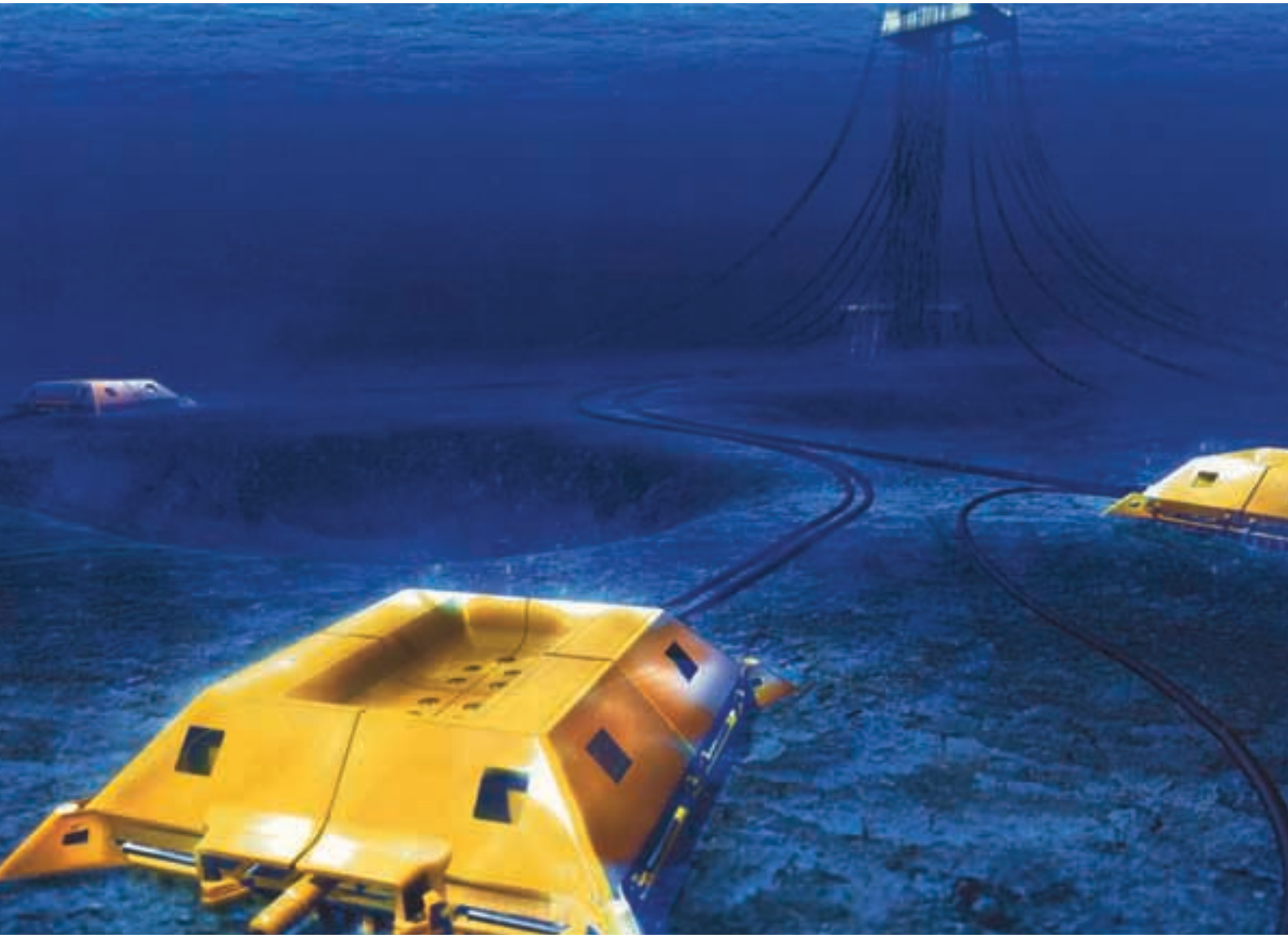
vetcogray™
a GE Oil & Gas business

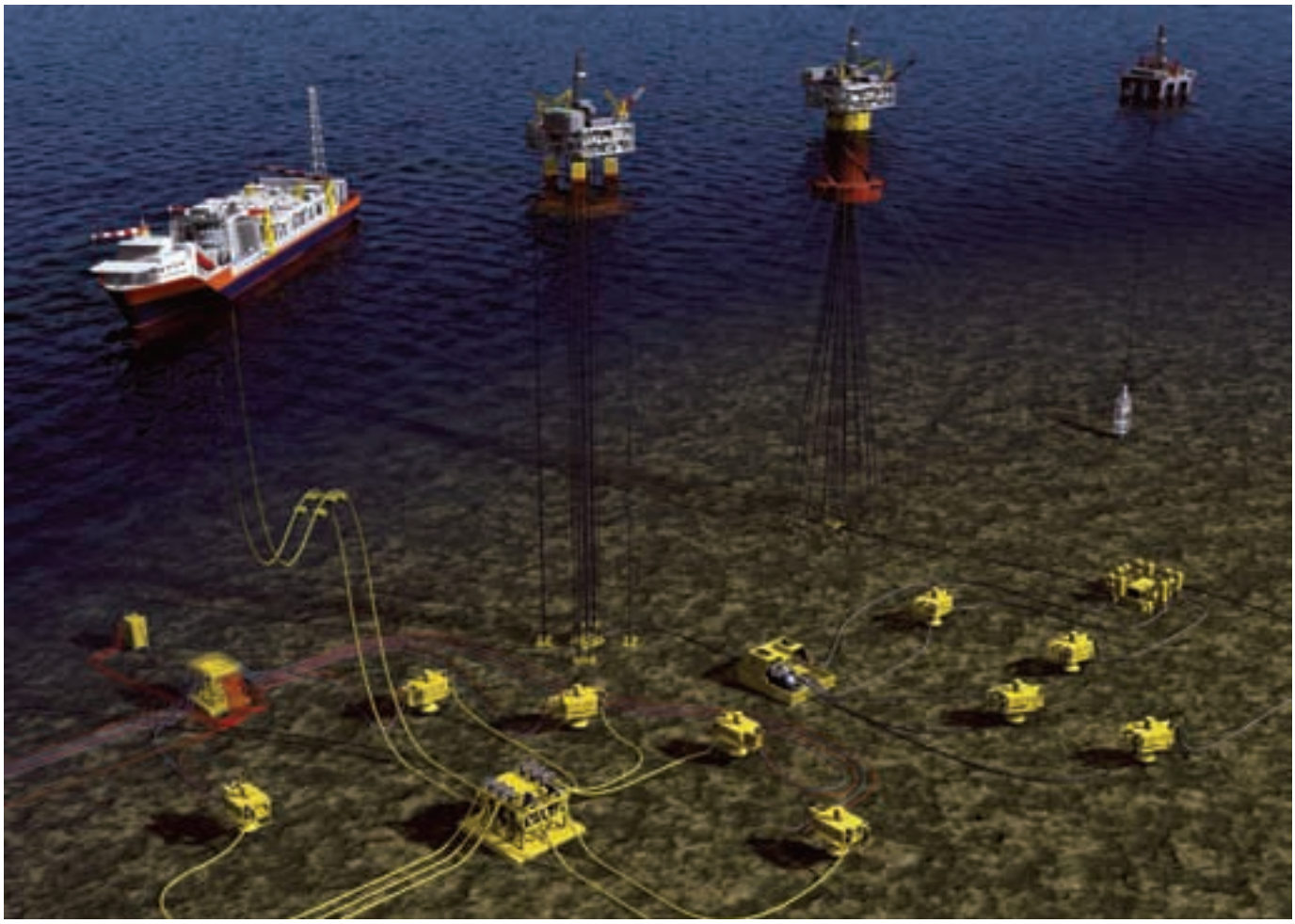


Subsea Processing and Power Systems

Subsea processing & power systems

VetcoGray, a GE - Oil & Gas business, has built up a highly skilled and experienced subsea processing, boosting and power systems team over a number of years. This capability has been developed to meet increasing market requirements to facilitate and enhance oil recovery in deepwater and long offset applications. Our competence in subsea power distribution systems enables us to provide power system solutions with a high degree of reliability and availability for subsea processing and production boosting in difficult environments.

