Proposal to Salvage Oil from a Sunken Tanker

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ABSTRACT

A tremendous potential for environmental disaster exists when catastrophe strikes and an oil tanker sinks while carrying its hazardous cargo. In addition to the large quantity of oil present on the surface from a stricken tanker, a much larger quantity of oil is usually still contained in the holding tanks of the ship as it rests on the seafloor. Due to the stresses involved from the initial sinking and subsequent trip down to impact the seafloor, these holding tanks will develop leaks. With as many as one million barrels of oil contained in the largest tankers, a slow leak can affect the surrounding environment for years and years.

When this occurs in the middle of the ocean, this leakage can largely be ignored as the oil will eventually be dispersed and absorbed by microbes in the ocean. When the wreck occurs near a coastline however, it cannot be ignored. The leaking oil can cause long term destruction of the environment and have a direct impact on the livelihood of people. The oil in the water has a detrimental effect on the native wildlife and impacts such things as fishing industries and tourism. This imparts a financial cost far greater than simply the loss of a million barrels of oil and one ship. In addition to the cost of the direct damage, the potential exists for billion dollar lawsuits and negative public opinion of the oil company responsible for the accident.

In order to minimize these long term pitfalls, a method of extracting this oil from the sunken tanker before it has a chance to enact long term damage has been developed. Utilizing existing offshore oil drilling technology, it is now possible to recover this oil to the surface where it can be properly disposed of. Using an underwater remotely operated vehicle (ROV), it is possible to install a pipeline from the sunken tanker to a oil drilling platform on the surface of the ocean. The salvaged oil can then be processed and refined as if it had been freshly pumped from beneath the surface of the earth. The potential savings from the prevention if further environmental damage more than offset the costs incurred by this recovery operation.
# TABLE OF CONTENTS

Introduction ................................................................. 1

Project Overview .......................................................... 1

Proposed Work .............................................................. 2

Plan of Action ............................................................... 3

Benefits ........................................................................... 3

Feasibility ......................................................................... 3

Theory of Operation ......................................................... 4

Site Reconnaissance ......................................................... 4

Recovery Operation .......................................................... 6

Components ....................................................................... 14

Site Survey ......................................................................... 15

ROV Support Vessel .......................................................... 15

ROV .................................................................................. 16

Drilling Operation .............................................................. 17

Christmas Tree .................................................................... 17

Flexible Pipeline ............................................................... 18

Pipeline, Support ROV, Tooling ........................................... 19

Riser ............................................................................... 20

Riser Repair ....................................................................... 21

MOPS ............................................................................... 21

Technical Background ......................................................... 22

Oil Related Data ............................................................... 22
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oceanographic Research Vessel</td>
<td>23</td>
</tr>
<tr>
<td>Side Scan Sonar</td>
<td>26</td>
</tr>
<tr>
<td>Sub-bottom Profiler</td>
<td>29</td>
</tr>
<tr>
<td>ROV Support Vessel</td>
<td>31</td>
</tr>
<tr>
<td>Remotely Operated Vehicle</td>
<td>33</td>
</tr>
<tr>
<td>Riser Information</td>
<td>35</td>
</tr>
<tr>
<td>Flexible Pipelines</td>
<td>38</td>
</tr>
<tr>
<td>Field Production and Storage Offloading Tanker</td>
<td>39</td>
</tr>
<tr>
<td>Cost Analysis</td>
<td>41</td>
</tr>
<tr>
<td>Conclusion</td>
<td>42</td>
</tr>
<tr>
<td>References</td>
<td>43</td>
</tr>
</tbody>
</table>
FIGURE LIST

Fig 1: Major oil tanker wrecks since 1967 2
Fig 2: Riser Deployment Methods 10
Fig 3: R/V Revelle 14
Fig 4: Klein Sonar System 15
Fig 5: GeoPulse Boomer System 15
Fig 6: Kommandor ROV Support Vessel 16
Fig 7: Hercules ROV 16
Fig 8: Broco Welding Stinger 17
Fig 9: Broco Ultathermic Cutting Rod 17
Fig 10: ROV in housing 19
Fig 11: Valve torquing tool 19
Fig 12: Hardline Cutter 19
Fig 13: Riser System 20
Fig 14: Riser Repair Clamp 21
Fig 15: FPSO Ocean Producer 21
INTRODUCTION

