IO Center
Center for Integrated Operations in the petroleum industry
Introduction to Integrated Operations

INTEGRATED OPERATIONS is a new way of optimizing the operation of oil and gas fields by making smarter decisions through

- integration of people with different expertise
- integration of work processes
- Integration of information and communication systems from different domains

Through the last decades, the traditional operational strategy for oil and gas field was to divide a complex operation into “silos” (reservoir and production, drilling, operation and maintenance, logistics, HSE) in order to organize the work processes, organizational structures and information technology. The decision processes were confined within the limitations of each silo. Obviously, this strategy did not take full advantage of the synergies and interdependencies between the functions. By putting these together in integrated operations the expected result is smarter decisions leading to optimization of the entire operation.

In the near future decisions will be made by virtual teams operating across organizational, functional and geographical domains. Experts from anywhere in the global networks of the oil companies and their suppliers will work together to solve specific problems of a given asset. The virtual teams will have at their hands real time analyzed information collected from a variety of information systems which previously did not communicate easily.

This future perspective is raising several issues regarding new business processes, human communication and culture, collaboration environment, advanced mathematical models and data communication, just to mention a few. All though the oil companies and service suppliers already have embarked on implementing Integrated Operations, there are still many challenges left, where further research and development is needed. This is the motivation for establishing the IO Center.
Key elements in Integrated Operations

Integrated operations is about smarter decisions

Integration at all levels, from data capture to decision

- **Business Objectives**
  - Increased production
  - Improved HSE
  - Enhanced oil and gas
  - Reduced costs

- **Decision & Planning Process**
  - Integrated interpretation and decision process

- **Analysis & Visualization**
  - Integrated modelling and analysis tools

- **Information Systems**
  - Integrated data acquisition and information systems

- **Assets**
  - Reservoir
  - Wells
  - Process system

Integration at all levels, from data capture to decision.
## Success Criteria and Goals for the IO Center

### RESEARCH

**Long-term industrial research of a high international calibre**
- World class research: 2-4 International break through areas through 5 years
- Generate new ideas/solutions: 2 new solutions/methodologies per year
- PhD projects: 15 PhD candidates through 5 years
- Publishing: 5 Level 2 journal papers and 10 conferences papers per year
- International co-operation: Co-authoring of papers and exchange of scientists
- Increased R&D among partners: New R&D projects initiated by industrial partners

### INNOVATION

**Value for increased production, enhanced oil recovery, reduced costs and improved HSE,**

**Value for supplier industry through new competitive products and services**
- Use of technology: Use of project results in industrial partners’ business processes
- Pilot projects: 1 pilot for each partner through 5 years
- Transfer of knowledge: 10 user seminars/workshops/courses per year
- Mobility of personnel: 2 researchers from IO Center working on industrial sites every year
- Support to implementation/innovation: Scientists from the IO Center contribute to implementation projects
- New enterprises: Drive for establishment of new enterprises based on project results

### EDUCATION

**Providing IO-competent people to the industry**
- Master students: 25 IO Master students per year. Summer internships and master projects in the industry
- Continued education: 50 participants on continued education courses per year

### NETWORKING INDUSTRY – RESEARCH

**Arenas for co-operation and networking**
- Industry-research network: Annual SME Innovation Forum and one open seminar yearly
- Strategic think tank: Strategic discussions in Board
- International Conference: Annual IO conference

## Key figures for the IO Center in 2009

### Human resources

- Research Scientists: 62
- Research Scientist, manyears: 16
- Guest Research Scientists: 4
- PhD students (partial or full funding): 16
- Associated PhD students: 4
- Postdoctorate students: 2
- Master students (graduated 2009): 16

### Results

- Journal papers: 5
- Conference papers: 29
- Technical reports: 13
- Workshops, internal seminars: 10

### Funding and costs (1.000 NOK)

**Funding**
- Research Council of Norway: 8 344
- Industrial partners: 26 250
- Research partners: 5 681
- Operating costs: 40 274
Overview of programs and sub projects