These systems complement VetcoGray's existing competence in deepwater drilling and subsea production systems where we already provide turnkey solutions to meet increasing market demand.



Subsea production

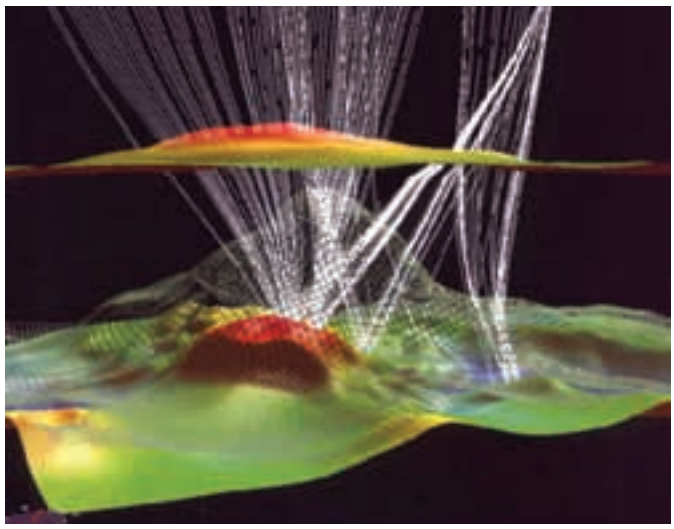
Systems integration

Fundamental to all subsea developments is the ability to bring together mission critical components, which will work first time on installation and be reliable throughout their field life. To provide this capability it is essential that all risks for the "total system" are identified and mitigated early in the field development planning phase. This means understanding the Technology Readiness Level (TRL) of the different components and providing mitigation programmes to ensure they are ready for field development. Technology readiness is not the only issue that needs to be overcome. The "process" has to be reviewed to ensure it provides the system & flow assurance capability for efficient and effective production throughout the field life. VetcoGray has, over the years, developed specialists in systems engineering and technical assurance who specify the required systems integration tasks to meet these challenges.

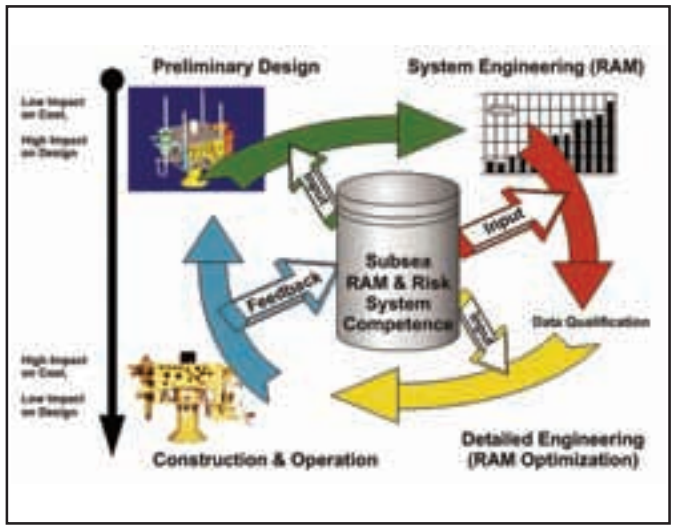
We undertake a technical assurance programme on all projects to identify the technical risks and mitigation requirements prior to developing a "system solution". This programme identifies the technical readiness or gaps in technology which need to be addressed. It also highlights the systems engineering required to ensure operating performance is achieved. It starts prior to contract award and continues throughout contract execution. Key activities are as follows:

- Technology Readiness Level (TRL) assessment
- Technology verification requirement review
- Reliability and availability assessments
- Electrical and hydraulic analysis
- Systems optimisation for drilling, installation and operation
- Flow assurance analysis for process conditions throughout operating life
- Cause and effect analysis
- Installation and operability assessments, HAZID, HAZOP
- Risk management and control

Our systems engineering teams undertake these activities initially as part of Front End Engineering and Development (FEED) studies and continue as all the project programmes are executed. These teams are set up in Houston, Oslo and Perth to support projects throughout the world.