We propose to make a system to extract oil from a sunken tanker. Oil tankers possess a great potential for causing environmental damage when catastrophe occurs. This is extremely relevant when the tanker sinks near an environmentally sensitive area. Currently Thales and Sonsub are attempting to salvage oil from the sunken tanker Prestige; however, they have yet to remove oil and their system is not universally applicable. Therefore, at the present time, there are no proven systems specifically designed for oil salvage. This proposal outlines the design for such a system and the plan of action for its implementation.

PROJECT OVERVIEW

NEEDS

A system is needed to prevent environmental catastrophe due to the release of oil from a sunken oil tanker. For example, in 2002, the tanker Prestige sank off the coast of Spain. She is currently sitting on the bottom of the ocean, 3800m down, leaking oil. The continuing discharge of oil from the wreck threatens the Spanish coastline. The impact on the wildlife and tourism in this sensitive area has been disastrous. The Prestige is just one example of many tankers that have wrecked near the coast of environmentally vulnerable areas.
Widespread environmental impact such as occurred with the Exxon Valdez in 1989 cost the company greatly, nearly 7 billion in lawsuits over 15 years, not including the loss of integrity in the eyes of the general public. Therefore, a reliable solution must be found to prevent ecological damage occurring with a disaster of this type.

**PROPOSED WORK**

An impending tragedy such as the Prestige could be avoided or severely lessened by extracting the oil from the sunken tanker before it does additional harm. We propose to remove the remaining oil from the tanker as it rests on the seafloor. This will eliminate further oil leakage and the possibility of environmental disaster.
PLAN OF ACTION

In order to extract the oil, our company will utilize cutting edge undersea technology in the form of an ROV (Remotely Operated Vehicle). This vehicle will travel to the wreck site, attach to the ship, and penetrate the hull, allowing for oil removal to occur. Once removed, the oil will be pumped, using an undersea pipeline, to the surface for storage in an offloading tanker.

BENEFITS

By oil containment, the surrounding wildlife is protected and the oil company maintains its upright standing with the public. In addition, the cost of extracting the oil through our system will be in stark contrast to the prohibitive cost accumulated through environmental cleanup and lawsuits resulting from an oil disaster.

FEASIBILITY

From the perspective of an oil company, you would only recover oil from a sunken tanker if it posed an environmental hazard. A tanker full of waxy or asphaltic oil at depth might solidify or gel due to the low temperatures at the seafloor. If this occurred, the oil would pose little environmental hazard because the oil would be "contained" and isolated from the surrounding ecosystem. Waxy oils are actually easy to biodegrade, and bacteria would eliminate much of the oil in a relatively short time period.

Our system is designed for oils that would not wax up at depth; these oils would eventually flow out of the ship to cause environmental harm. There is also a depth consideration for the feasibility of extracting oil with our system. Because our system relies on an ROV to do the work, it should only be used in instances where the sunken tankers sits at a depth below 100 meters, which is the maximum depth that divers can practically go.
There is also a maximum depth limitation of the system. While ROV technology is advanced enough to go to any depth in the ocean, technology to pump oil to the surface from depth is not as advanced. Therefore, it will be necessary to have a maximum working depth of 3000 meters on the system. This depth is only a limiting factor in the middle of the ocean where the chance of a sunken tanker doing environmental harm is minimal and in near shore trenches which are too deep to work in.

The oil recovery system, while a new concept, uses many off-the-shelf parts from the offshore industry and will require few custom designed parts and systems. This fact makes the project feasible in that, while it is a novel use of underwater systems, at the same time it relies mostly on proven technology to get the job done.

