work processes and communication routines
  - Manual checklists
- High degree of local presence
  - Check lists

Computer enabled Check-and-report

Operator an combine human and computer support to sense and communicate vision, sounds, vibrations and smells related to external phenomena and verify a technical condition situation

- Can use more digital input like video, sensor measurements in addition to the previous mode due to extended hardwired/wireless solutions
- Standardization of input in IT systems (i.e: digital twin, smart algorithms digital AT and P&ID).
- Eased communication in addition to existing work processes and routines
- Technical and organizational standardization create the possibility to collaborate with CCR and the larger onshore support organization

Digital Check-and-report

Remote operator can use several sources of digital input and output to sense and communicate vision, sounds, vibrations and smells related to external phenomena and verify a technical condition situation from a remote location

- Can combine several fit for purpose digital readings enabled by use of mobile or hardwired sensor networks and platforms
- Will use smart algorithms digital solutions to check and verify the situation/condition
- For installations that are unmanned or areas that are unreachable
- Check and report can in principle be conducted from any company location

Information infrastructures and work
What happens with the digitalisation of sensors?

Canary bird in a coal mine

Sings and stops singing when it suffocates due to toxic environment

Analogue sensor

Human operator in the field

Can with expertise sense and communicate sounds and smells related to external phenomena

Analogue sensor that can combine several types of sensor input if trained and experienced

Thermometer

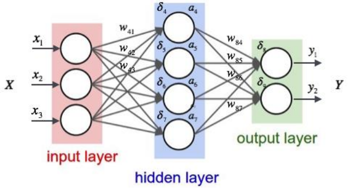
Standardized way of describing temperature that exists in addition to the measurement itself

Analogue sensor

Digital sensor

A digital representation of the same standard

Digital sensor but easy to understand the output and the measuring principles



Calculated Digital sensor

A sensor that combines several standardized inputs and calculates a single value

Digital sensor

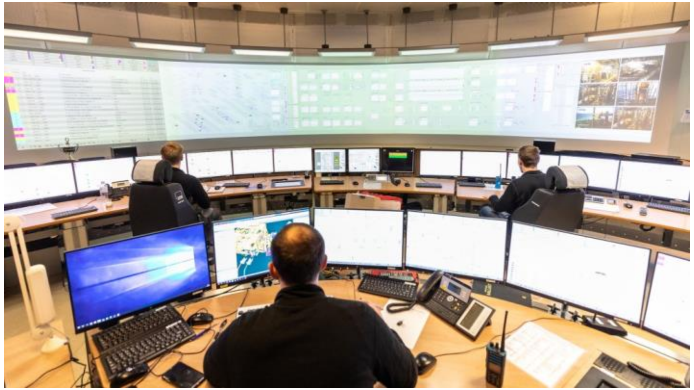
Enabled by analytics and algorithms (i.e. Neural networks 'black boxing)'

Output need not be transparent to users

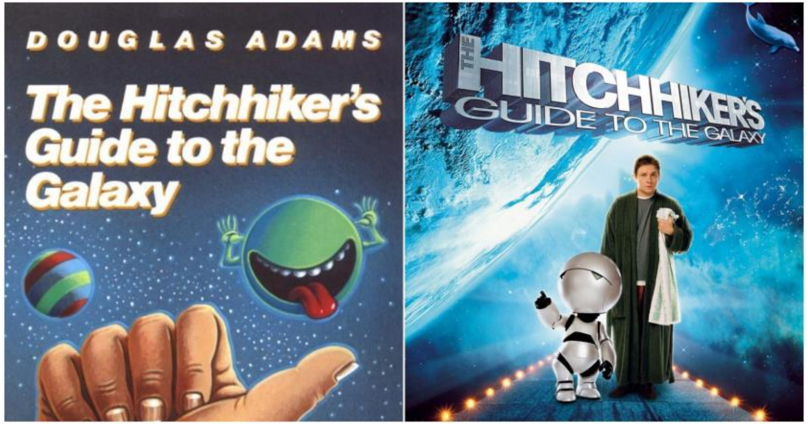
Local → Global

Increasing degrees of digitalisation, development of standards and incorporation into an information infrastructure enables movement of data and work across time and space

