SHELL EXPRO'S PLANT OPTIMISATION AND SYSTEMS MANAGEMENT PROJECT

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BACKGROUND

Shell U.K. Exploration and Production (Shell Expro) operates in the U.K. sector of the North Sea on behalf of Shell U.K. Limited, Esso Exploration and Production UK Limited and other co-venturers. As such, Shell Expro is one of the major producers of natural gas within the Northern North Sea.

Shell Expro's gas gathering and processing facilities for the Central and Northern North Sea areas are operated by the Gas Systems and Plants (GSP) business unit. These facilities include the FLAGS and Fulmar pipelines as well as the gas processing plant at St. Fergus, the St Fergus to Mossmorran Natural Gas Liquids (NGL) pipeline, the Mossmorran Fractionation Plant, and an LPG and condensate marine export terminal at Braefoot Bay in Fife. The latter two are collectively known as the Fife NGL Plant.

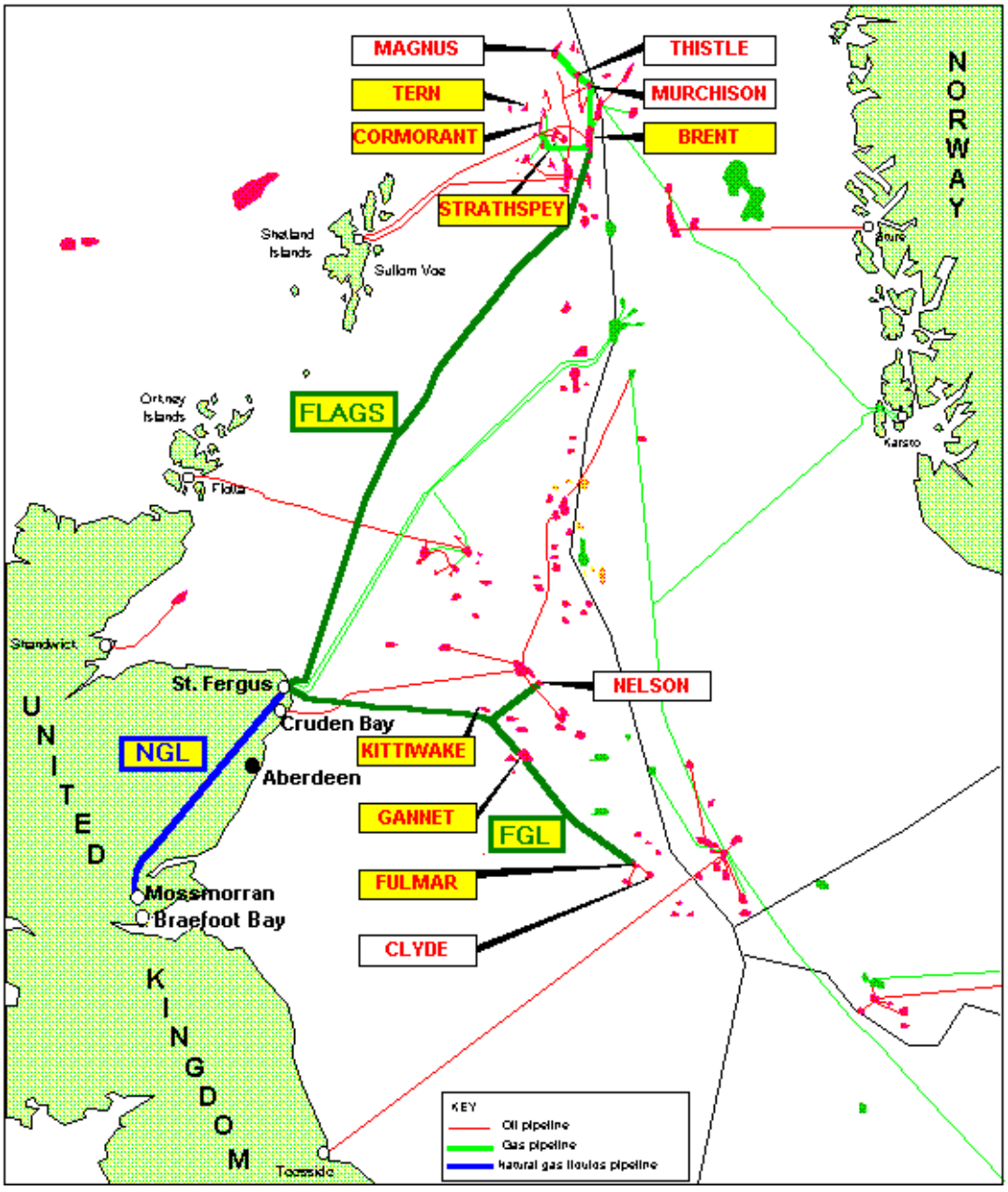

Figure 1

In 1994, the Plants Optimisation and Systems Management (POSM) project was instigated to provide improvements in the computer-based systems for the production scheduling and management of the GSP assets. The POSM project relies on the use of three key technologies:

- High Fidelity Plant Models (the so-called Rigorous On-line Models or ROMs^{TM}) which are being installed at the St. Fergus and Mossmorran plants.
- Dynamic models of the St. Fergus NGL, the Fulmar and the FLAGS pipelines.
- Advanced Scheduling tools for optimisation of plant set-ups to meet pre-defined commercial or product quality goals.

The 290 km Fulmar Gas Line (FGL) transports dense phase gas from the Central North Sea to St. Fergus. The line was originally constructed to carry gas from the Fulmar (Shell) and Clyde (BP) fields. New fields have since been brought on stream (Kittiwake, Gannet, Nelson and Anasuria), and new developments, including Curlew, are scheduled to join the FGL transmission network.

The 450 km Far North Liquid and Associated Gas System (FLAGS) pipeline transports gas from the Northern North Sea to St. Fergus (for part of the year, this FLAGS pipeline operates in two-phase flow). Most gas is supplied by the Shell Expro Brent Field, with the remainder provided by a number of other Shell and third party fields via the "Northern Leg" and the "Western Leg" transmission systems.

