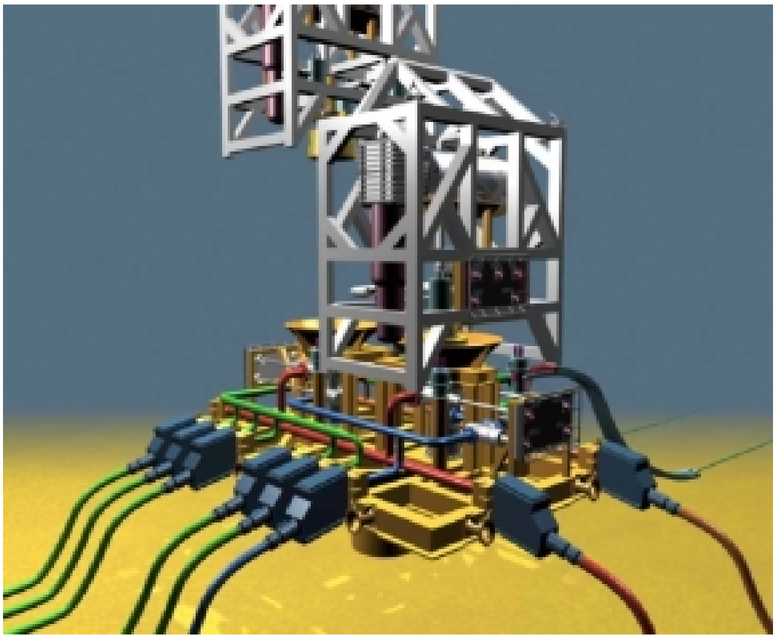
AlphaPRIME – THE MODULAR ANSWER
The electric subsea production option



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Presented by David Appleford at the
Offshore Production Technology Conference
London, 31st January/1st February, 2001

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Introducing the AlphaPRIME Project

The AlphaPRIME diverless, all-electric, System-Modular concept was developed in order to provide the most economic and reliable means of deploying, operating and retrieving seabed processing systems. This paper will show that it provides significant advantages for seabed processing systems. It will also be demonstrated that AlphaPRIME System-Modular technology is now ready for field development.

AlphaPRIME is the result of decades of the engineering development of integrated seabed processing systems: Alpha Thames' experience dates from the 1970s when Alan Webb, one of the founders of the Company, worked on BP's Zakum field on which an electrically powered seabed processing system was installed and operated. This was followed by GA-SP, a modular seabed processing system that was engineered and successfully tested underwater by Alpha Thames; this led to the AlphaPRIME Project.

Certain key items of subsea equipment, that were necessary for AlphaPRIME, were not available from the industry; Alpha Thames has therefore developed MATE (a single datum multi-ported connector with integral AB3 valves), ELEx (a high voltage, high power underwater-mateable connector), CUSP (Connection of Underwater Systems and Pipe/flowlines), and also a range of underwater electric actuators: REAct, PROAct and FLOAct.

It may be seen, therefore, that Alpha Thames has considerable expertise in the design and development of seabed oil and gas processing systems and equipment, and also in the development of System-Modular installations.

This System-Modular technology has been embodied in AlphaPRIME and it now utilises field-proven technology; AlphaPRIME is fully ready for field application and is now being actively marketed. Furthermore, this paper will show that AlphaPRIME is an ideal vehicle for the development and control of "smart assets".

Why the need for a modular system?

Seabed processing systems need to:

- optimise production and minimise cost
- be reliable and minimise risk
- provide flow assurance at all times
- ensure ease of installation
- be commissioned rapidly
- be reconfigured and maintained easily during field life
- be capable of step-by-step expansion of the field

These needs are readily met by a System-Modular approach; significant additional advantages also accrue as outlined below.

The AlphaPRIME System-Modular design approach facilitates an efficient manufacturing route by which early production can be realised. This is achieved as the Base Structure, the Docking-Manifold, and the System-Modules can be manufactured/fabricated in parallel, not necessarily in the same location or country.

The Base Structure and the Docking-Manifold can be installed early, and the pipelines/flowlines tie-in operations undertaken whilst the System-Modules, which contain the long lead items, are being completed and fully system integration tested in

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the factory. Once completed, the System-Modules can be readily and quickly installed, as fluid and electrical connections are minimised.

AlphaPRIME provides 100% redundancy with continuous availability. Each installation comprises twin operating System-Modules: if one is removed for any reason, the other maintains production. The deployment of a replacement System-Module quickly restores the 100% redundancy. This is in contrast to certain other systems that offer built-in redundancy; in those systems, once the duplicate components are brought into service, the remaining redundancy has diminished. Moreover, the System-Modular approach avoids the numerous wet-mateable interfaces and additional isolating components that are necessary in insert retrievable systems and that thereby significantly diminish reliability.

If field characteristics dictate, the System-Modules can accommodate separation systems. This will enhance the production rate and lengthen viable field life and also provide flow assurance by avoiding, for example, the problems of slugging and hydrate formation.