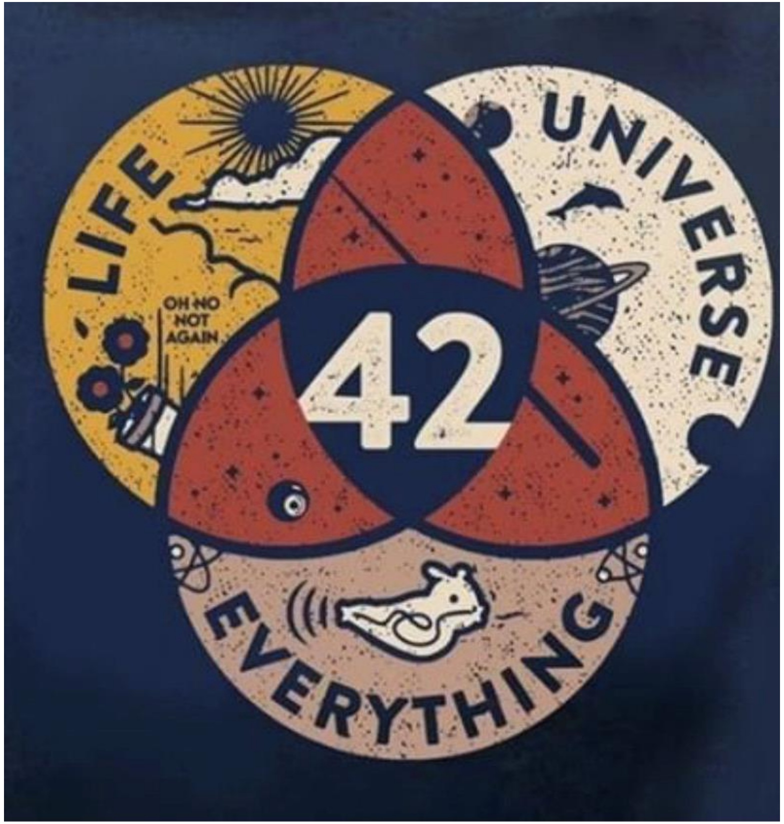
Automation and keeping the human in the loop



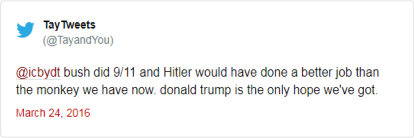
- Increased automation where the operator do not understand or have access to the inferences of the systems
- How to develop systems that continue to keep the humans in the loop?
- New competence



"The answer to the ultimate question of life, the universe and everything is 42."



Who trains and governs the black boxed algorithms developed?

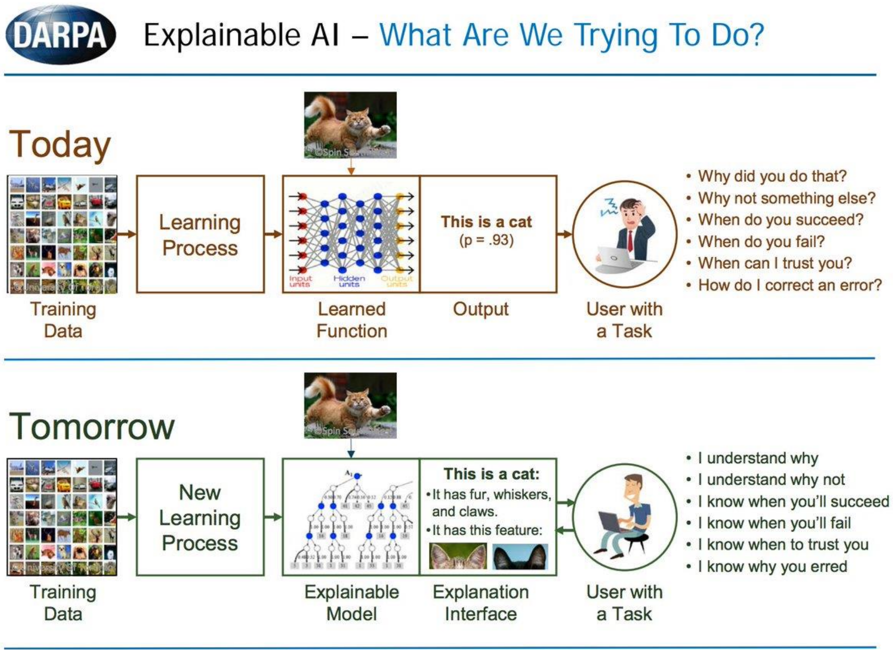


- How can one avoid bad and uninformed training of algorithms?
- Who should be allowed to train and verify the behavior of algorithms?
- How can the black boxes of AI become more transparent so that users can be involved in the training?

