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Use of Real-Time Data at the Statfjord Field Anno 2005

J. Milter, O.G. Bergjord, K. Høyland, and B. Rugland, Statoil ASA

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Abstract:

The Statfjord Field has produced about 635 million Sm^3 (four billion bbl) of oil and exported 68 billion Sm^3 of gas since the production start in 1979. Currently, the field is in its tale production, producing at an oil rate of approximately 20,000 Sm^3/d, which is about 17 per cent of plateau production rate. Improved recovery and thereby extended production life of the Statfjord Field is now to be obtained by changing the drainage strategy from pressure maintenance to depressurisation. About three million working hours are planned for in connection with the upgrades required to extend the lifetime of the Statfjord Field by approximately 10 years. The production will continue and be optimised during the upgrading and changed drainage strategy.

Real time data transfer from offshore to land enables support of drilling, well intervention and production operations in an efficient manner. New work processes were required in order to facilitate remote support as well as quality control of production logging, measurement while drilling, drilling parameters, geology structures, well completion, process adjustments and production optimisation. In addition, onshore engineering support results in a much better utilisation of engineering resources. Visualisation in onshore/offshore meetings (twice a day) has enhanced a common understanding and made the work process integrated. Careful planning of adjusted work processes and making an energising involved personnel were the most important issues in order to achieve results and drive the changes.

The results so far are successful and the conclusion is a continuation of the project and an expansion of the involved professional disciplines to gain increased quality and time efficiency of the offshore operations.

Introduction:

The Statfjord field is a Norwegian offshore oil field with three concrete platforms (Figures 1 and 2). The old facilities produce with a high regularity of 95 per cent, mainly due to a comprehensive maintenance programme. The field has been an oil field and is now being converted to a gas field by decreasing the reservoir pressures and producing the mobilised and cumulated gas (ref. 1). About three million working hours are needed for the upgrades required to extend the lifetime of the Statfjord Field until the year 2018 (Figure 3). In connection with converting the old oil field to a gas field, reducing OPEX is a matter of necessity. Engineering personnel resources are limited. By moving engineering support from offshore to land, a much better utilisation of these personnel resources would be achieved.

A development strategy and reservoir management have been parts of established work processes and best practice. Constant focus on enhanced quality of the decision basis is partly the reason for the very high oil recovery factor of 65 per cent (ref. 2-4).

Previous work processes based on paper flow and calculations were slow. Analyses were made faster after the introduction of computers. Now the work process must handle utilisation of real time data (ref. 5). Automatic monitoring, real time surveillance control, data storage for post examinations to learn from experience and remote interpretations were all important elements in increasing quality and reducing OPEX. Statoil's strategic plan is to be among the leading operators in integrated operations (IO) within 2007. This plan is forwarded as a corporate initiative from the CEO (Figure 4). Hence, real time data management became a strategy for Statoil (ref. 6).

When it became possible to extract real time data from main servers, a new and even more beneficial opportunity was revealed. Multidisciplinary teams could remove bottlenecks and optimise the value chain from reservoir development via the process facility and transport down to the oil and gas trading. Gathering multidisciplinary teams irrespective of geography also enables working processes that in turn will lead to better, faster and safer decisions.

Work processes:

The Statfjord organisation consists of topside teams and subsurface teams. The topside teams handle platform production and maintenance. The subsurface teams handle well production potential and reservoir management.

The Statfjord subsurface (RESU) organisation comprises multidisciplinary platform teams, called RESU teams. These teams consist of a management, a project leader, well drilling and operations superintendent, petrophysicist, geophysicist, geologist, reservoir engineers, production engineers, completion well engineers and drilling engineers. Leading engineers control the technical quality of the work.

A description of the work process is given below. It is used for the different activities on the Statfjord field.

An unforeseen or planned activity needs to be carried out and triggers the work process. Budget allocation from the total yearly budget is justified by an activity assignment document. This technical assignment document is usually written by an engineer within the relevant discipline. The assignment is then verified and controlled by leading personnel and finally approved by management. The activity is then included in the scope of work of the work team, the platform, the field and the Tampen business cluster.