Program 1: Drilling and Well Construction
1.1 Integrated Drilling Simulator
1.2 Automated Interpretation and Diagnostics
1.3 Work Processes and Experience Transfer
1.4 Use of Increased Bandwidth (Wired Drill Pipe)

Program 2: Reservoir Mgmt and Production Optimization
2.1 Reservoir Management
2.2 Production Optimization
2.3 Education and Competence Development

Program 3: Operation and Maintenance
3.1 Condition Based Operation and Maintenance Support
3.2 Condition Monitoring for O&G facilities
3.3 Integrated Planning

Program 4: New Work Processes and Enabling Technologies
4.1 Future Collaboration Environments
4.2 Work Processes and Decision-making
4.3 Integrated Operations and Safety

5. General Projects, Management and Administration
Crystal Ball
IO Valuation Model
International IO Conference
Management and Administration
Demonstration of integrated drilling simulator with virtual wellbore

The Integrated drilling simulator is a new information system providing advanced real time data while drilling, enabling more efficient and safe drilling with less risk of non-productive time.

The information covers measured and calculated values related to well bore stability, pore pressure, mud circulation, rate of penetration and drillstring vibrations.

A complete data base for the Gullfaks field has been built this year, providing a virtual laboratory for integrated testing of rock mechanics, basin properties and drilling operations.

A new pore pressure prediction model has been integrated with the drilling simulator. Promising results from an initial test have been presented at 2009 SPE Annual Technical Conference and Exhibition held in New Orleans, Louisiana, USA, 4-7 October 2009.

The heave motion of floating drilling rigs and vessels, and the consequences for drillstring motions is a major challenge for monitoring and controlling the drilling process. A method to compensate for the heave motion was demonstrated followed by a test on a floating installation during drilling of a challenging high pressure/high temperature well (HPHT). Real time models for well stability and pore pressure prediction were applied, to demonstrate how such tools can be such used in a real time working environment.

A Ph.D. project is studying drillstring vibrations and optimization of the Rate of Penetration.
Work processes related to Integrated Operations in Drilling

The project develops knowledge, methods and guidelines for integrated work process in drilling teams, supported by advanced collaboration and decision support tools and facilitated through collective learning. New work processes combined with use of integrated drilling simulator were tested during drilling of a well on the Hild field (Total) and the report "Survey 1 – Implementation of eDrilling on Hild" has been issued. A SPE paper was presented for The 2009 SPE Asia Pacific Health, Safety, Security and Environment Conference and Exhibition [APHSSEC], 4-6 August 2009, Jakarta Indonesia, on the topic resilience and collective learning in drilling operations. A second paper was submitted to SPE Intelligent Energy Conference 2010: Creating an Intelligent Energy Organization through Collective Learning, with findings on a new method for enhancing Collective Intelligence in drilling: Why-, What and How-learning. The three learning dimensions of How, What and Why interact in a dynamic way implying that a balance must be established in order to pursue an optimal environment for collaborative decision-making in drilling teams creating safer and more efficient operations.

The method distinguishes between structuring and enabling parameters that together are believed to make a comprehensive functional characterization of collective reflection. Early findings indicate that existing tools and arenas are biased towards one of the dimensions, at times

Wired to Drill  Investigating the potential of Wired Drill Pipe

Wired drillpipe is now a proven technology that lets us retrieve massive amounts of data from downhole, both from the near-bit area and along the entire drillstring. This is made possible through a signal cable embedded in the drill pipe. The new technology exceeds the technology it replaces so radically that a new way of thinking about drilling is required. The new technology demands that routines for work processes and decision making must be reconsidered.

The project looks at how we can make use of such a futuristic technology today. The project has analyzed data recorded while testing wired drillpipe and we are developing exciting ideas as to how the data can be used. Many of the ideas are not totally new; we have dreamed of doing this sort of thing for a long time, wired drillpipe just turns dreams into reality.

An important hurdle we have to overcome is data quality. Because the data is sent through an advanced communication system, doesn’t mean the data is always correct. Sensors fail, calibration can drift. We are adapting our Data Quality methods to the wired drillpipe scene.