Each identical System-Module has a footprint of 5 m x 4 m and is some 6 m high; it weighs only 25 to 50 tonne in air, depending upon the equipment required within it, and can therefore be deployed by relatively light support vessels equipped with a suitable crane or A-frame. ROV assistance is required but all installation, maintenance and retrieval operations are diverless. The only wet-mateable connections for each System-Module are the wellhead-type connector for fluid and mechanical connections, and the electric power and control connectors.

Each System-Module accommodates a processing system that is complete with electrical power distribution and control systems. The entire assembly is an excellent example of systems integration in design, manufacture and testing. With hard wired, fully factory tested connections and minimum use of wet-mateable interfaces, the entire system undergoes total system integration testing and also “burning-in” of the components for increased reliability. As a result of this approach to the design and testing, commissioning on the seabed entails little more than a leak and function test.

The installation (or change out) and commissioning of a System-Module can be achieved speedily, allowing the advantage to be taken of a short weather window. The ease with which the System-Modules can be changed out provides the opportunity to reconfigure the processing system at any time during field life. For example, a system that only requires manifolding at the start of field life can be reconfigured to a separation system, when required, in later years. This means that CAPEX occurs only if and when it is needed instead of being concentrated at the start of field life. Furthermore, the equipment need only be specified to suit its reduced operational life in a given System-Module configuration. The equipment in both twin System-Modules is operated simultaneously from the outset and therefore start-up problems, when bringing online dormant equipment, are eliminated. In the same way, new technology can be introduced into the system as it becomes available to the industry.

The AlphaPRIME system can readily accept future expansion of the field, or tie-in of an additional field. Obviously, the capacity of the system will need to match that of the total production throughput anticipated. The AlphaPRIME system can be sized and configured to best advantage if potential future expansion is allowed for at the design stage.

Decommissioning is an important consideration; it was the subject of no less than five articles by Martyn Wingrove in a recent issue of Energy Day (edition dated 22nd January

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2001). AlphaPRIME System-Modules slot into a Docking Manifold that, in turn, is accommodated within a Base Structure. The Base Structure normally utilises a foundation system such as a monopile or mudskirt gravity base depending upon the particular seabed conditions. The System-Modules and the Docking-Manifold can be readily retrieved to the surface for refurbishment, reconfiguration and re-use elsewhere. In the case of a monopile foundation system, the base structure can also be readily retrieved. However, other foundation systems, would be recovered by conventional means.

What were the parameters for the AlphaPRIME project?

The overall aim of the project was to optimise AlphaPRIME for maximum revenue and reliability, minimum CAPEX and OPEX; the latter being provided by the well-documented advantages of installing processing systems on the seabed as well as by the savings in maintenance costs that are to be made by the utilisation of the diverless, all-electric System-Modules. It was also to ensure that the versatility of the system is sufficient to include new technology in addition to established processing technology.

In order to demonstrate that these aims have been realised, the following paragraphs give a brief overview of the development history of the System.

AlphaPRIME embodied the integrated System-Modular approach from the outset. The initial design concept (then known as MUST) gained DNV approval in 1991 (and complies with DNV RP 0401 and API RP 17A). Intermediate designs followed and Lloyds Register's approval in principle was gained in 1998. The prototype System-Module was successfully tested under the auspices of the EC-funded ÆSOP Project in 1999 and these in-factory and underwater tests were witnessed and approved by DNV.

Alpha Thames and its sister company Kockums Engineering undertook the testing and demonstration of a prototype System-Module and associated equipment e.g. underwater, electric actuators. The prototype System-Module was electrically powered and controlled, and was equipped with a horizontal, two-phase separator, a single-speed pump and REAct and PROAct electric actuators. The interfaces with the Docking-Manifold were the MATE valved, multi-ported fluid connector, the ELEx 11kV Connector and the control system connector. The test system included a simulation of a subsea well that fed a 20,000 bbloe/d input flowrate to the System-Module. The prototype System-Module was built and tested in Kockums' factory in Malmö, Sweden and was also tested underwater in the adjacent harbour. As there were environmental restrictions on the use of hydrocarbons, water and air were commingled in the test system. The System-Module successfully separated these two fluids and the outputs were monitored to ensure complete separation. Demonstrations of the diverless deployment and underwater tests were subsequently given to representatives of the offshore industry. The short time taken to commission the System-Module, immediately following installation, was the topic of much favourable comment!

Powering the system in deepwater

AlphaPRIME is essentially an all-electric system that is powered by a high voltage supply from the host facility. The absence of hydraulics and the utilisation of all-electric power and control combine to minimise the number of interfaces and optimise reliability. This an important consideration in deepwater applications.

