CH: 4 Deepwater Technologies and Remedial Action

Production of NG from deepwater has a similar operation's problems like that in shallow water, but the main difference between both of these ways of production lies on the methods of remediation of the resulting troubles and maintenance of the assets to keep them working safely and in a perfect way.
Almost the remediation of the problems resulting from deepwater technology to produce NG relies on the intervention by using Remotely Operated Vehicles (ROVs), are used along with other remotely operated tooling.

4-1 ROV Technology and Development

As the capability of ROV has increased, the range of application in which they are used has expanded greatly. Tasks that previously could only be undertaken by divers can now be handled more safely and cost effectively by ROV. The development of oil and gas equipment specifically designed for ROV intervention.
At water depths of over 200m it becomes impossible to use direct human intervention option that ROVs are used. The ROV is a mobile tool which at its most basic consists of a camera and a two way communications mechanism that allows the operator to control the vehicle. The vehicle is likely other tools, also remotely operated which can be used to perform simple subsea operations subsea. ROV can be classified to a 3 main types, the small observation class or eyeball, the work class ROV and the tracked vehicle or plough. Work class ROV (WROV) is the most widely used in intervention operations. . WROVs can operate at depths of up to 3500 m below sea surface. They are much larger than the observation vehicles. They are more powerful ranging from 50 – 250 HP, and can carry a greater range of equipment. Figure 4.1 shows an example of ROV's system [**21, 22**].