Reservoir modelling image



Risk assessment process diagram

Subsea processing

VetcoGray has developed key technologies for efficient and reliable subsea separation and boosting. This expertise has been derived from extensive laboratory and field experience. We initiated this development programme in 1996 in support of the Troll C subsea separation project, which has been operating successfully for the last six years. This project was the forerunner of a number of subsequently successful projects.

VetcoGray developments in subsea processing have now resulted in efficiency improvements for both subsea and surface applications. These include effective prediction of 'produced' fluid and solid handling throughout field life, which is critical to subsea processing.

Technology & applications

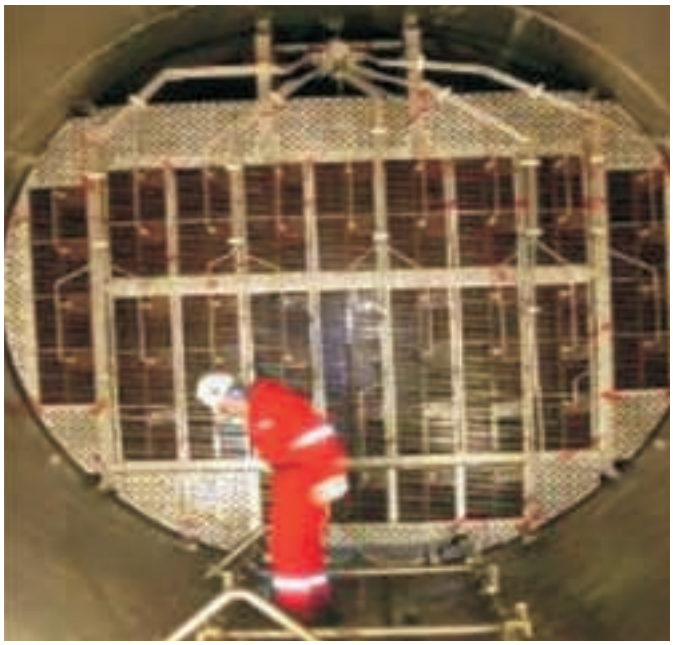
We have developed key subsea processing technologies and competencies in the following applications:

- Oil/water separation
- Gas/liquid separation
- Electrostatic separation and emulsion control – VIEC
- Level monitoring & control
- Sand monitoring and removal
- Data management and feedback control
- Power distribution

Troll C

Subsea separation

Field experience in subsea separation has provided valuable operational expertise. Effective level monitoring and control are both essential elements in subsea separation and processing. We have over six years experience in this field and use inductive and nucleonic level sensors as key enabling technologies. We have also developed sand monitoring, flushing and disposal systems.



VIEC

Subsea VIEC

The subsea VIEC (Vessel Internal Electrostatic Coalescer) uses technology which enables more efficient and cost effective oil/water separation, resulting in shorter residence time and smaller separators for deepwater applications. The VIEC is especially effective on high viscosity fluids and has now been installed on a number of topsides applications to reduce weight and solve emulsion problems.

Software

An example of software applications is the 'virtual flow meter' which provides accurate well allocation and real time production data. This can be a cost saving substitute or alternatively a useful back-up to physical flow measuring devices.