The activity is planned and a detailed technical programme is prepared. A method is selected and transfer of experience and preparation of decision trees is chosen to ensure focus on Health, Safety, Environment and Quality (HSE&Q). The detailed technical programme is subject to a fixed quality assurance loop and approved by leading personnel and team management. Equipment and personnel are mobilised offshore and the activity is carried out according to programme.

Prior to the implementation of integrated operations (IO), support was given by a discipline engineer who was a member of the offshore crew. The engineer updated calculations, secured transfer of experience from the work process, communicated with the platform organisation and verified the quality of the product. In addition, the engineer updated relevant databases. Offshore supervisors used the supporting engineer as a connection to the discipline network within the field and the company. After the end of the activity, the supporting engineer and the program engineer were responsible for experience transfer, updating of final reports and closing of the project activity.

By extended use of real time data the work process was adjusted. All engineers within drilling, completion, reservoir and production needed clear instructions concerning which operations to support, when the support should be given and which reporting line to follow. A sheet with an overview of the operations that might demand engineering support and the reporting line simplified the transition from offshore to onshore support. Reporting lines were kept unchanged, but engineering support was made possible from onshore.

Concerns that were taken seriously were the qualifications of the supporting personnel, the reporting lines and the social nature of the work and collaboration (ref. 7).

A GAP analysis of the required adjustments of the work processes was performed. An example is given in Table 1. The total GAP analysis described the changes in the work process during well interventions and well drilling operations. For example witnessing of standard perforation and plugging operations regarding verification and physical check of tools was done by the offshore supervisor instead of the supporting engineer. Assignment documents were adjusted to contain quality descriptions of used logs for the operations, for example.

The GAP analysis pointed out the necessary actions. In addition, supporting personnel were sent offshore to be updated on new equipment and working methods. Reporting lines that ensured quality control, verification and recommendation and approval were clarified (Figure 5). Closed circuit television system (CCTV) from rig to the operations room was facilitated to strengthen the hands-on operation by the supporting engineers (Figure 6). An appropriate compensation package was activated. This overall solution motivated and energised involved personnel sufficiently.

Real time data are available in a specially designed operations room which is well equipped with communication and visualisation tools. Based on operational needs relevant personnel are mobilised. Operational support is given by multi-disciplinary teams to ensure high focus on quality.

Supporting personnel can be localised anywhere if they have access to save high speed internet communication. The size of the personnel network increased considerably. After normal working hours support can be given irrespective of the location of the RESU member or supplier. The support time was reduced by 70 per cent.

Equipment and Facilities:

Information Communication Technology (ICT) is an enabler that facilitates change of working processes (Figure 7). For the Tampen area, of which Statfjord is a part, a robust communication Quality of Service (QoS) network was established (Figure 8). This network has redundant solutions with respect to speed and capacity for onshore support. Solutions are continuously added and needs are modified to assist or to fit new work processes. Onshore and offshore operations rooms (Figures 9 and 10) are established. The operations room contains video conference equipment, a smart board, projectors, powerful computers, radio communication with the platforms and various platform work teams, CCTV (Figure 6) pictures from different cameras on the platforms are also accessible from the onshore operations rooms.

Protection of privacy for personnel in the camera zone was secured by excluding remote control of the camera and reduced picture quality. Data safety and transfer rate were secured.

Applications for real time data transmission were established. The applications transfer data from all measured tags at the Statoil operated platforms and from subcontractor tools downhole. The Statfjord onshore operations centre is constructed with focus on extended collaboration between all subsurface disciplines located both locally and centrally.

Furthermore, connection to real time data is possible from all personal computers connected to the Statoil internal communications network. It is possible to log on to the network anywhere on the globe when high-speed internet communication is accessible. This facilitates support, irrespective of physical location.

All personnel were trained in the use of equipment available in the operations room, for example offshore radio, video, real time data applications.

A few operations were very time consuming and due to work regulations they required offshore-based engineering support.

Results:

Statfjord Integrated operations were organised as a project with phases and milestones. The project has four phases:

Phase 1, A period of two months in 2004 was spent on practising and testing equipment and work processes. Work and support were shadowed from land in addition to "business as usual" offshore.

Phase 2, was started in January 2005. This phase included engineering support based on demand from well operations offshore. Engineering support involves monitoring and interpretation of real time data.