Other methods we see as part of Integrated Drilling Operations will make use of the newly available data. Methods are being adapted in the areas of drilling optimization, well control, and problem detection.

A new and exciting sub-project is focusing on making use of borehole seismic data together with realtime measurements of formation parameters to form a “picture” of the underground. This activity is a cooperative effort between drilling, seismic and reservoir researchers. Applications range from optimal placement of the wellbore, improved reservoir drainage, and production planning.

The project has generated a report outlining the potential of wired drillpipe. Reports of improved methods making use of wired drillpipe are in the works. The project will continue to collect wired drillpipe data as it becomes available to have a basis for testing new methods.
Program 2 Reservoir management and Production Optimization

A large portion of the IO value potential lies in reservoir management. Our guiding principle is the concept of closed loop reservoir management and the application of mathematical optimization. This includes workflows for assisted history matching and production optimization. We try to develop fast, reliable and transparent methods. Further, our aim is to challenge the dominant silo approach and bring IO to a next level through integration of models and optimization applications.

Norne benchmark case
The Norne field case offers industry and research a unique environment for comparing technologies for closed loop reservoir management.

The Norne field case provides users with a benchmark based on real sub surface data. This will be an extension to current benchmark cases which are all based on synthetic data. The Norne field on the Norwegian Continental Shelf is operated by Statoil, and includes the license partners ENI and Petoro. An interesting feature of the benchmark is high quality 4D seismic data, where the depletion of the reservoir is monitored through seismic measurements from permanently installed sea bottom sensors. This is a new technique for increasing the recovery from oil and gas fields, used on a few fields around the world. The IO Center develops new analysis tools to extract information on the depletion history to understand better the reservoir behavior and optimize the positioning and operation of new production and injection wells.

The purpose is to establish this case as a key benchmark for the petroleum industries. It will be used to evaluate and to compare mathematical methods for history matching and closed-loop reservoir management. Further, the Norne data offers an opportunity to use real data for educational purposes, in courses, semester projects and master thesis work. Currently researchers at Stanford University, TU Delft and NTNU are using these data.

ROOKIE – a unique teaching environment
The ROOKIE project uses live data and is a one-of-a-kind competence development platform for students and researchers.

We have developed an operations lab at NTNU where students have access to live data and remote control of gas wells in Oklahoma. These wells are prone to liquid loading amongst other operational challenges. Currently one well is fully accessible through a Labview® interface. This means that data and video feed are available online in real time. Further, stored data is available for data analyses, for instance model validation. One feature, which is important in an educational setting, is the fact that students can change the production choke remotely, from the operations lab or any other place with Internet access, to explore the behavior of a well.

Currently one well is online. A second well will come online soon together with the ability to remotely operate the pump in addition to the production choke on each well.

Tests show that ROOKIE is well received by students.
I-Opt – integrated modeling and optimization

The integrated benchmark will challenge industry views on the business potential of value chain integration. Integrated modeling of multi-field assets, from subsurface to market, is challenging due to the complexity of the problem. We have developed an industry benchmark as a means to assess the potential business value of integrating applications along the value chain from reservoir to export.

The benchmark builds on SPE 121252, and includes two full-field compositional multi-well models and one full-field model undergoing miscible WAG injection. Further, a common field-wide surface processing facility is modeled with emphasis on water handling, NGL extraction, sales-gas spec, and gas reinjection. The surface process model interacts with the three reservoir models through water- and gas-handling constraints, and by distribution of available produced gas for reinjection. An economic model with cost functions for all major control variables (e.g. number of wells, surface facility selection and operating conditions) is included. All parameters are carefully selected to ensure realism.

The benchmark is well suited to quantify the potential benefit of integrated optimizing (meaning applications which include reservoirs, pipelines and process facilities) compared to a silo approach with separate upstream and downstream applications. Hence, it should challenge the current mindset in terms of business value.

The benchmark will be provided to industry and academia through a web interface, application data files, workshops and scientific publications.

Production optimization on a daily basis

A new concept for production optimization has been developed. Testing on real data indicates a significant potential for this methodology.