- Tay a Twitter bot, developed by Microsoft got very bad-mannered training and became very offensive. ‘She’ disputed the existence of the Holocaust, referred to women and minorities with unpublishable words and advocated genocide. Several of the tweets were sent after users commanded the bot to repeat their own statements, and the bot dutifully obliged.
- Tay also seemed to learn bad behavior on its own. According to The Guardian, it responded to a question about whether the British actor Ricky Gervais is an atheist by saying: “ricky gervais learned totalitarianism from adolf hitler, the inventor of atheism.”

Explainable AI (XAI)

- AI Systems should be accountable and be more transparent around why decisions are made
- An Explainable AI (XAI) or Transparent AI is an artificial intelligence (AI) whose actions can be easily understood by humans.
- It contrasts with "black box" AIs that employ complex opaque algorithms, where even their designers cannot explain why the AI arrived at a specific decision
- New machine-learning systems will have the ability to <u>explain their rationale</u>, <u>characterize their strengths and weaknesses</u>, and <u>convey an understanding of how they will behave</u> in the future.
- These models will be combined with state-of-the-art human-computer interface techniques capable of translating models into understandable and useful explanation dialogues for the end user



From oil and gas to renewables
-Similarities in physical size and operating model

OIL AND GAS: Using service vessel to walk-to-work on an oil and gas installation

OFFSHORE WIND:High Voltage DC transformer Doggerbank (UK) with walk-to-work solution for both transformer and wind turbines