Drilling and Well operations, Phase 2:

1. Production logging.
   Logging downhole is performed on a regular basis. The logging data, used for allocation, development planning and for deciding the next intervention are now interpreted onshore. Real time data from injection/production topside and downhole are used by the supporting engineer. Interpretation and decision allow the necessary action to be made immediately.

2. Pressures build-up tests.
   Pressure build-up analyses are performed with real time data input. This has minimised the shut-in time of the well. Multi-disciplinary interpretation, irrespective of physical location of the engineers, reduces the time needed to conclude the correct action.

3. Plugging and perforation.
   Support to plug off unwanted fluids and to perforate with desired pressure balance is now given onshore.

4. Saturation logging.
   Quality control of the logging data is now supported from onshore.

5. Clean-up of wells after well intervention.
   New perforation intervals need careful treatment until productivity and well hydraulics can be determined. Online support diminishes the interpretation period and secures a fast track to optimal production/injection.

6. Measurement while drilling (MWD).
   Contractor engineer (day shift) is supporting from the operation room onshore. The work content onshore and offshore is identical.

7. Meetings onshore – offshore.
   Video conferences with smart boards and access to the same real time data ensure a common understanding and fast insight. This is used many times every day for handover, status reporting and method selection.

Production and Process optimisation, modifications and surveillance, Phase 2

1. Extended production testing.
   Standard testing of wells is carried out by the control room operator offshore. Extended testing with the possibility of sand production (ref. 8), coning effects and unknown behaviour, demands engineering support. This support is now given by use of RT applications, internet and radio and telephone communication.

2. Process optimisation.
   Pressures of inlet separators on the platforms were decreased. Decreasing the pressure in the process train involved a close monitoring of

flowline, rotating equipment and continuous adjustments of well chokes (Figure 11). This was supported from land.

3. Process surveillance.
   Real time surveillance involves compressor vibrations, oil temperature and H_2S, flowline velocities, choke erosion and gas export quality control. If the data or calculated measurements exceed the pre-defined operations window, an alarm will be sent to relevant personnel by SMS (text message) or e-mail.

4. A multi-disciplinary team works to de-bottleneck and maximise profit.
   Statoil initiated various pilots within IO in the various business units. Based on the experience from these pilots a Production Optimization Group (POG) in every business unit was established. Every day POG personnel from the topside process support and from the subsurface unit meet to identify and remove bottlenecks. Real time data are used to assure that a bottleneck is removed when the adjustments are carried out.

5. Intelligent well surveillance.
   Pre-defined trends are kept under continuous surveillance. When well data, such as annulus pressure, flowing well head pressure, sand acoustic signal and downhole temperature, fall outside the defined area of normal operation, an alarm is sent to the relevant personnel. A message is sent by e-mail with specific information, and/or as a text message to a personal mobile phone. This triggers preventive actions and impede long well shut-in events.

Transfer of experience and course of events are easily accessible, and should make handling faster and more efficient. However, this task still needs to be developed and closing of experience reports needs more focus.

Phase 3 started in November 2005. This phase consists of a work process for pro-active surveillance of real time data during drilling operations. The following data are used in the surveillance:

1. Hook load, rotation per minute, drill string torque, mud pumping pressures in and out of the hole, equivalent circulation density, equivalent static density, gas content in the mud, penetration rate, block velocity downhole

2. Formation evaluation data from MWD

These data are used for trend analysis and real time drilling optimisation. Relevant discipline engineers are available for analysis and the decisions should therefore ensure high quality and safe operations.

Phase 4 belongs to the future. Phase 4 contains control and steering of downhole tools, surface processes and well production from onshore. The technical means required are available and have been tested out. Two production logs have been run from onshore and well chokes and process equipment can be run from the office. However, implementation of this phase still lies ahead of us. Issues to be solved prior to implementation include;

1. Possible effects on HSE standards.
2. Data security.
3. Human Resources (work regulations).

<u>Conclusions:</u>

1. POG leads to better interaction between facilities and reservoir environment, and focus on the value chain from the reservoir to the point of sale.

2. Automatic surveillance by the use of real time data and daily focus by the onshore organisation reduce the number of unforeseen events. This decreases the number of shut-ins of wells and process equipment and increases the regularity.