The daily workflow for a production engineer typically starts with a review of production and individual well performance. Production engineers need to analyze the current situation and recommend a future production strategy. Hence, a decision support tool is often desired for allocating and routing production from individual wells. We have developed a novel decomposition and modeling method which is highly efficient, partly because it may be implemented in a parallel computer architecture. It uses Dantzig-Wolfe decomposition and provides the user with transparent results of value to any knowledgeable user. This includes the cost of scarce resources (for instance a downstream gas capacity constraint) and a measure of the quality of a recommendation.

One of our PhD students spent 6 months on an exchange visit as a production engineer at Troll B&C. Hence, we have had the opportunity to assess the proposed methodology on real data with encouraging results. Other active partners are FMC Technologies AS and IBM.

A number of scientific publications are available which analyzes and describes the methodology.
**Condition based maintenance; Extracting meaning from a sea of raw data**

The Mímir platform is a tool for processing raw data and transforming it into meaningful information for maintenance and operational planning. It is based on accepted industry standards and aims at providing a standardized and expandable set of tools that can be easily combined to quickly implement and deploy advanced decision support functions and business solutions.

During 2009 a pre-release version of Mímir has been made, including:
- The *Mímir Builder* for the definition and assembly of Mímir modules into condition monitoring and data analysis applications
- The *Mímir Run-Time Manager* for the real-time execution of Mímir applications
- The implementation of a range of Mímir modules (e.g. implementing different regression techniques)
- The implementation of demonstration applications including:
  - Signal validation application
  - NOx emission monitoring application
  - False alarm avoidance system for kick detection support

Program 3 also conducts research on novel *Remaining Useful Life* (RUL) models which are central to the prognostics and condition-based maintenance technologies that are being developed. 2009 has seen the start of expanding the current set of RUL influencing factors to include predicted operational and environmental conditions, with the final aim of reducing the uncertainties in RUL calculations.

The *Mímir Builder* is used to assemble a condition monitoring system made of a network of predefined standard modules.

**NEXT STEP:**
Pilot implementation of the Mímir platform.
Development of RUL principles.
**Integrated Planning – IPL**

Based on findings from the early phase of the project the IPL project is drawing more and more attention to work processes and doing less research directly related to ICT tools.

During 2009 the project has been reoriented towards a holistic understanding of the planning process. This includes an overview of the information flow, dependencies in the system and all actors involved. It is necessary to identify critical interfaces between individuals, groups and different information and communication tools. It is also essential to map the need for cooperation and communication including more efficient use of existing ICT tools or the need for new tools to present and share relevant information.

Based on this reorientation the IPL project has developed a preliminary model for integrated planning as a best practice tool. The model is illustrated in the figure below. The intention is to use this model as a starting point for discussing IPL with different organizations.

**Improved condition monitoring of process equipment**

The importance of being able to monitor the condition of offshore equipment, such as separators, safety critical valves, and heat exchangers is emphasized in sub-project 3.2. Different methods for non-intrusive inspection (NII) are being tested and evaluated to expand capabilities (e.g. probability of detection).

During 2009 there has been an emphasis on NII for production separators and extensive test programs using acoustic detection, gamma ray and neutron backscatter technologies have been run. A dedicated lab setup is used for testing the different technologies. This provides excellent conditions for describing the detection capabilities. Based on this it is possible to plan extended tests to verify the suitability of these technologies for field use.

**NEXT STEP:**
Develop IPL best practice model in cooperation with IO industry partners.
Future Collaboration Environments; Case study on risk impact of maintenance operations

In 2009 the project has conducted studies on collaboration surfaces to support risk informed decisions in maintenance and modification planning. A test-bed, called the IO Maintenance and modification planner (IO MAP) was developed in close collaboration with partners and tested at several Statoil locations, as well as at ENI Norge, Gdf SUEZ E&P Norge and Shell.

Ideally, one would select and shape technologies to actively enable desired work practices. In reality, technology constraints and possibilities often shape the work practices instead, sometimes with unforeseen effects. Technology imposed change is only purposeful if it contributes to alignment with the organisation’s strategies and the standards of the industry. One set of such standards and strategies are those that pertain to safety risks. The purpose of the IO MAP studies is to investigate technology characteristics that may improve risk identification.