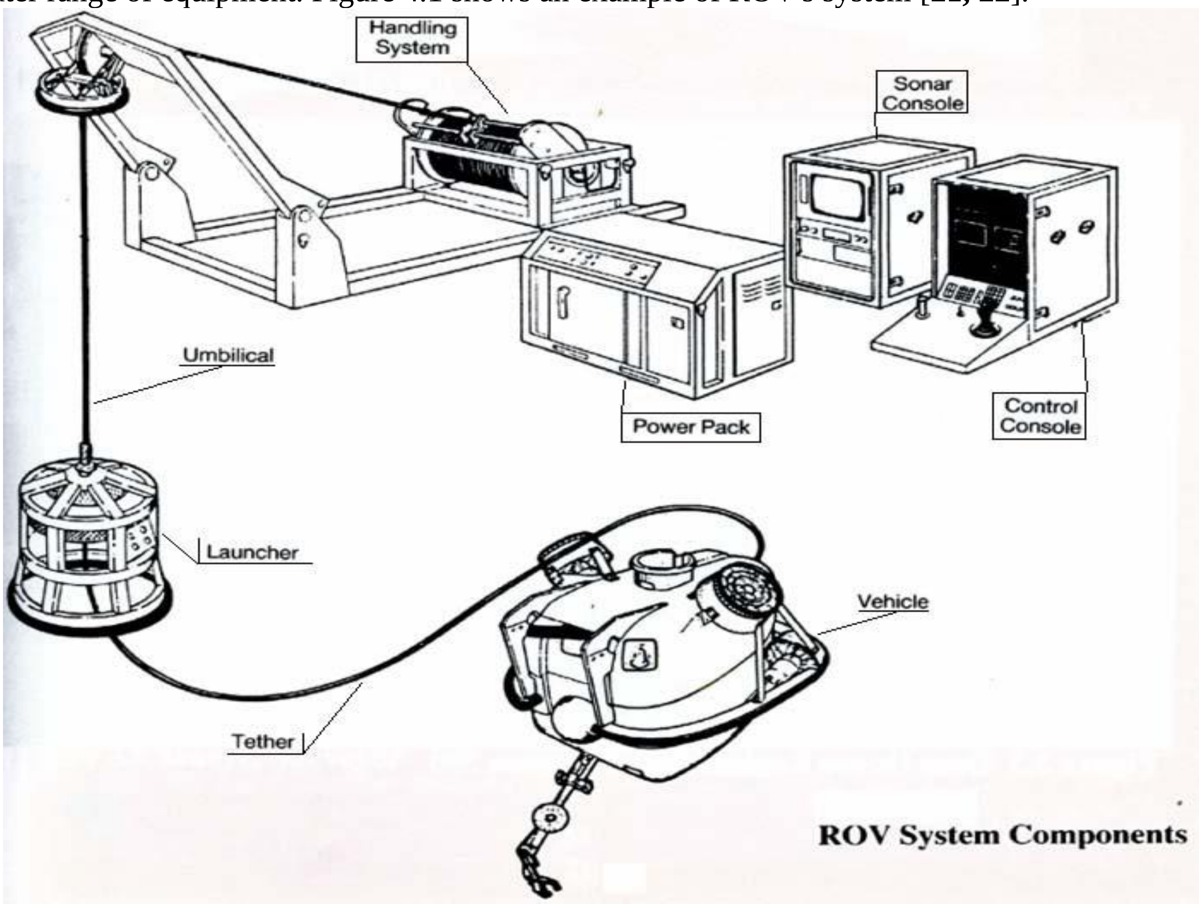


Figure 4.1 ROV System Components [**22**]

WROVs are usually powered through a Hydraulic Power Unit (HPU) driven by an onboard electric motor. The hydraulic system powers the hydraulic thrusters, manipulators and any hydraulic tooling onboard ROV. The control of the thrusters and other hydraulic equipment is achieved by electronic servo valves which regulates the flow of hydraulic oil throughout the system.
ROVs are deployed from the surface support vessel and ‘fly’ to the job site where they are manoeuvred around using thruster power. There are a number of factors that affect the deployment regarding the support vessel itself, the method of deployment, the work task and the vehicle class and configuration.

4-1-1 Hydrodynamic Forces

The hydrodynamic forces may be considered as being:
1-Wave action
2-Tidal effects
3-Currents
4-Wind
All of these effects will affect both the vessel and the ROV. The vessel will have a designed thruster configuration that will determine its actual operating