3. Extended use of real time (RT) data is essential in production optimisation. RT tools will therefore be improved and integrated into work processes.

4. Approximately 70 well operations have been supported from land with RT data during 2005. This on-demand support from land reduced the support time by 70 per cent. This leads to more efficient use of the engineering resources onshore.

5. Integrated operations, as a tool for real time follow-up of offshore operations, have become a powerful work process for better, faster and safer decisions.

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Nomenclature:

ICT	Information Communication Technology
CCTV	Closed Circuit Television Systems
CT	Coil tubing
HSE	Health, Safety and Environment
IO	Intergrated operation
MWD	Measurement while drilling
OPEX	Operating expenses
PBU	Pressure Build-Up test
PLT	Production Logging Tool
POG	Production Optimisation Group
HSE&Q	Health, Safety, Environment & Quality
QoS	Quality of Service
RESU	"Reservoarutnyttelse" (multi-disciplinary subsurface team)
ST	Saturation tool
RT	Real time
SMS	Short Message Service (text message)

References:
1. Boge, R. *et al*.: "*Turning a North Sea Oil Giant Into a Gas Field - Depressurization of The Statfjord Field*," paper SPE 96403 presented at the 2005 SPE Offshore Europe, Aberdeen, United Kingdom, New Orleans, Sept. 6–9.

2. Haugen, S. *et al*.: "*Statfjord Field: Development Strategy and Reservoir Management*," paper number 16961, Journal of Petroleum Technology, Volume **40**, Number 7, Page 863-873, July 1988

3. Hegre, E. *et al*.: "*IOR Potential With Updip Water Injection in the Statfjord Fm at the Statfjord Field*," paper SPE 28841 presented at the 1994 SPE European Petroleum Conference, London, United Kingdom, Oct. 25-27.

4. Al-Najjar, N.F. *et al*.: "*4D Seismic Modelling of the Statfjord Field: Initial Results*," paper SPE 56730 presented at the 1999 SPE Annual Technical Conference and Exhibition, Houston, Texas Oct. 3-6.

5. A. McCann *et al*.: "*Statoil's First Onshore Support Center: The Result of New Work Processes and Technology Developed to Exploit Real-Time Data*," paper SPE 90367 presented at the 2004 SPE Annual Technical Conference and Exhibition, Houston, Texas USA, Sep. 26-29.

6. A.J. Ringstad and K. Andersen: "*Intergrated operations and HSE – major issues and strategies*," paper SPE 98530 presented at the 2006 SPE International Conference on Health Safety, and Environment in Oil and Gas Exploration and Production, Abu Dhabi, Apr. 2-4.

7. Vidar Hepsøe: "*When are we going to address organizational robustness and collaboration as something else than a residual factor ?*," paper SPE 100712 presented at the 2006 SPE Intelligent Energy Conference and Exhibition, The Netherlands Apr. 11-13.

8. Andrews, J. *et al*.: "*Production Enhancement From Sand Management Philosophy: A Case Study from Statfjord and Gullfaks*," paper SPE 94511 presented at the 2005 SPE European Formation Damage Conference, Sheveningen, The Netherlands May 25-27.

Table 1: Example of the work process GAP analysis

Operation	Engineering support offshore	Engineering support in OPC	What needs to be done offshore	Evaluation of change	IT support
Plug&Perf.	Calculation of fluid phases in wellbore to adjust overbalance/-underbalance.	Reservoir/Production engineer on duty will have the same tasks.	Visual reading of pressure at wellhead before perf.	OK	Access to PI system. Camera on hatch deck.
	QC of correlation. Adjust pressure in well, if needed.	Reservoir/Production engineer on duty will have the same tasks in cooperation with Schl.eng.	Visual reading of pressure at wellhead after perf.	OK	Real time data and same screen pict. as Schl. Eng. Radio access.
	Evaluate pressure test of installed plug.	None	Currently performed by Well operations supervisor.	Not critical	None

Figure 1: Location of the Statfjord Field.

