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# LOWER COST HYDROCARBON PRODUCTION: AN ACHIEVABLE OBJECTIVE UTILISING ROV TOOLING SYSTEMS

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Contributions to the discussion either at the meeting or by correspondence are welcome

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# Lower cost hydrocarbon production: an achievable objective utilising ROV tooling systems

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## SYNOPSIS

*Despite the dramatic collapse in the price of oil in 1986 the 1980s have seen a continuous development of equipment and procedures aimed at ensuring that technology exists to produce hydrocarbons in deepwater and in hostile environments. A crucial aspect of these developments has been the method of intervention for subsea maintenance which in the majority of areas has concentrated on some form of remotely operated vehicle (ROV).*

*Esso Exploration and Production (UK) has been particularly active with its Esso Deepwater Integrated Production System (EDIPS) project initiated in 1985. One of the results of that program was the establishment of design principles for a subsea intervention system, based upon simple ROV transportable tool packages, which could be deployed by any of the major work class ROVs. A tool package designed to replace subsea control pods was successfully tested in 150m water depth and proved the tool to be a very efficient means of component replacement.*

*In concurrent developments, Fuel Subsea Engineering Limited has prepared designs for Integrated Mini Production (IMP) systems, based on a clustered well concept, which offer a very low cost means of subsea manifolding. Combination of the ROV intervention principles, established in the EDIPS program, with the IMP subsea production system concept, has resulted in designs for diverless maintained subsea production systems which are operable in any water depth down to 1000m and may also be cost effective, relative to traditional diver intensive intervention procedures, in comparatively shallow water depths.*

## INTRODUCTION

The dramatic fall in the market value of oil in 1986, combined with the maturing of the North Sea oil arena, has resulted in strong incentives for the development and deployment of lower cost hydrocarbon production systems.

The life cycle cost of such production systems results from both the initial capital cost and the in-service operating costs. A further factor often significant in economic evaluation of a potential field is cash flow, and therefore minimising pre-investment will generally have a significant, positive, influence on economic evaluation of offshore hydrocarbon production developments.

Since 1984, several subsea production system concept designs have been developed in which means have been considered to achieve the key financial objectives of:

1. minimised pre-investment;
2. low capital cost;
3. minimised operational cost.

Over the same period, major development studies have been undertaken in order to devise methods for diverless maintenance of subsea production systems. It is the convergence of ideas and technology developed for deepwater production systems and current designs for low cost shallow water production systems, that has promoted designs for subsea production systems that are remotely maintainable and also meet the key financial objectives of today's oilfield developments.

## AN APPROACH TO SUBSEA MAINTENANCE

The Esso Deepwater Integrated Production System (EDIPS) programme,<sup>1</sup> was initiated by Esso Exploration and Pro-

John White has over 15 years practical, technical and management experience in subsea engineering, particularly in diverless intervention technology related to both subsea pipelines and subsea production systems. He has held senior positions since 1978 first as General Manager of Vickers Underwater Pipeline Engineering and currently as Projects Director of Fuel Subsea Engineering Limited (FUEL). Mr White served as an engineering apprentice with the Lucas Group, obtaining an ONC, before reading Mechanical Engineering at City University. He graduated in 1970 and following three years mechanical and production engineering experience with the Lucas Group, joined Vickers Oceanics to develop underwater engineering systems for submersible vehicles. In 1979 he became co-founder/director of FUEL, successfully establishing the company's London based subsea engineering business. He has been Project Manager for a wide range of subsea engineering projects including many conceptual design studies, applying subsea production technology to specific field developments, and several significant subsea related design and development projects. These included Diverless Pipeline Repair Systems for Statoil and Exxon, Clustered Well Manifold Systems for Shell and Esso and the Esso Deepwater Integrated Production System (EDIPS).

duction (UK) Ltd in 1985 with the objective of ensuring that technology would be available to produce hydrocarbons in 600-1000m water depths, in harsh environments on the UK continental shelf. A hypothetical field development scenario