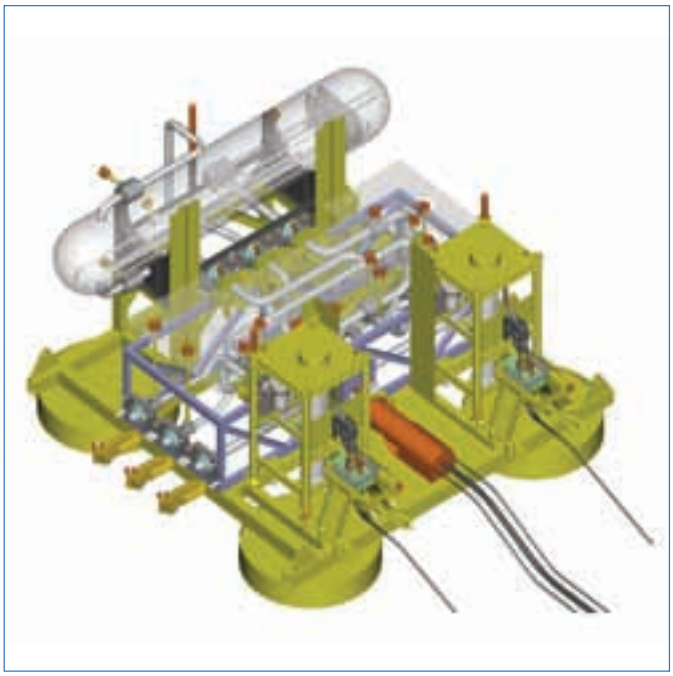
This advanced model based software solution for online, real-time calculation of oil, gas, water content and flow rates from each well, is the key to executing successful flow assurance, optimization and slug prevention strategies.

Subsea boosting

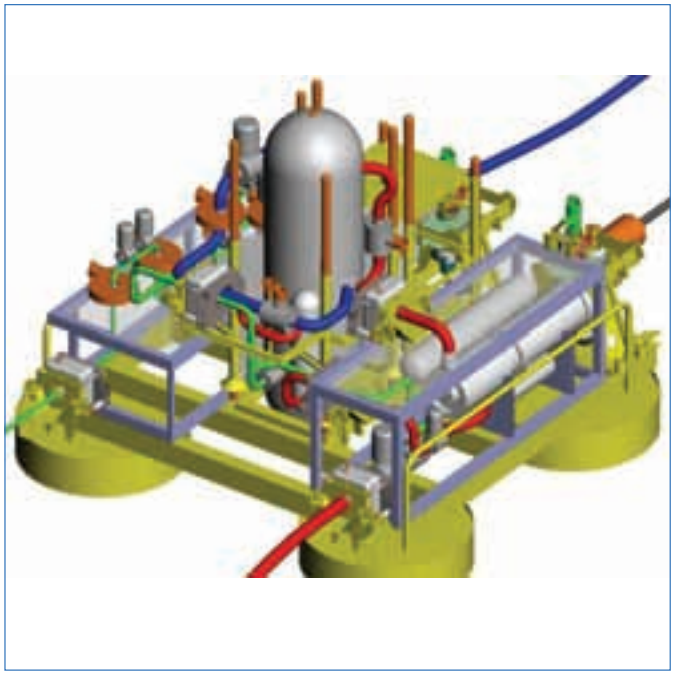
Pumping & compression

Over the last six years, VetcoGray has gained extensive knowledge of subsea pumping and compression requirements and executed EPC contracts for the supply of pumping systems for the West of Shetlands and Troll C Field in the North Sea.

We are able to evaluate various equipment and system alternatives to provide the optimum configuration to suit the field development. This, in conjunction with the technical assurance process, provides the client with the confidence that the final installation will be reliable and cost effective.