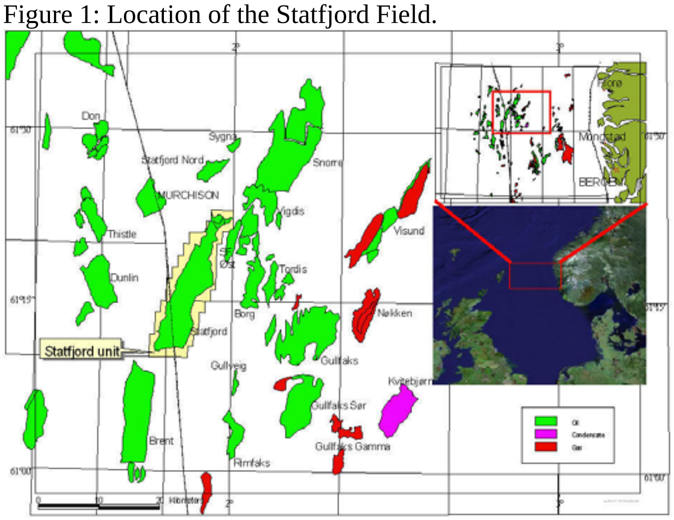

Figure 2: Infrastructure of the Statfjord Field.

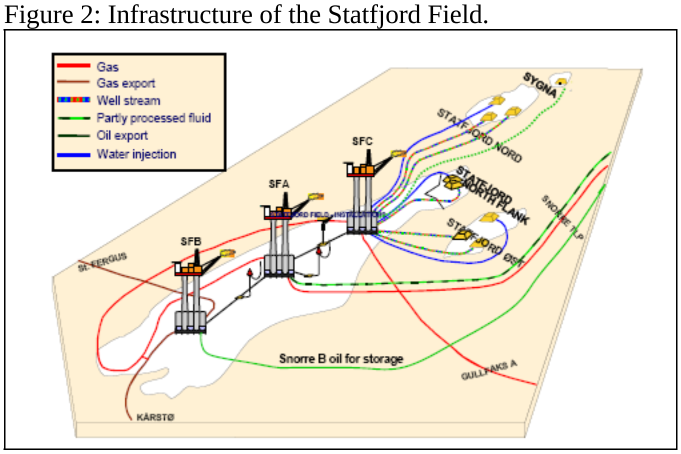

Figure 3: Actual from 1979 and expected oil production until 2018.

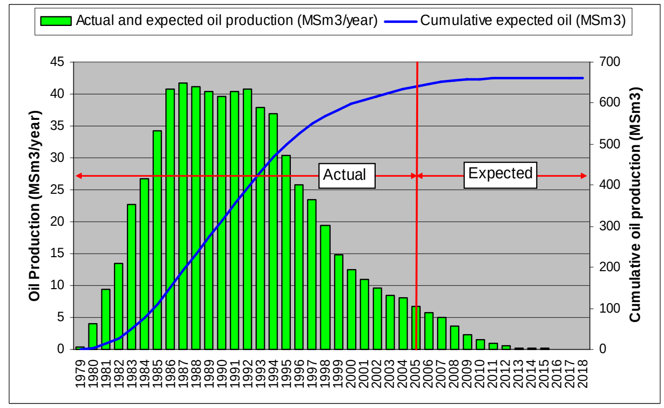

Figure 4: Statoil plan for exploitation of integrated operations.