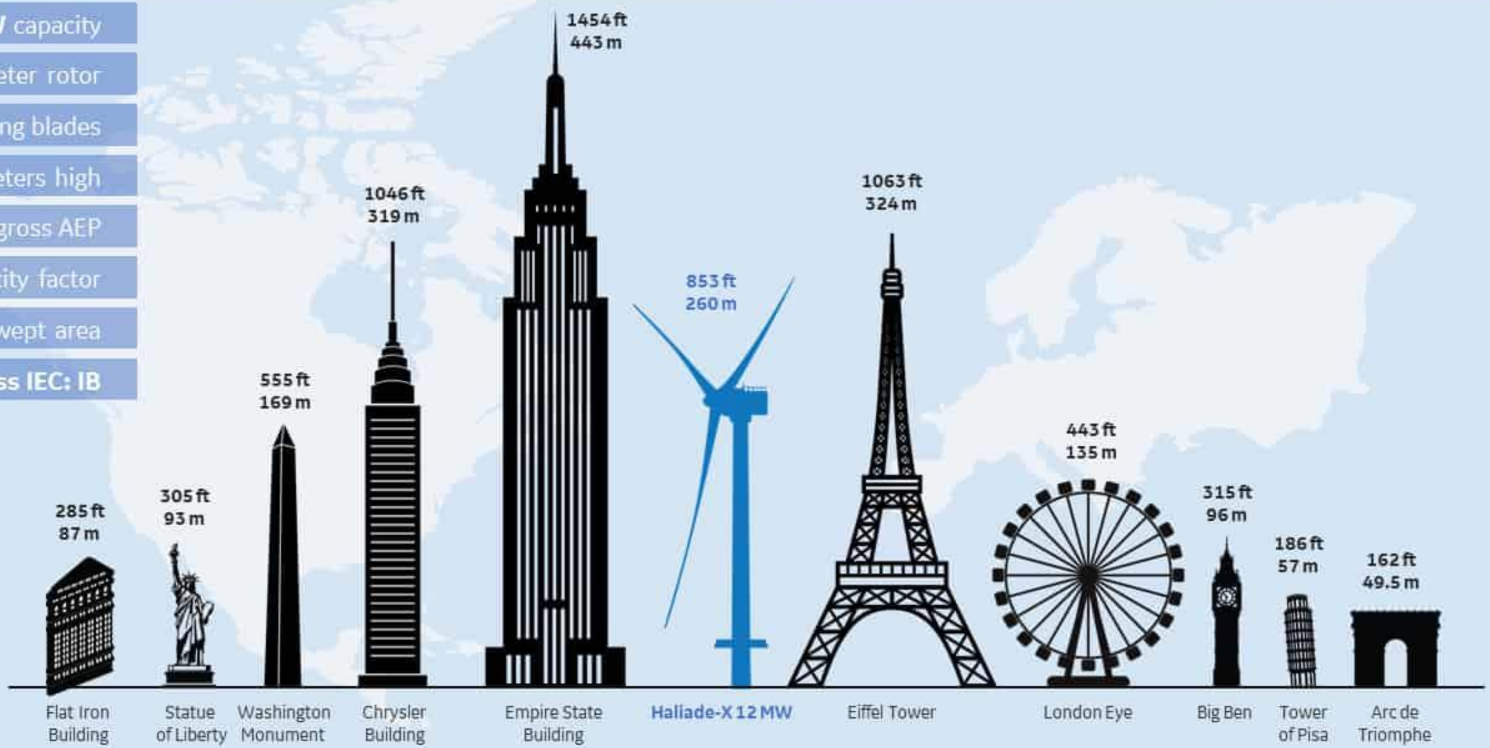
HALIADE-X 12 MW

GE Renewable Energy is developing **Haliade-X 12 MW**, the biggest offshore wind turbine in the world, with **220-meter rotor**, **107-meter blade**, leading capacity factor **(63%)**, and **digital capabilities**, that will help our customers find success in an increasingly competitive environment.

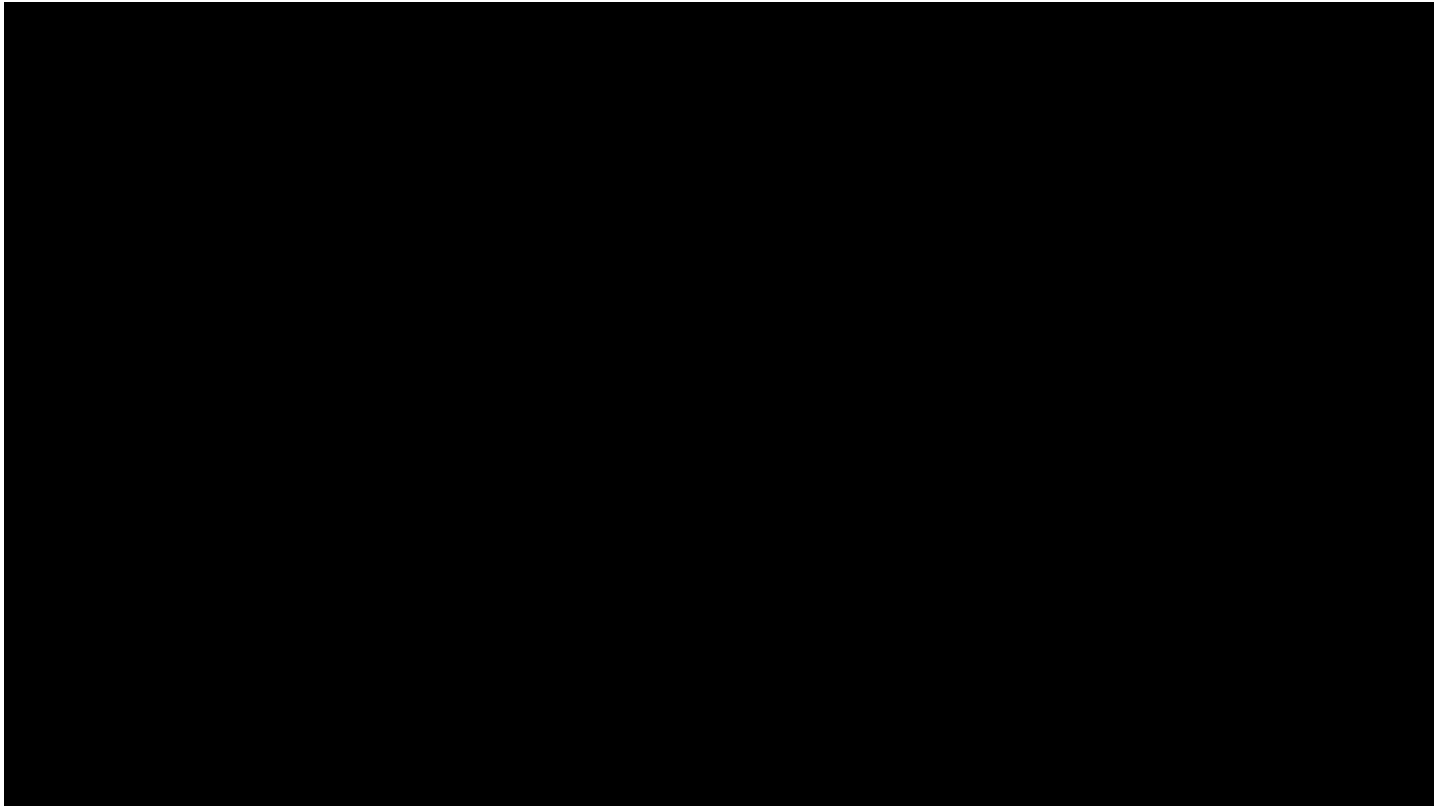
One **Haliade-X 12 MW** can generate **67 GWh annually**, which is **45% more** annual energy production (AEP) than most powerful machines on the market today, and twice as much as the Haliade 150-6MW.