Subsea separation and pumping module

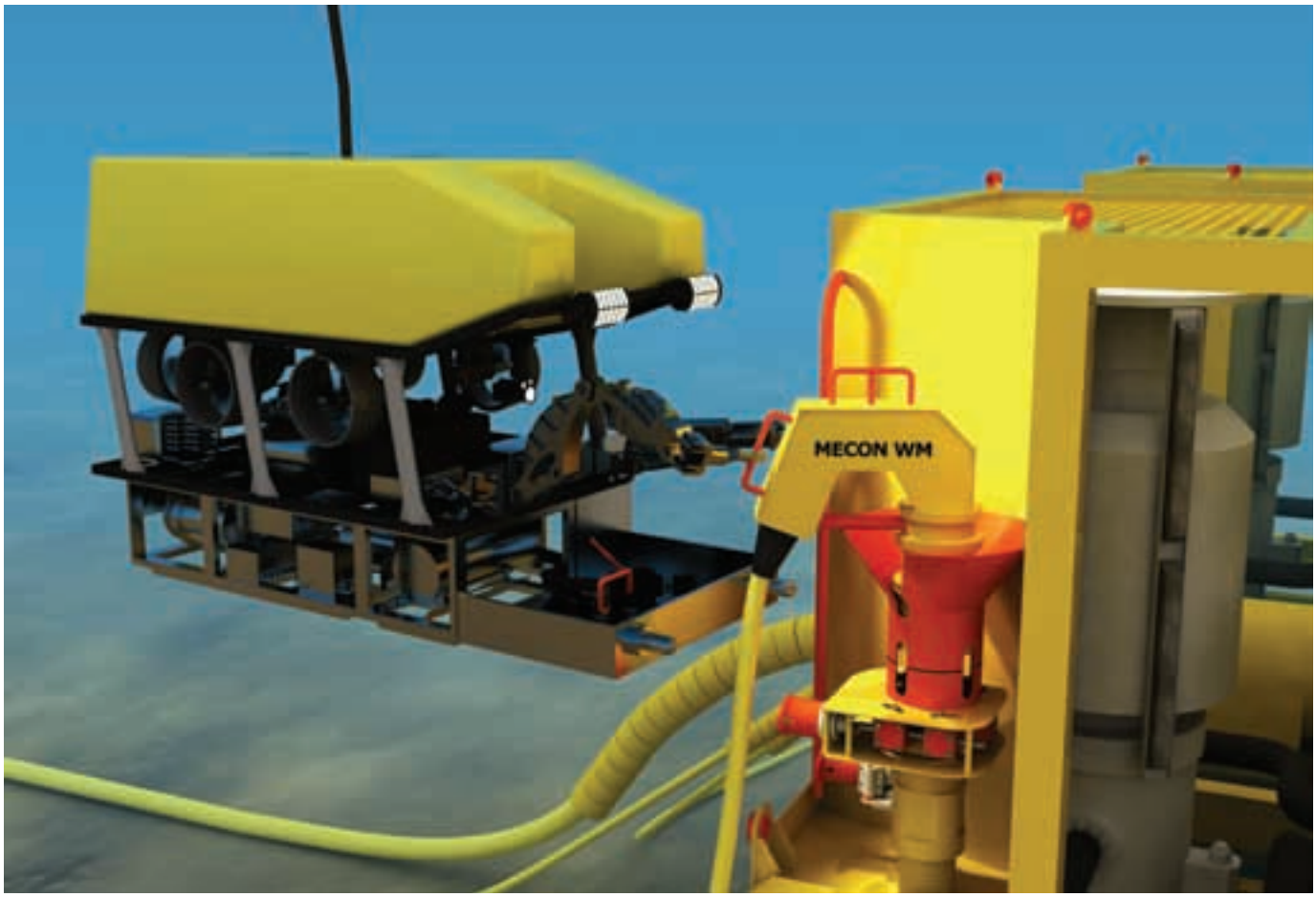


Subsea compression module

VetcoGray has evaluated a number of single phase and multiphase subsea pump / compressor manufacturers and is aware of the technology limitations (TRL) used by each. This enables us to advise on / optimize the appropriate pumping / compression technology whether radial, centrifugal, screw, heli-coaxial (or hybrid combinations) and establish the qualification required to bring them to field development readiness.

GE's Oil & Gas business has developed a revolutionary subsea compressor which offers a viable alternative to boosting gas production in subsea pipelines without the need for topsides facilities offshore. This increases our capabilities to design, manufacture and test effective, highly integrated subsea compressor modules.