At the St. Fergus plant, the gas is dehydrated and, in the case of the FGL system, is also sweetened in molecular sieve treaters. The gas is then separated by cryogenic distillation into a methane-rich stream for export to British Gas, and also into an NGL stream that is combined with third party NGLs (from the adjacent Mobil and Total sites) before export for further processing at the Mossmorran Fractionation Plant. NGLs are also exported to the Scottish Hydro-Electric power station at Peterhead and, in exceptional circumstances, to the BP Forties land line at Cruden Bay. NGLs are transported from St. Fergus to Mossmorran through a buried 20", 224 km pipeline which has a current maximum capacity of some 14,000 tonnes/day.

BUSINESS OPTIMISATION

For some years, it has been recognised that the development of new gas fields in the Northern and Central sectors of the North Sea would present new challenges to the existing pipeline and on-shore processing facilities. The new demands on assets relate not only to the increased throughput of gas, but in addition, the plants are required to efficiently handle gas receipts of variable composition. They must also operate optimally within an increasingly demanding commercial regime of production nominations with severe financial penalties attached.

GSP manages a variety of contracts specifying flow rates and qualities of gas, (for example, ethane, propane, butane and gasoline components). Differences in composition, platform shut-downs, complicated banking arrangements and changing nominations mean that sophisticated tools are required to optimise the business in order to maximise the commercial benefits. The POSM project relies on a number of high technology tools providing a flexible planning and scheduling environment under which GSP operations can be managed for maximum business benefit.

The POSM project comprises eight separate but complementary components, each with a distinct technology focus. These are assigned to three separate project phases, as shown in Table 1.

Phase 1	Phase 2	Phase 3
St. Fergus Open Loop ROM™	Fulmar Pipeline Dynamic Model	St. Fergus Closed Loop ROM™
Mossmorran Open Loop ROM™	FLAGS Pipeline Dynamic Model	Mossmorran Closed Loop ROM™
Scheduling System		
NGL Pipeline Dynamic Model		

Table 1 - POSM Project Phases & Component Activities

For phases 1 and 2 of the POSM project, the financial benefits to Shell Expro will be in excess of £2m per annum against a project cost of some £4.7m.