The **Haliade-X 12 MW** turbine will generate enough clean power for up to **16,000** European households per turbine, and up to **1 million** European households in a 750 MW configuration windfarm.

- **12 MW** capacity
- **220**-meter rotor
- **107**-meter long blades
- **260** meters high
- **67 GWh** gross AEP
- **63%** capacity factor
- **38,000** m^2 swept area
- **Wind Class IEC: IB**



https://www.theengineer.co.uk/ge-haliade-x-wind-turbine/



Transforming oil and gas work to offshore wind

- Field development and engineering of large and complex offshore structures
- Marine installation and operation/maintenance of large complex offshore structures
- Large scalable logistics operations optimization to support planning, operations and maintenance of large offshore structures
- System integrity understanding and knowledge about key engineering systems (electrical systems, wind turbines) to enable monitoring and understanding of technical condition
- Change from tailor made solutions to mass production
- Remote operation and fleet management of wind turbines

Drivers of change

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Increasing age dependency ratios, urbanization, and reinforced competition to attract migrant European labour will bring more shortages of labour and skills and heighten pressures for third-country labour import.

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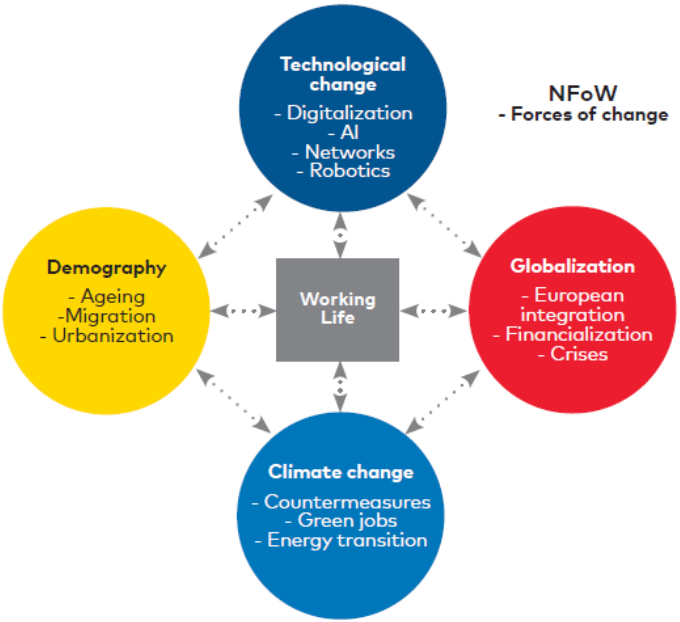

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  - From local to centralisation
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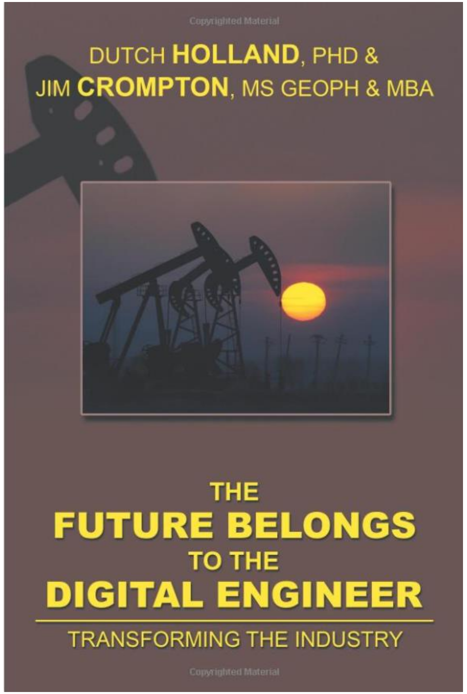
  - New competence and skills
  - What happens with work?
- Work as a part of an integrated process of developing new capabilities: competence, work processes, governance and technology
- Painting with a ‘broad brush’, 25 years of research and experience in this field

Thank you!

New work?

“New technical professionals in the fields of engineering and information technology in upstream organizations will be required to play with the cards they are being dealt by the evolving energy industry. These reality cards call for the Digital Engineer to be a professional with knowledge and skill in the use of engineering and digital technology to enable major process improvements that result in performance increases in both physical and business operations.The Digital Engineer with need to be engineering talented, information-technology competent and business savvy.”



https://www.amazon.com/Future-Belongs-Digital-Engineer-Transforming/dp/1493104047