parameters. However, the ship’s master and watch officers will get to know their vessel and will be able to position it to its best capabilities within its design parameters. Generally speaking ROV deployment is possible in slightly more severe weather conditions than air divers.

4-1-2 Vehicle Maneuverability Affected by Hydrodynamic Forces

The vehicle thruster configuration will determine how it can react to the hydrodynamic forces acting on it. There will be a maximum power output available for thrusters and each thruster will also have a maximum power consumption and output. The vehicle has to maintain position in three dimensions and try to deal with any wave surge when operating at shallow depths. This may prove impossible at times and in marginal weather conditions there is a limit to how shallow any vehicle can operate even though it may be safe to launch it. Figure 4.2 illustrates the Vehicle Reaction to Hydrodynamic Forces [**22**].

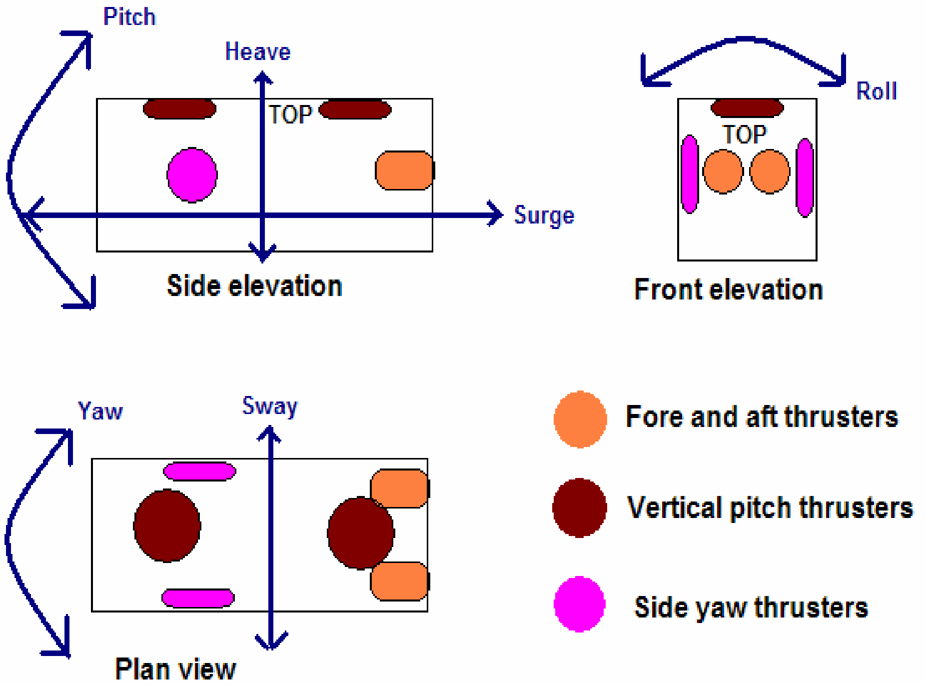


Figure 4.2 Vehicle reactions to hydrodynamic forces [**22**]