THEORY OF OPERATION

Once the oil tanker is resting on the seafloor, a thorough investigation of the wreck site is needed. Many questions need to be answered. What is the condition of the shipwreck? Is the ship in one piece or in many? Is the ship resting on its keel, or is it on one side or the other? What is the topography of the seafloor around the shipwreck? Is the bottom flat, or is there a steep incline? Is the bottom sandy, rocky, or muddy? What are the prevalent currents, both at the surface and at the bottom? These and other questions must be answered in order to plan for safe operations to recover the oil from the tanker.

SITE RECONNAISSANCE

The first step in answering these questions is to perform a scientific survey of the wreck site. Initially only the sinking position on the surface of the ocean is known. Due to ocean
currents, the ship may travel some distance before resting on the bottom. The precise location of the wreck on the seafloor must be determined. To aid in this, a side scan sonar survey is required.

A side scan sonar system utilizes an underwater vehicle with a side looking sonar system as opposed to one pointing straight down. This vehicle, commonly called a towfish, is deployed behind a ship on a long cable at a depth close to the seafloor. The advantage in this type of system is that objects with height off the seafloor will show up as dark objects with a light shadow behind them. Through processing on a surface computer, this object can be accurately measured, and an assessment can be made as to the type of object identified.

During the planning stage of the side scan survey a search pattern must be identified. An examination of the ocean currents and the water depth can predict the sinking path of the ship. A series of probability boxes are defined as likely locations for the wreck; these areas are then surveyed with the side scan sonar. A low resolution scan, frequency of 50 to 100 kHz, search will cover more area, around 4000 m for one pass, but will miss smaller objects. Given the large size of existing oil tankers, currently around 300 meters, the hull of the ship should be identifiable at this resolution. If the bottom is relatively smooth, this stage will proceed rapidly. If however the terrain is rough, identification of the hull can prove difficult.

Once a list of probable targets has been identified, a high resolution scan is performed. With a frequency of around 300 to 500 kHz, a swath of 200 meters can be surveyed in one pass. At this resolution a highly detailed picture of the condition of the ship on the seafloor is obtained. A positive identification of the wreck can be made to ensure that the object is in fact the wreck in question and not some preexisting shipwreck or geographical feature on the bottom. Many of the questions concerning the physical condition of the wreck can now be answered.
Now that the location of the wreck has been identified, a highly detailed survey of the wreck is performed. A bathymetry survey is performed to create a topographic map of the depth of the seafloor surrounding the wreck. Core samples are taken around the wreck to determine the sedimentary consistency of the seafloor. A sub-bottom profile is performed to identify the bottom conditions. Measures of the ocean currents through the water column are gathered. An investigative ROV may also be utilized to photograph the wreck and perform close examination. It may also be used to determine the current rate of oil leakage from the wreck, and take steps to slow this leakage. All of the information gathered in this stage will be used to plan the recovery operations.

Back on land, a paper investigation of the ship is taking place. The blueprints of the ship are thoroughly examined. A sense of the overall layout is gathered in order to answer a series of important questions. What is the size and number of oil tanks? What is the hull thickness? Is there one hull or many? What existing piping may be utilized to extract the oil from the tanks? How many new penetrations in the hull are required to perform the task? What existing structures may be in the way of creating these new penetrations? With the answers to these questions, a penetration method can be decided upon to extract the oil.

Once a series of likely hull penetration locations have been determined, a work class ROV is deployed to perform a close inspection of the desired sites. Any hazards that might impede the work can be investigated, and possibly removed. The locations can then be prepared for installation of a penetration device.

**RECOVERY OPERATION**

To complement the ROV, support equipment is deployed at the work site. A cutting/welding tooling sled is placed on the bottom containing the devices to be installed on the
hull. The ROV is configured for welding, cutting, and grinding operations. If the oil tanker has two hulls, as modern tankers are required to have, the outer hull must be penetrated. A large section will be removed to allow the ROV access to the inner hull behind which the oil is contained. The valve assembly is then welded to the inner hull. Once this is secured in place, a device to cut through the inner hull is inserted through the valve assembly. After the tank has been penetrated, the valve on the penetration nozzle is closed so that no oil leaks out. At a later stage in the operation, a hose will be attached to this nozzle in order to extract the oil.