Subsea power & distribution



MECON Wet Mate connection

The increasing requirement for subsea processing and boosting in relation to efficient field development has generated the need for highly reliable subsea power and distribution systems. The growing power requirements to enable efficient and economic boosting of hydrocarbons has demanded significant development in power systems. Over the last ten years, VetcoGray has built up a highly skilled and experienced team in subsea power transmission system design and can provide all the major components to deliver the total system solution (EPC contract).

We use high reliability components to ensure high availability of consumer units such as subsea pumps, compressors and other utilities.

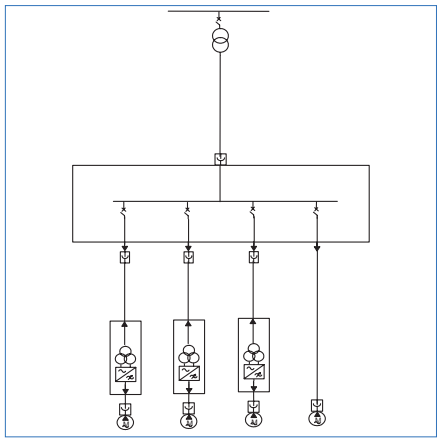
Technology & applications

We specialize in the key design tools and technologies which support power transmission system design, such as power system analysis, load flow analysis, electrical stability analysis, electric field analysis and related mechanical and thermal engineering. These technologies have been focused into the following key components:

- Topsides transformers / switchgear / Variable Speed Drives (VSD's)
- Electrical power umbilical design / high voltage cable design
- Subsea terminations and penetrators
- Subsea Wet and Dry Mate connections
- Subsea switchgear
- Subsea transformers
- Subsea Variable Speed Drives (VSD's)

Power system design

The requirements for surface or subsea components are driven by the transmission distance and power needs for each application. VetcoGray undertakes all necessary analyses to define and design a complete power distribution system. Full technical and commercial responsibility is taken to supply a complete electrical power system.



Subsea HV power distribution

Power products

MECON –Dry Mate (DM) connections

The subsea Dry Mate connection is a vital part of the high voltage termination system and can be used in pressure compensated systems or as a high pressure barrier to penetrate a pressure vessel. A range of Dry Mate connections has been qualified to IEC standards and verified by SINTEF.

IEC rating [kV] Uo/U(Um)	Current rating [A]	Water depth [m]	Max differential pressure motor side [bar]	Max differential pressure water side [bar]
3.6/6(7.2)	600	1250	34	125
6/10(12)	240	500	207	50
6/10(12)	600	1250	345	125
12/20(24)	600	2000	100	200
18/30(36)	700	2000	100	200
145	700	1100	10	10

MECON –DM Subsea HV dry connections

MECON – Wet Mate (WM) connections

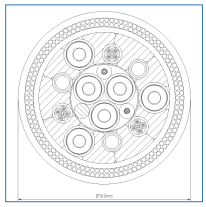
The MECON high voltage wet-mateable connector is a highly reliable connector for HV electrical power cables for subsea applications. This connector uses the MECON Dry Mate cable termination technology and has a unique in-situ di-electric conditioning system for the connector internals. This ensures a reliable make-up subsea. The MECON product has already established six years of subsea service. The following range is available: 12 – 24 – 36 kV/500A.

MECON –WM Subsea Wet Mate connections

Subsea umbilical & power cables

VetcoGray has established a centre of excellence in HV power cable and control umbilicals for the design and supply of subsea HV/LV power systems, electrical and fibre optic communication systems and hydraulic control distribution solutions. We provide:

- Key competence in umbilical layout, design and analysis for studies
- Umbilical and power cable system design including tie-in/connection systems for subsea projects
- Full technical and commercial responsibility to define, procure, integrate and deliver the umbilical system as a package to the client or VetcoGray EPC projects



Subsea HV umbilical design

Subsea switchgear and Variable Speed Drives

We have developed a subsea high voltage switchgear module for 24kV/500A full-load switching. The module provides automatic and/or remote switching operation.

A 3.5 MVA/85Hz Variable Speed Drive has been developed and tested.

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GE imagination at work