4-2 Inspection, Repair, and Maintenance (IRM) Technique of Subsea Assets

The IRM of subsea structures should be carried out by using Diving Support Vessel – DSV and must be a dynamically positioned vessel (DP2 or DP3) and contains one WROV with the appropriate tooling, sometimes OBSROV (Observation Class ROV) and sufficient crane to be used for deployment and recovery of any structure – the crane is preferred to be a heave compensated crane. These IRM activities are called as a light intervention. The various intervention activities which can be performed by DSV and WROV include:

1- Change out of the faulty SCM, Choke Valves, GCU, GFU, SRM, EDU, EFL, and HFL by utilizing the appropriate tooling – will be discussed later.
2- Depressurization, Dewatering, and Dehydration through operating the valves at the various subsea structures (X-tree – Manifold – PLET – UTA) by using torque tools through WROV.
3- Injection of some chemical inside Trees and manifolds through skid installed n WROV.
4- Flowlines inspection by Ultra Sonic measurements (UT), Cathodic Protection (CP), Flooded Member Detection (FMD) particularly for underwater part of Platform.
5- Sand Detection by installation of sand sensors to the flowlines.

Figure 4.3 shows an example of an intervention vessel contains WROV and heave compensated crane

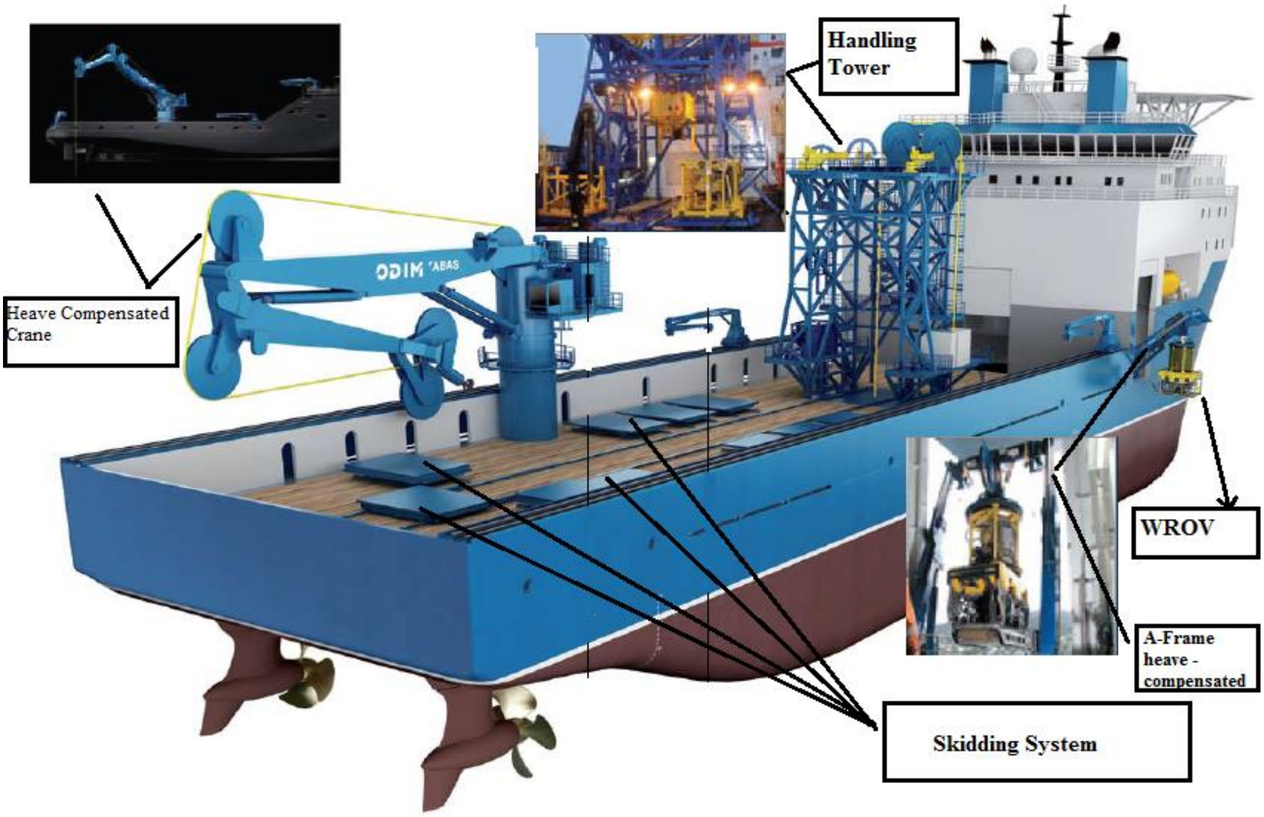


Figure 4.3 Intervention Vessel

4-2-1 Subsea Equipment Change Out

Some faulty subsea equipment existed inside the subsea structures like X-tree, manifold, and UTA can be changed out by using the appropriate tooling. These objects are summarized as WROV, suitable tooling, heave compensated crane, suitable rigging, at least DP 2 Vessel, hydrographic survey equipment, and qualified personnel.

4-2-1-1 SCM Change Out

Once MCS's operator at topside facility reported that there are some faults found in readings of Pressure, temperature, sand quantity, or WGFM, sending or receiving signals from subsea controlled structure to MCS, it means that there is some imperfection in SCM and it must be tested. To test SCM, it has to be retrieved to surface to be checked electrically and hydraulically. SCM must be changed out with a new one, if the test of SCM failed.SCM can be changed out by a Running Tool (RT).

The scenario of retrieval and installation of SCM is as follow:

-RT to be deployed by crane over the exact structure which its SCM needs to be changed.

- Once RT become above Structure SCM to be latched to RT – this step must be done by ROV assistance that ROV has to inject some hydraulic oil to RT to be able to carry out its function which includes latching, unlatching, and raising SCM from SCMMB to the top level of RT.

-Then RT starts to be recovered to surface by crane.

- After recovering RT combined with faulty SCM to deck surface, SCM must be tested, once the test proves that SCM has damage, decision will be taken to change SCM

-New SCM has to be latched to RT and the reverse scenario of retrieval will be repeated with the installation procedures.

Figure 4.4 shows the interface between RT and X-tree for SCM change out and the steps of recovery [**23**]

Figure 4.4 SCM Change out steps [**23**]

4-2-1-2 Choke Valve Change Out

Each tree has a retrievable choke valve. The choke is used to regulate well flow and to control produced well pressures so that well production can be commingled at the manifold. The subsea system design allows choke insert replacement while the other wells are in normal production. Once choke valve defected, the same tool (RT) can be used for choke valve change out.

Figure 4.5 shows the choke change out procedures [**23**].