Two penetrations are required in each tank, one for inflow of seawater to displace the oil, and one for the outflow of the oil. The seawater penetration should be as close to the bottom of the tank as possible, while the oil penetration should be as close to the top of the tank as is feasible. Additionally, at the oil penetration nozzle, de-waxing agents will be injected in order to prevent clogging of the pipeline as the oil travels to the surface.

When using sub sea pipelines to transport oil, there are two problems to contend with: 1) waxy deposition and 2) hydrate formation. Both of these problems can potentially clog the pipe requiring an expensive and time consuming clearing operation. Both of these problems can be solved with the introduction of chemical additives that are injected when the oil enters the pipe. These chemicals keep the oil from waxing and from condensing methane hydrates allowing for problem free flow along the length of the pipe.

Oil typically contains some percentage of wax. This wax could potentially crystallize out in the tubing due to temperature gradients as the oil proceeds to the surface. The resulting clog in the pipeline can seriously hinder the extraction of the oil and is costly to remove. In order to avoid this problem, polymeric wax crystal modifiers are added to the oil as it enters the tubing.
This will prevent the oil from waxing as it flows down the pipe, even when the temperature of the oil is approaching its pour point.

Because there is always some methane dissolved in crude oil and water may also be present as an emulsion or sucked into the tubing from the surrounding seawater, methane hydrates may form. This formation depends on the temperature, pressure, and flow rate in the tubing. In order to avoid this problem methanol, glycol, or some other hydrate inhibitor is injected as the oil enters the tubing. This will prevent any hydrates from condensing out of solution, and it will also dissolve any hydrates that have already formed in the oil.

Concurrently with the operations to install the penetrations into the tanker, a Mobile Offshore Production System (MOPS) is deploying the oil recovery riser. Three main types of MOPS exist, a tanker based floating production, storage and offloading system (FPSO), a semisubmersible based floating production system (FPS), and a jack up based production unit (JPU). For deep water and short-term operations, less than a year on site, the FPSO is the platform of choice.

The FPSO is an oil tanker that has undergone extensive modifications in order to perform drilling operations of a short-term duration. It is typically used for exploratory purposes and installation of undersea wellheads that will be tied back to an existing oil pipeline. It is self-propelled, has onboard oil tanks, and has a superstructure capable of assembling and supporting the loads of a deep-water riser. Being a stand-alone system, no additional support vessels are necessary on the oil recovery side of the operation. Once operations are completed, the platform can be easily and inexpensively removed, leaving no permanent signs of its presence.

The subsea oil recovery field equipment will be deployed from the FPSO. Once a suitable location has been determined, the Christmas tree will be deployed next to the wreck. A
typical oil tanker has anywhere from 10 to 30 separate oil tanks. Therefore, the Christmas tree must have multiple connections for simultaneous removal of the oil from multiple tanks. As a minimum, ten individual circuits for connecting to the tanks are desired. Each circuit contains three parts: seawater flow from the FPSO, oil flow from the sunken tanker, and de-waxing agents from the FPSO. Depending on the number of separate tanks, any number of connections can be used or all ten pipelines can be used simultaneously.

The Christmas tree is the connection between the riser from the FPSO to the various tanks on the shipwreck. Three lines will come from the surface through the riser. A manifold system will be needed on the Christmas tree in order to split each one of these lines into the ten lines running to the oil tanker. Each line will have its own shutoff valve to allow for individual operation if necessary. When a tank has been drained of its oil contents, the corresponding valves can be shut off while the flexible lines are moved to the next oil tank without requiring stoppage of the oil removal operations from the other tanks. Additionally, if a problem develops in one of the loops, it can be isolated while repairs are made.

The pipeline tooling sled will include the parts necessary for the ROV to make all the connections, from the riser to the Christmas tree, the Christmas tree to the pipelines, and the pipelines to the valves on the hull penetrations. It will also include tools used to repair the riser and pipeline in case of damage during the operation or installation.