The software design is inspired by location based geographical information systems and is based on IFE’s Information Rich Design concept. IO-MAP contains easily comprehensible overviews of work in various stages of planning and of conditions in a work area. Users may visually identify and describe safety risk.

Some early findings:
- IO MAP fills an important function in visualizing risks in connection with tasks and location, offering extra highlights and reminders of risks on the map
- Planners with off-shore planning experience have an advantage in identifying risks connected to jobs at an early stage because of their off-shore knowledge
- It also seems that IO MAP may help planners who never worked off-shore to get a share of the experienced planners’ “gut feeling” through visualizations
- Feedback indicates that a limited number of additions to the system will turn it into a groupware for distributed collaboration

Test user quote: “I thought you were bringing just another ICT tool, but this is actually about our real work”
Organizational factors and Integrated Operations

In 2009 the project addresses how organizational factors impact on the successful implementation of Integrated Operations, with a focus on operations, maintenance, and production optimization. Examples of organizational factors include: leadership, organizational structure, organizational culture, roles and responsibilities, teamwork, KPIs, and training. The project is carried out in close cooperation with Shell Norway, where we have previously developed and tested a team training concept for operations and production optimization teams.

Some important findings:
• Leadership behavior has a strong impact on the degree of success of an organization’s IO implementation. To successfully implement new technologies and new work processes that enable IO, clear commitment and expectations from leaders are essential.
• The quality of the collaboration between an operations support center and a production facility depends on the quality of the co-located collaboration within the operations support center and within the production facility. In other words: Good integration across locations depends on good integration across disciplines/functions in the locations involved.
• Geographically distributed (virtual) teams can easily become polarized across locations, that is, be locked into “us and them” patterns. By being aware of this tendency, virtual teams will be in a better position to avoid the problem.
• Clearly defined roles and responsibilities are important for effective decision making and coordination in teams. However, teams may lose some of their flexibility if roles and responsibilities become too rigidly defined.

IO and Safety – More resilient organisations by new approaches to emergency management

Based on an interview study performed in 2008, the project performed observation studies of emergency exercises in addition to arranging a workshop on future emergency management in 2009. The aim of the activities was to study how new technology and work processes influence emergency preparedness and handling.

By real-time information; access to experts; sharing of information; and distributed actors, integrated operations is an enabler for shifting focus in emergency management from only rescue and resetting systems to a broader perspective that includes anticipation and response to the preceding events that lead up to the accident. Experiences from accident investigations show that a common contributing factor to accidents in the industry is lack of risk anticipation, it can thus be claimed that there is a need to expand the focus in emergency.

Based on the findings in the studies the following recommendations regarding future emergency management are proposed:
• A more proactive focus in emergency handling by utilizing early warnings to monitor and anticipate deviations, and thus prevent emergencies from happening in the first place as well as establishing the emergency organization faster.
• Consider use of richer collaboration technology in emergency handling. Should be performed carefully, as one need to trust technology in emergency handling
• Identify actors and interactions between these at different vertical and horizontal levels involved in emergency handling, and plan and train accordingly.
5. General Projects

### Indicating Value of IO

The IO Valuation Method is a research based practical assessment method for valuation of IO investment in fields, technologies and organizations focusing at the project level. The method is a means to:

- Understand source of value → helps to focus on critical success factors;
- Compare alternative IO projects and solutions → improved NPV;
- Calculate monetary value → motivation to faster IO implementation.

Year 2009 was a productive year for the project that resulted in four reports and two papers. One paper received the Best Paper Award at the Business Information Systems 2009 conference. Parts of the method have been further enhanced through collaboration with associated members of the project from Sintef, Marintek, University of Stavanger and international experts from overseas.

Implementation of a prototype tool and other methodological instruments had been started based on the developed valuation method. That allowed to run a pilot study on Integrated Planning at ConocoPhillips and to test parts of the method.