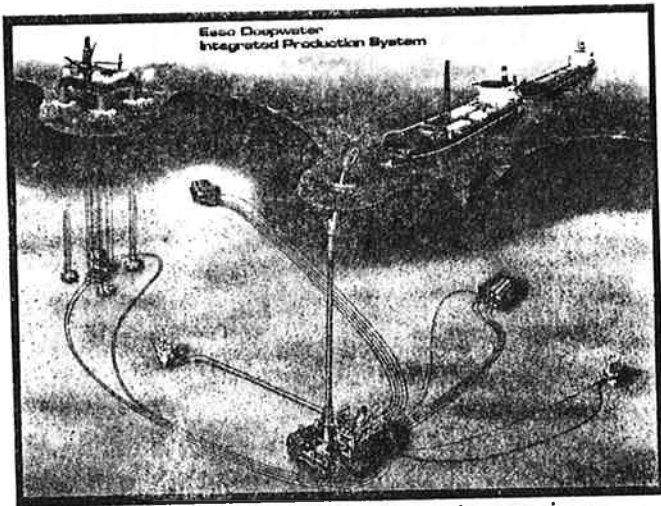


Fig 1: EDIPS field development scenario

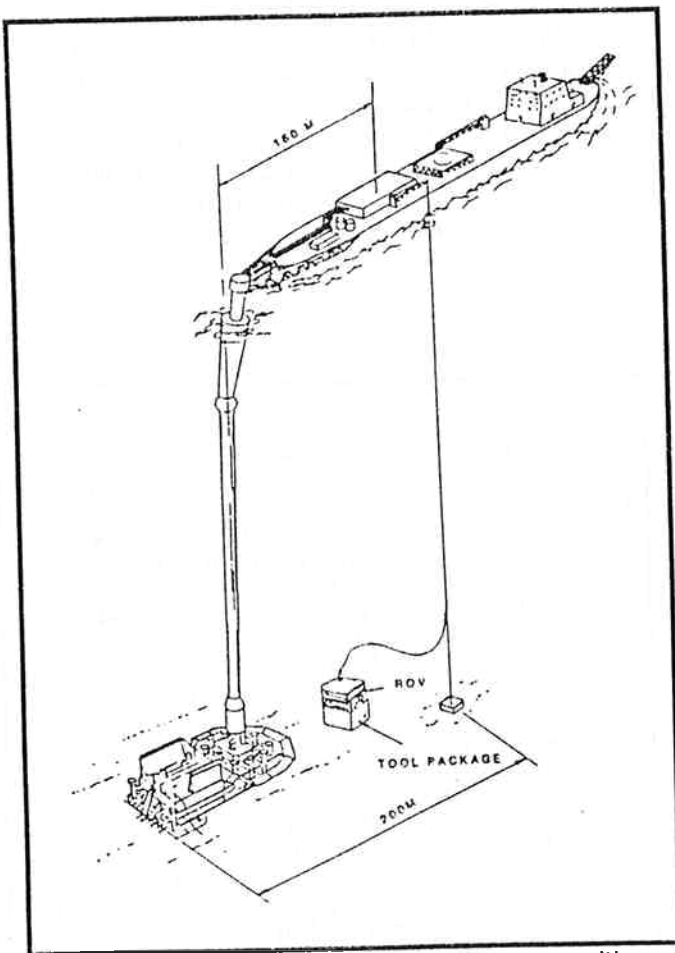


Fig 2: Maintenance system designed to cope with a horizontal offset between the surface launch position and subsea work site

was assumed in order to investigate the various technologies involved; this is illustrated in Fig 1.

The system comprised a tension leg platform (TLP), two underwater manifold centres (UMC), two satellite wells (SSW), a single anchor leg mooring (SALM) with a production manifold at the base (RBM), and a floating production and storage unit (FPSU).

The riser base manifold (RBM) commingles production from the UMC and satellite well for processing and storage

Table 1: Analysis of failure modes for period 1970-1978

Failure mode	Numbers	%
Downhole (includes DHSVs)	13	20
Connectors and seals	6	9
Valves and actuators	8	12
Controls and umbilicals	14	21
Flowlines and pipelines	1	1
Catastrophic marine damage	4	6
Unknown	0	0
Total no of failures	46	69

\* Total population = 66

onboard the FPSU, and handles routing of the TLP processed crude, injection water, gas-lift gas, pumpdown tools, and electro-hydraulic controls for all the subsea systems. The manifold incorporates several 3, 6, and 12 in insert valves, diverters, and isolation valves, as well as four electro-hydraulic control pods mounted on a control distribution module (CDM).

A key consideration in the design of the RBM was the manner in which repairs were to be effected, given the proximity of the FPSU.

The presence of the FPSU, a tanker of approximately 250 000t moored to a SALM buoy, provided a potential platform for supporting subsea maintenance operations but because of tanker weathervaning, maintenance operations had to be capable of being safely abandoned at approximately 6h notice, without additional complexity. A further factor to be considered was the shape of the vessel and the mooring arm design, which required that any deck mounted launch equipment associated with the subsea maintenance system be located a considerable distance aft of the bow of the FPSU. As illustrated in Fig 2, this produced a requirement for the maintenance system to cope with a horizontal offset between the surface launch position and subsea work site of 150-200m.

Maintenance of the RBM was considered at three levels as follows:

- Level 1: Inspection;  
Recovery of components weighing less than 2t.
- Level 2: Recovery of modules weighing up to approximately 40t.
- Level 3: Recovery of the complete manifold, a module weighing 630t.

Of particular relevance to developing cost effective ROV maintenance techniques was the development of designs to cope with level 1 maintenance. These included:

1. A valve retainer and tool package designed to enable commercially available ROVs to replace subsea valves and chokes.
2. Design of a connector and ROV tooling to enable a commercially available ROV to replace subsea control modules.
3. A range of tools enabling an ROV to operate 3, 6 and 12 in manual subsea valves.
4. Design of a flowline connector enabling an ROV to replace seals and fallible connector elements.

## THE REQUIREMENT FOR SUBSEA MAINTENANCE

An important element in developing the EDIPS maintenance philosophy was the perception of how frequently these tasks would need to be undertaken, an aspect which has