Damage to the outer sheath of flexible risers can result in having to replace the entire riser. A method using an ROV to install a repair clamp has been developed by Perry Slingsby Systems Ltd. to avoid this problem. Repair clamps can be stored at the tooling sled where it will be easily accessible to the ROV in case of any damage. Repairing the damage instead of replacing the entire riser will save money and time.
The flexible pipeline will be installed using the J-Lay Method. This method, unlike the shallow water S-Lay Method, is used for installing offshore pipelines in deep water. Lengths of pipe are joined to each other by welding or other means while supported vertically by a tower on the FPSO. As more pipe lengths are added to the string, the string is lowered to the ocean floor.

![Image of Riser Deployment Methods]

**Figure 2: Riser Deployment Methods.**

Using this method, the riser will be lowered to the seafloor. Once sufficient length has been assembled to reach the bottom, the ROV will be utilized to perform the connection to the Christmas tree.

The size of the riser is controlled by the pressure rating. The seawater outflow pressure into the oil tanks on the wreck must be higher than the ambient pressure of the surrounding seawater at depth. The riser pipeline must be able to hold this pressure at the surface. The riser will have a 10” diameter, a size capable of withstanding the pressure at 3,000 meters. This size limitation will have an effect on the maximum flow rate obtainable by the overall system. The
pipelines connecting the Christmas tree to the hull of the wreck will be 3” in diameter, while the manifold lines in the Christmas tree will be 4” in diameter in order to get the desired flow rate of up to 20,000 barrels a day at a bottom line pressure of 10,000 psi.

Our success depends greatly on time; therefore, to make the installation procedure quicker and simpler, the de-waxing agents will be pumped in using the same pipeline used for the oil extraction. The pipeline will have a separate internal line that will take the de-waxing agent and release it at the oil flow valve installed on the side of the oil tank. The small de-waxing agent line will include a one-way valve at the end to prevent the intake of oil.

Once the Christmas tree has been deployed to the seafloor, a connection to the newly installed penetrations into the hull of the tanker must be made. The ROV is now outfitted with a special tooling sled designed for this purpose. This tool sled has a grabbing mechanism that latches onto one end of the flexible pipeline and guides it onto an underwater mateable connector. One of these connectors has been preinstalled on the Christmas tree valve assembly and on the hull penetrations. This operation is repeated until all connections to the numerous oil tanks have been made.

With the completion of the connections from the FPSO to the sunken tanker, pumping operations are ready to commence. The ROV is now used to open a series of valves on the Christmas tree and the hull penetrations to allow flow into and out of the oil tanker. The tanks can be drained one at a time, or simultaneously by operation of these valves. Additionally, if a problem develops during extraction operations, the lines in question can be closed without hindering extraction from the other tanks while repairs are made.

For the oil to flow smoothly out of the tanker, it will be necessary to displace the volume of oil extracted with an equal volume of seawater. Due to the extreme pressure at the wreck, it is
impossible for a gas to exist due to the gas compressibility laws. The solution to this problem is to inject a non-compressible fluid to fill the void left by the removal of the oil. This fluid must be environmentally safe since this injected fluid will remain in the tanks once the oil has been extracted. The obvious solution is to inject seawater. Since the density of seawater is greater than oil, the seawater will displace the oil and force it out of the tank into the oil extraction pipeline. This is the reason for placing the seawater injection line near the bottom of the tank, and the oil removal line near the top of the tank.

Separation of these two lines will prevent substantial mixing of the oil and seawater. While some mixing is inevitable, machinery contained in the FPSO is responsible for separating this seawater and any other impurities from the oil. It should be noted that this is the same method utilized by the oil companies to extract oil from underneath the surface of the seafloor.

A method of determining when all the oil has been removed from the tank must be utilized in order to monitor the completion of the task. A special sensor installed on the Christmas tree will measure the conductivity of the fluid passing through the pipeline. Since seawater is pumped into the tank in order to displace the oil, eventually seawater will begin flowing back to the Christmas tree when all the oil has been pumped out. By monitoring the conductivity of the oil, which is lower than that of seawater, it is possible to determine when no more oil is present in the line. The valves to this line can then be closed allowing the pumping operations to concentrate on the other tanks. The ROV can be utilized to remove the flexible pipeline for this section and either install it on another tank or prepare for its retrieval to the surface.