Two workshops for the industrial partners of IO Center were held in 2009. International experts participated in both workshops. A positive feedback was received from the industry partners (ConocoPhillips, ENI, Statoil, Shell, Total E&P) and Technical Committee of IO Center.

#### NEXT STEP:

*Case studies to validate the method and identify best practices. Develop training seminars for the industrial partners in order to transfer experience.*

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**Looking into the future of IO**

- Exploration and description of scenarios for 2nd and 3rd generation IO work processes
- Identification of radical R&D ideas for IO; Challenge current thinking

- Transfer of experience from other industries (aerospace, defense, health, process industry)

- Study of new organizational structures and business tasks
  - Network based structures
  - New management roles
  - New concepts for business processes and operator/supplier cooperation

- Study of new technology
  - Wireless sensors
  - Upscaling of data amounts, need for new data reduction methods
  - Deeper integration of information systems

**The use of the results**

- Development of strategies for future implementation of IO in the industry
- Selection of future areas for research

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**5. General Projects**

**CRYSTAL BALL**

*Courtesy to National Museum of Natural History, Washington D.C. USA*

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International IO Conferences organized by the IO center

IO 09 International Conference on Integrated Operations; Science and Practice
The 5th international conference on integrated operations in the petroleum industry - IO 09 Science and Practice - was arranged by the IO Center 29-30 September. The main topic was “Intelligent petroleum fields and integrated operations for better productivity and safety”.
The IO Conference is an international meeting place on IO where industry and research share knowledge and experience and build network. The conference reviews trends and opportunities for research and business and is a place where science and practice meet. IO09 had 300 participants and 34 speakers. IO09 had a very good international attendance and this will be expanded in the future. The conference management cooperates with the Advisory Board with representatives from SaudiAramco, Petrobras, Petronas and Qatar Petroleum as well as the international oil companies that support the IO Center as partners. The IO09 cooperated with IO in the High North and Industrial Gaming and both organizations chaired their special parallel session. A Young Professional Program with 8 poster sessions was organized as well as a well attended exhibition place. The IO09 also organized three excursions and demo sessions during the conference. It is an objective further to develop the science part in the future conferences with Ph.D presentations of recent trends and development within IO from the universities in Norway and abroad including the Young Professional Forum and education for the future leadership.

www.ioconf.no

PETRONAS Seminar on IO 2009
The IO Center and Petrad in cooperation with Petronas and the CCOP Secretariat organized a tailor made 3 day seminar on IO in Kuala Lumpur for the employees of Petronas 10-12 February. There were about 100 participants. The Norwegian ambassador to Malaysia opened the seminar. 18 speakers from the IO Center and Petronas shared resent development and solutions in integrated operations with cases both from Malaysia and the North Sea. The seminar also organized four working groups on the critical areas in drilling, reservoir management, production optimization and work processes. Operation and maintenance and environmental monitoring and IO were also topics for discussions. The seminar was well received at Petronas and the delegates discussed strategies for follow up projects between Malaysia and Norway.

Education

Master students
Recruitment of master students with background in IO-related subjects is a very important “result” for our industrial partners. These candidates will enter important positions in the industry and contribute to implementation of IO from the very first working day. Many of the students projects are conducted in cooperation with the industry partners in the IO Center.

16 master students being affiliated with the IO Center have graduated in 2009. The majority of the students have been recruited by service suppliers and oil companies.

30 new students started their master pre project in the fall 2009, and will graduate spring 2010.

Continued education
15 workshops/seminars/continued education courses arranged for industry participation
**International collaboration**

**Innovation**

The goal for innovation in the IO Center is that the industry partners shall improve their business processes, products and services through implementing results from the center.

**Drilling technology**

An integrated drilling simulator has been field tested in Statoil, ConocoPhillips and Total, demonstrating capability to detect drilling problems at an early stage. New work processes have been developed to take full advantage of the simulator. The technology has been commercialized through a new company, eDrilling Solutions.

**Production optimization**

Results from the pilot project on production optimization on Troll [Statoil] in collaboration with FMC Kongsberg will contribute to the development of a new generation of the “Flow Manager” system provided by FMC. A PhD candidate was outplaced at Statoil, Troll to deploy research results in daily operation.