GAS PLANT OPTIMISATION

With the gas plants at St. Fergus and Mossmorran operating close to capacity, significant benefits can be achieved by installing ROM™ based process optimisation systems. These systems, based on Simulation Sciences Datacon and the PRO/II modelling language, provide equipment performance monitoring, case study development and the generation of optimised targets for the plant operator. The targets are applied manually in an *open-loop* mode to the plant distributed control system.

In phase 3 of the project, it is intended that optimised targets will be downloaded directly into the plant control system (*closed-loop* mode) with a manual override capability.

SCHEDULING SYSTEM

A steady state Northern North Sea model developed by Exxon in the early 1980s as a short term scheduling tool for North Sea Operations concentrated on oil production with minimal representation of gas systems. This model does not recognise new third party platforms nor the Mossmorran NGL Fractionation Plant, and is therefore not now representative of the GSP assets. The new scheduling facilities provided under POSM have been developed by MDC Technology Ltd using RTO and modelling language. The system includes modified configurations of Northern and Central North Sea fields, the St. Fergus and Mossmorran gas plants and simplified pipeline models for accurate accounting of transportation time lags.

NGL TRACKING MODEL

Following extensive trials on the NGL Pipeline which demonstrated that the leak detection requirements could be satisfied, the POSM Project is installing a LICconsult dynamic model-based leak detection system enhanced with the Sequential Probability Ratio Test (SPRT) to reduce detection time. Identical systems are also being installed on the export pipelines to Peterhead power station and to Cruden Bay. Using the Hewlett Packard ‘RTAP’ based display/supervisory systems provided by Scomagg Ltd., the LICconsult real-time model tracks batches of natural gas liquids and calculates the bubble point pressure of the liquid approaching the pipeline high point, and hence enables the end-of-pipeline pressure to be optimised.

Composition data is made available to the Aberdeen Operations Control Centre (AOCC) for pipeline management, and to Mossmorran for operational adjustment and predictive modelling.

FGL TRACKING MODEL

The gas collected by FGL varies considerably in composition dependent on the producing fields. In addition, the different operating modes of fields such as Gannet also yield changes in gas quality. Mode changes, in combination with occasional platform trips, can therefore produce batches of gas of differing composition in the FGL pipeline. Without accurate positional information on the rich/lean gas batches, unexpected operational transients at the St. Fergus gas plant can lead to flaring of ethane at Mossmorran and efficiency losses at the neighbouring Fife Ethylene Plant.

LICconsult is providing a real-time dynamic model of the FGL pipeline to track changes in composition along the pipeline, enabling St. Fergus to prepare for any transients and allow the schedulers to manage the overall assets in a more effective manner. The model also provides an improved leak detection capability for the Fulmar Gas Pipeline.

FLAGS TWO-PHASE MODEL

During winter, the FLAGS pipeline is constrained by the capacity of the St. Fergus Gas Plant to treat/handle liquids generated in the pipeline. FLAGS line-pack is sometimes used to cater for short term losses in the FGL system, and this can also result in liquid drop-out from the gas. Without accurate tools to predict the conditions for liquid drop-out and the rate at which those liquids will arrive at St. Fergus, it is not possible to make optimal use of the FLAGS line pack.

LICconsult is providing a real-time two-phase model of the FLAGS pipeline to predict the formation of liquids in the pipeline, and accurately forecasts the arrival of the liquids at St. Fergus. The model also provides a ‘best available technology’ leak detection capability for FLAGS.

SUMMARY

The POSM project is demonstrating the commercial benefits that can be gained through the application of appropriate modelling and scheduling technologies. The benefits of the project are not purely financial, but also include such improvements as enhanced pipeline integrity monitoring, enhanced safety (through the use of upgraded alarm display and monitoring systems), and improved hardware reliability (achieved by replacing ageing and obsolescent equipment). There are also associated environmental benefits, for example, by minimising the need for flaring at the Mossmorran plant.

The POSM project illustrates Shell Expro’s commitment to business and environmental improvement through the deployment of relevant technology.