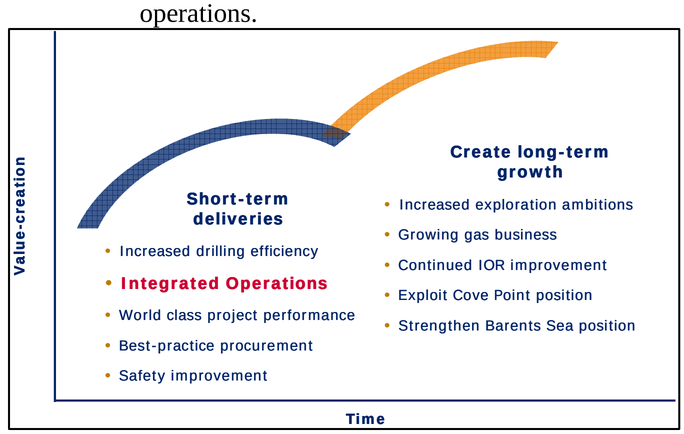

Figure 5: Reporting line

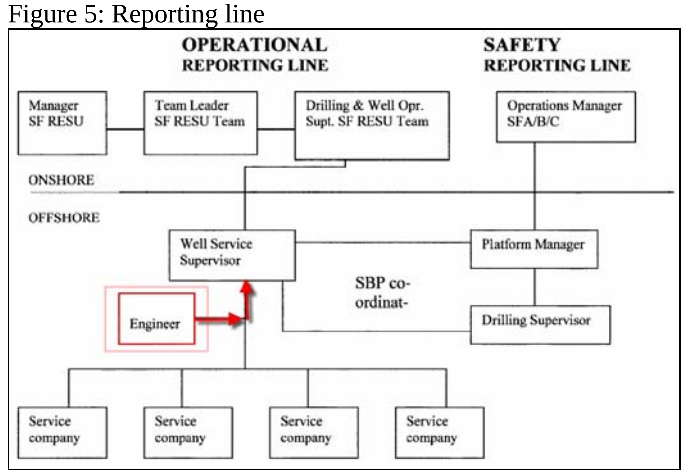

Figure 6: Statfjord C Drillfloor during a well completion.

Figure 7: ICT network with fibre optic cable connection between land and offshore facilities.

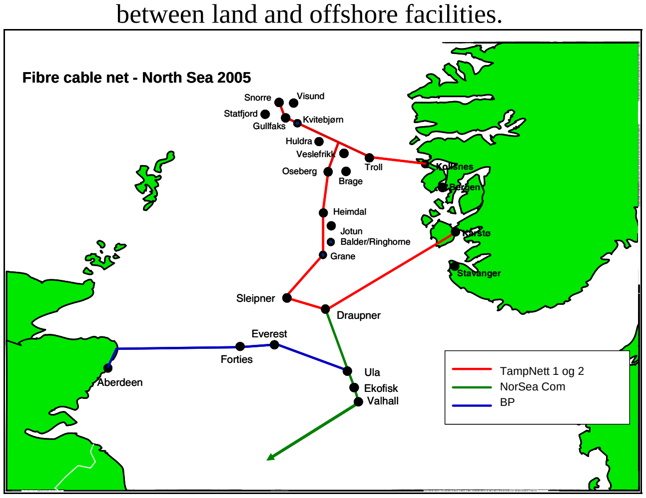

Figure 8: Data stream

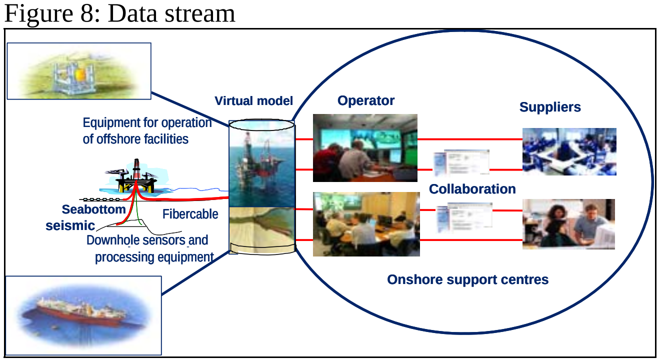

Figure 9: Statfjord Onshore Operations Centre with the Statoil and Schlumberger team during logging of the first remote wireline logging operation.

Figure 10: Statfjord Offshore well Superintendent office during a PLT operation.

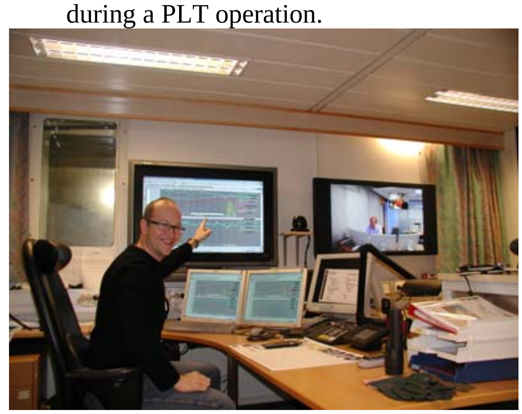

Figure 11: Sketch of a process flow, Statfjord B and of a process flow with real time data