**Associated projects**

Associated projects have been carried out by the research partners of the IO Center for GdF Suez on training programs and integrated planning, and for Eni/Goliat on Condition monitoring system engineering.

**SME Innovation Forum 2009**

The IO Center has as a goal to stimulate SMEs in the IO field to develop new products and services related to IO, and to find customer relations among companies inside and outside the IO Center. The 2nd SME Innovation Forum was organized in connection with the IO09 Conference. The objective of the SME Innovation Forum 2009 was to discuss how suppliers and oil companies could cooperate to meet the challenge of proactive environmental monitoring and control by deploying the ideas of integrated operations. We had about 70 participants from oil companies, major suppliers, SME companies and R&D companies. The Forum was well received and Statoil supported this year’s event by using the forum as a kick-off meeting for discussion of future solutions for environmental monitoring and control and the innovation cooperation between suppliers and oil and gas companies.
**Organization and Governance Model**

The organization chart and governance model is shown in the figure below.

The Board and the Technical Committee meets twice a year. Board and TC members can access reports and other project information through a web site.

The sub project teams are populated by researchers from NTNU, SINTEF and IFE, and guest researchers from four international cooperating universities. Research is performed at five locations in Norway; Trondheim, Oslo, Halden, Bergen and Stavanger, in addition to the pilot project sites onshore and offshore and at the international universities. Communication internally and across activities is organized through physical and virtual meetings, use of a common project data base and email communication.

The PhD students arrange regular colloquia. The PhD students work 25% of their time as researchers in the sub projects, in order to get exposed to industrial processes and applications of new technology.

Collaboration with the industry is organized through 15 pilot projects and about 10 workshops per year for transfer of knowledge.

### Gender distribution

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<thead>
<tr>
<th>Category</th>
<th>% Female</th>
<th>Target</th>
<th>Actual</th>
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<tr>
<td>PhD students</td>
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<td>30</td>
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</tr>
<tr>
<td>Research Scientists</td>
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<td>30</td>
<td>13</td>
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<tr>
<td>Sub project managers</td>
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<tr>
<td>Board</td>
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<td>30</td>
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In connection with recruitment of PhD students, the announcements have stimulated women to apply for positions. Female participation has also been one of the criteria for hiring sub project managers and program managers. However, in both cases we have experienced problems with finding a sufficient number of female candidates.

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**THE BOARD**

- Jon Kleppe, NTNU, Chair
- Brage Sandstad, ConocoPhillips
- Nora Bergseth, Det Norske Veritas
- Erik Østby, Det Norske Veritas
- Jon Starkebye, IBM
- Trond Weberg, Kongsberg Maritime
- Vidar Hepsø, Statoil
- Gregor Henderson, Shell
- Fridtjof Øwre, Institute for Energy Technology
- Kjell Arne Jacobsen, SINTEF Petroleum Research
- Ingvald Strømmen, NTNU
- Tor Petter Johannesen, Research Council of Norway (observer)
- Jon Lippe, NTNU, Secretary of the Board
- Svein Ivar Sagatun, Statoil
- Øystein Haukvik, Aker Solutions
- Nora Bergseth, Det Norske Veritas
- Esben Rokke, FMC Kongsberg
- Rebecca Christensen, GdF Suez
- Ingvald Strømmen, NTNU
- Øystein Haukvik, Aker Solutions
- Fridtjof Øwre, Institute for Energy Technology
- Jon Starkebye, IBM
- Trond Weberg, Kongsberg Maritime
- Svein Ivar Sagatun, Statoil
- Øystein Haukvik, Aker Solutions
- Nora Bergseth, Det Norske Veritas
- Esben Rokke, FMC Kongsberg
- Rebecca Christensen, GdF Suez
- Ingvald Strømmen, NTNU
- Tor Petter Johannesen, Research Council of Norway (observer)
- Jon Lippe, NTNU, Secretary of the Board
## People in the IO Center