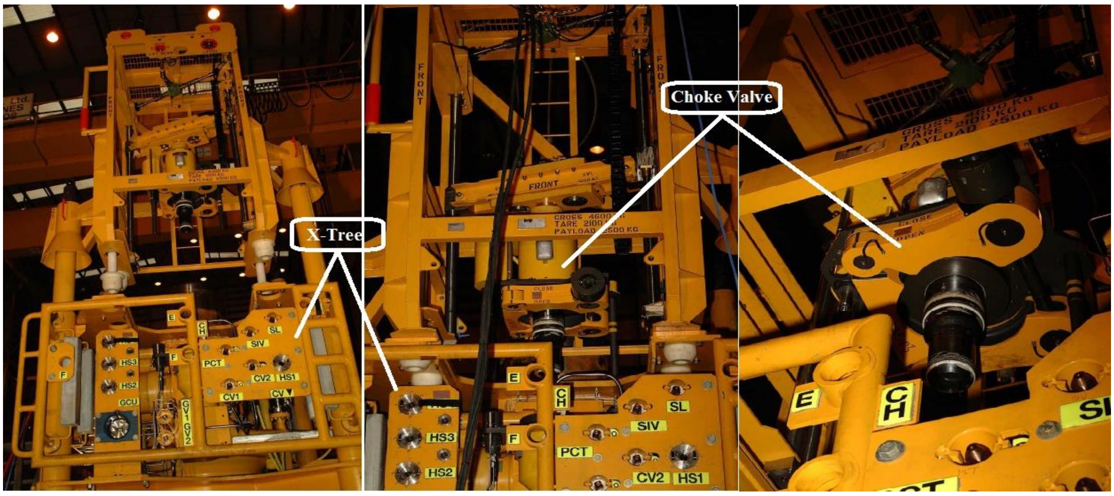


Figure 4.5 Choke change out steps [**23**]

4-2-1-3 Glycol Control Unit (GCU) Change Out

The reading of MEG's pressure may be subjected to some drops, so the investigation by ROV must be required to determine if there's any internal or external leakage at GCU installed on x-tree. Once the GCU needs to be changed, intervention will be done by a new one. Change out of GCU can be done by removing the old GCU from tree by ROV via torque tool to unlock the old one, and then the crane has to lift GCU up to surface. The reverse procedures will be applied to install the new one. Figure 4.6 shows the steps of GCU removal from tree.

Figure 4.6 GCU Configuration – photo has been taken from ROV DVD

4-2-2 Inspection of Subsea Assets

ROVs are incredibly to the installation and maintenance of all subsea structures, especially flowlines and pipelines. Flowlines require not only pre-and post lay surveys but also trench or burial surveys and routine surveys used to plan or carry out maintenance procedures.

During this type of work the ROV is required to carry a large range of equipment to allow the collection of data such as the position of the flowline relative to the seabed, corrosion levels, cathodic protection status, flooded member detection for the underwater parts of platforms, marine growth, fouling which can be analyzed back ashore. Figure 4.7 shows the main items in the pipeline inspection [**24**].

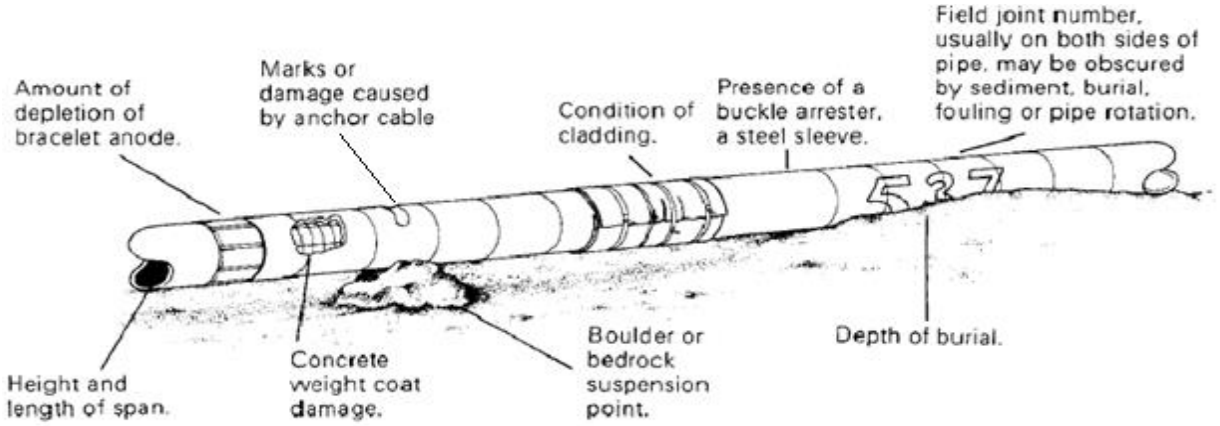


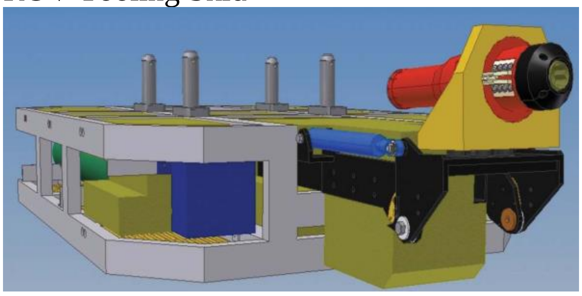
Figure 4.7 Pipeline inspection [**24**]