The power is fed to each System-Module by means of a power/control umbilical cable that may also incorporate chemical injection lines. The System-Modules can also be

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connected to each other to form a “ring main”. This has the advantage that any one System-Module can be isolated by means of switchgear in the adjacent System-Module and/or that at the host facility. Therefore, it is possible to isolate and retrieve a System-Module, whilst maintaining power to the remaining modules, even if its switchgear is faulty. Each System-Module has a main transformer within a pressure-balanced housing and a power and control pod. The latter is a pressure vessel with two compartments, one for power equipment (secondary transformers and switchgear) and one for control equipment.

All the equipment within the pod operates in a dry, notionally one-atmosphere environment; this enables well-proven, industry-standard, highly reliable, solid state, electronic control systems to be utilised. The programmable logic controller (PLC) which is located in the power and control pod controls the process and responds to signals from the subsea sensors. Commands are sent from the master control station (MCS) on the host platform or shore-based facility and process values are sent to the MCS. As most process values vary fairly slowly, the requirements for data transmission are moderate. By this means, the seabed system continuously monitors and controls itself, sending data to a topside master control unit but only needing to alert topside staff of unusual events, whereupon manual control can be assumed. As the system is software-controlled, software changes can be made at the MCS via the communication link often without interrupting the production process. As the System-Modules function as autonomous systems, they can be programmed to continue to operate (for a pre-determined time) in the absence of control signals from topsides, after which they will automatically shutdown in a controlled manner.

Pressure and temperature sensors are located inside the power and control pod; level switches are also fitted to verify that there has been no water intrusion. There are also sensors that monitor voltages, currents, electrical insulation and contactor positions to ensure that information on the electrical and electronic system conditions are provided at the MCS.

An AlphaPRIME installation can distribute power to neighbouring seabed systems. It can also act as a control centre that provides feedback data especially as it operates autonomously yet offers the operational flexibility of being reprogramable from the host facility. Moreover, AlphaPRIME can incorporate reservoir surveillance. If required, AlphaPRIME can be configured to include hydraulic power units (HPU) in order to control conventional electro-hydraulic trees.

In the seabed processing system, the valves are operated by the electric actuators that have been specially developed by Alpha Thames and that are available for use in seabed systems and land-based applications. It should be noted that existing proprietary subsea valves are used and that the electric actuators do not come into contact with the hydrocarbons.

If the configuration of a System-Module were to include a separation process, the fluid levels in the separator are monitored and are adjusted as necessary by the use of modulating valves in the system; these valves are operated by PROAct electric actuators. This enables single speed pumping to be used to boost the liquid outputs. The pumps can therefore be selected to operate at their optimum speed for maximum reliability and efficiency; moreover, the need for complex and bulky speed control systems is obviated. As a proportion of pump output may be recirculated back to the separator, any heat generated is imparted to the separator thus assisting in the processing of the fluids. An electrically powered system can, if necessary, be configured to provide additional heat to the process system and to the pipelines.

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Where the modules are equipped with choke valves, they are operated by FLOAct electric actuators. The separator is protected by an isolation valve that is operated by REAct, a fail-safe electric actuator which, in the unlikely event of a power failure (or if an emergency control on the panel on the host platform is operated), will immediately close the valve.

Future of subsea production systems

System-Modular installations can accommodate a great variety of hydrocarbon processing systems and power and control equipment; they can be readily reconfigured during field life to cater for reservoir, infrastructure and technology changes such as the introduction of subsea compressors. This would increase drawdown and maximise early production; it would also increase the flowing pressure of the gas from the seabed processing system and would allow the use of a smaller diameter pipeline back to the host facility and would allow even longer tie-backs. Another example is the monitoring of the oil content of produced water; whereas it is possible to separate produced water, a satisfactory method of continuously monitoring its oil content has not yet been developed for subsea use. However, a number of methods are being investigated and once this goal has been achieved, separated water may be jettisoned to the sea without the need for transporting the water to the host facility.

AlphaPRIME can act as central processing units (or nodes of a field development network) for step-by-step field development, power and control. The System-Modular installations can provide a control hub for an autonomous “smart” control system, distribution of control data, reservoir monitoring, remotely re-programmable software and data communications. Revenue would be maximised by the incorporation of these intelligent systems which optimise production and provide total hydrocarbon recovery management. OPEX is minimised by closer monitoring of the process system combined with greater precision in the injection of chemicals. These intelligent systems can operate with a power/control buoy and HF radio or satellite link. Field electric power distribution, electric actuators for Christmas trees and power for HPUs can also be provided.

Further development is planned: BEL Valves are testing the AB3 isolation valve and this will be incorporated in the MATE Connector so that manifolding valves will be within the System-Modules. This will facilitate rapid well testing without any need to shutdown production and without the need for a dedicated test line. The CUSP connection system for rigid flowlines is to be developed further.

In conclusion, it may be seen that AlphaPRIME diverless, all-electric, System-Modular technology provides seabed hydrocarbon processing and smart field control, packaged for initial choice and subsequent flexibility. Field studies show that this technology can be configured to achieve optimum returns from specific fields with minimum expenditure and maximum reliability. It can also be applied to installations in lakes and other inland scenarios.

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