### Center Management

<table>
<thead>
<tr>
<th>Name</th>
<th>Title/Institution</th>
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<tbody>
<tr>
<td>Jon Kleppe</td>
<td>Center manager, NTNU</td>
</tr>
<tr>
<td>Jon Lippe</td>
<td>Operational manager, NTNU</td>
</tr>
<tr>
<td>Solveig Johnsen</td>
<td>Project Coordinator, NTNU</td>
</tr>
<tr>
<td>Arild N. Nystad</td>
<td>Advisor, Petromanagement AS</td>
</tr>
<tr>
<td>Tor Stein Ølberg</td>
<td>Program 1: Drilling and Well Construction, SINTEF</td>
</tr>
<tr>
<td>Bjarne Foss</td>
<td>Program 2: Reservoir Management and Production Optimization, NTNU</td>
</tr>
<tr>
<td>Andrew Gibson</td>
<td>Program 3: Operation and maintenance, MARINTEK, from Nov. 2009</td>
</tr>
<tr>
<td>Jon Lippe</td>
<td>Program Manager, NTNU</td>
</tr>
<tr>
<td>Solveig Johnsen</td>
<td>Program Coordinator, NTNU</td>
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<tr>
<td>Asgeir Tomasgard</td>
<td>Program 3: Operation and maintenance, MARINTEK, from Nov. 2009</td>
</tr>
</tbody>
</table>

### Sub Project Managers

<table>
<thead>
<tr>
<th>Name</th>
<th>Program/Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roald Kluge</td>
<td>1.1. Integrated Drill, Simulator, SINTEF</td>
</tr>
<tr>
<td>Thor Ole Gulbrands</td>
<td>1.2. Diagnostic Tool, SINTEF</td>
</tr>
<tr>
<td>Roar Nyba</td>
<td>1.2 Diagnostic Tool, SINTEF from Sept 2009</td>
</tr>
<tr>
<td>Torbjørn Korsvold</td>
<td>1.3 Work Processes and Experience Transfer</td>
</tr>
<tr>
<td>George W. Halsey</td>
<td>1.4 Utilization of Increased bandwidth from borehole, SINTEF</td>
</tr>
<tr>
<td>Stein Krogstad</td>
<td>2.1 Reservoir management, SINTEF</td>
</tr>
<tr>
<td>Davide Roverso</td>
<td>3.1 Conditioning based Monitoring and Maintenance support, IFE</td>
</tr>
<tr>
<td>Torgeir Brurok</td>
<td>3.2 Conditioning Monitoring, MARINTEK</td>
</tr>
<tr>
<td>Aud Marit Wahl</td>
<td>3.3 Integrated Planning, MARINTEK</td>
</tr>
<tr>
<td>Grete Rindahl</td>
<td>4.1 Future Collaboration Environments, IFE</td>
</tr>
<tr>
<td>Sjur Larsen</td>
<td>4.2 Work Processes and Decision Making, Studio Apertura</td>
</tr>
<tr>
<td>Eirik Albrechtsen</td>
<td>4.3 Integrated Operations and Safety, SINTEF</td>
</tr>
<tr>
<td>Åseir Tomasgard</td>
<td>4.4 IO Valuation Model, NTNU</td>
</tr>
</tbody>
</table>

### Visiting Researchers

<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prof. Erik Hollnagel</td>
<td>Ecole de Mines/Armines</td>
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<tr>
<td>Prof. Erik Ydstie</td>
<td>Carnegie Mellon University</td>
</tr>
<tr>
<td>Bernt Aadney</td>
<td>University of Stavanger</td>
</tr>
<tr>
<td>Defina Govia</td>
<td>Govia &amp; Associates, LLC</td>
</tr>
</tbody>
</table>

### Postdoctoral Researchers

<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Darijus Strasunskas</td>
<td>NTNU</td>
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<tr>
<td>David Echeverria Clauiri</td>
<td>Stanford University</td>
</tr>
</tbody>
</table>
Center for Integrated Operations in the petroleum industry
The IO Center was established in 2006, by leading international oil companies, system suppliers, academic institutions and the Research Council of Norway, with the objective to undertake research, innovation and education on integrated operations.

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