4-2-3 ROV Interfaced Tooling Utilized for IRM

As described before that IRM's work can't be carried out without utilizing the various ROV interfaced tooling. Most of these tooling undertake to ISO & API standard, ant the others can be manufactured according to the specified intervention required.
The various tooling's manufactures have to design these tools to be sufficient for the present subsea structures, for example the torque tools which are used for valve operation, the valve bucket must be interfaced with the specified torque tool.
The following table 4.1 summarizes the main tooling used for IRM's work and their main functions [**25**]
Table 4.1 The main IRM's ROV tooling

No	Tooling	Function
1	17 H Low Torque Tool (T.T) 	This T.T provides a means to develop up to 70NM torque for actuation of ball and needle valves, clamps, etc throughout a subsea production system. Hydraulic control is achieved either from an ROV intervention system or separate panel.
2	17 H High Torque Tool (T.T) 	The high torque tool provides a means to develop up to 2700 Nm torque for actuation of valves, lockdown, clamps, etc. throughout a subsea production system. Higher torque versions are available as special builds. The conical nose option can ease deployment by ROV manipulator.

3	17 H Toque Analyzer 	The torque analyzer is a hand-held stalling devise used to determine /set the output static torque of suitable hydraulic torque tools during pre-dive checks. The torque is displayed on a free standing electronic display console in ft-lb or Nm.
4	17 D Torque Tools Class (1-4) 	This torque tool provides a means of developing torque of actuation of valves, lockdown clamps etc. throughout a subsea production system. The torque reaction lugs on each side of the tool include an integral latching mechanism which anchors the tool into the specified interface. This provides a means of stabilizing the ROV during valve operations and allows for secure handling of "fly to place" electro-hydraulic flying leads.
5	Linear Valve Override Tool (LVOT)  	The (LVOT) is used to transmit axial force to the stem of hydraulically actuated gate valves. The tool consists of a bayonet profile end effecter which locks the tool to the valve interface and activates the axial override force generated by the tool's piston. The tool consists of two discrete units, the tool itself and a tool carrier which is used to deploy and retrieve the tool.
6	Tool Deployment Unit (TDU) 	This Tool has to be deployed by ROV at the back side of ROV to carry the specified tools specially 17 HT.T to complete the task quickly and efficiently that using ROV's manipulator to insert 17 H T.T is not safe for installation into the valve receptacle. Using docking probes, rather than attaching with a gripper, the system is able to locate and stabilize the ROV in a known position and precisely deploy a dedicated tool via an XYZ mechanism. TDU is self contained, being equipped with a dedicated buoyancy module and control system. Interfacing to the ROV is through mounting brackets, two hydraulic lines and on electric cable.

7	Subsea Production Sample Skid 	This unit is designed t take hydrocarbon samples from a live subsea production system with zero emissions to the environment. Fluid samples are equipped in order to determine fluid chemistry from individual wells and to enable calibration of the subsea flowmetre. The sampling system is mounted in a skid that interfaces to the underside of WROV.
8	Hydraulic Hot Stab 	The hydraulic hot stab system has a many configurations according the specified receptacle of hot stab which is existed on the subsea structure. The hot stab on the figure comprises a male and female mating halves, is used to provide hydraulic power from the ROV to a subsea production system. Typical applications are actuator operations, pressure testing, chemical Injection and planned and emergency release. The male stab is connected to a storage reservoir via a flexible hydraulic hose and is deployed by ROV. The female receptacle, permanently mounted to a subsea system.
9	ROV Tooling Skid 	This tooling skid is designed to package all the intervention tooling that may be considered 'standard' on a typical deepwater project. The skid is fitted with a multi-fluid HPU and reservoir system capable of pumping mineral oil, subsea control fluid, corrosion inhibitors or seawater. At the front of skid, Flying Lead Orientation Tool (FLOT) can be mounted with a 17D latching torque tool with its classes to facilitate both " fly to place" control umbilical and valve override operations during the same dive.