In this manner the tanks will be drained one after another until all tanks on the wreck have been drained of oil. Depending on the size of the tanker and the quantity of oil contained
within, this could take several months to complete the entire project. Seasonal weather conditions must also be taken into consideration. A severe storm at the surface could jeopardize operations on the FPSO and endanger the personnel on board. If the length of the project is in danger of running into undesirable seasonal weather conditions, a riser support structure could be deployed to float the top portion of the riser at a depth where it would be safe from the surface conditions. This allows the FPSO to temporarily suspend operations and move out of harms way without requiring the retrieval of the entire riser, which would be a time consuming and lengthy procedure. Upon return to the work site, an ROV would reconnect the FPSO to the riser at the sub-surface float and operations could recommence.

Once the task of recovering the oil has been completed, the ROV is utilized to recover the equipment. The flexible lines are disconnected and retrieved to the surface. The riser is disconnected from the Christmas tree and recovered by the MOPS. The Christmas tree is raised to the surface, and the tooling sleds are recovered by the ROV support ship. The FPSO returns to port and proceeds with the offloading of the recovered oil.
COMPONENTS

Oceanographic Mapping Vessel

Figure 3: R/V Revelle.

Locating and surveying the wreck site will require an oceanographic research ship such as the R/V Roger Revelle. This ship is a member of the UNOLS fleet of vessels, and is operated by SCRIPPS Institution of Oceanography. The University-National Oceanographic Laboratory System (UNOLS) is an organization of 63 academic institutions and National Laboratories involved in oceanographic research. This ship has the capability to deploy a deep towed sidescan sonar towfish that will be used to locate the wreck on the seafloor. Then the wreck site will be mapped using the Simrad EM120 bathymetry system permanently installed on the hull of this vessel. All of the relevant technical information about the conditions at the wreck location such as currents, temperature, salinity, and seafloor type, will be gathered by equipment that is operated off of this vessel.
SITE SURVEY

The wreck location needs to have both low and high-resolution sonar scans completed in order to determine the location and condition of the wreck. To complete these surveys, a customized Klein 3000 Sonar System from Klein Associates, Inc. will be used. A sub-bottom profiler is also necessary to give a portrait of the seafloor conditions. For this application a GeoPulse Boomer from GeoAcoustics will be employed.

ROV SUPPORT VESSEL

ROV operations will be performed by the Kommandor Subsea ROV support vessel (ROVSV) operated by Subsea 7. This ship has been specially designed with the sole purpose of performing ROV operations for the oil industry. This ship deploys the ROV through a moonpool which allows for safe operations in harsh weather. The ship has dynamic positioning capabilities and is able to hold a constant position on the surface, a necessary requirement for ROV operations.
Figure 6: Kommandor ROV Support Vessel

ROV

A workclass ROV will be needed that is capable of operating at 3000m depth. The ROV will be performing all of the underwater installation tasks at the wreck and must be powerful and versatile. Subsea 7’s Hercules line of ROV’s meets these requirements:

1. One Seven function Shillings Manipulator
2. One Five function Shillings Manipulator
3. 120 Hp Shaft Power
4. 8 Thrusters (4 Vertical, 4 Lateral)
5. 6 Video Camera
6. 4 x 500 Watt lights
7. Capabilities to Support Tooling Sleds
8. 150 Kg lifting Capabilities
DRILLING OPERATION

To retain as much oil as possible, a valve must be welded onto the hull at the drill site. A Welding Stinger from Broco Underwater Cutting & Welding will perform this task. Following the welding operation, a section of the outer hull of the tanker needs to be removed to access the oil. To cut out this section, an Ultrathermic Cutting Rod from Broco Underwater Cutting & Welding Systems will be used.

Figure 8: Broco Welding Stinger

Figure 9: Broco Ultrathermic Cutting Rod

CHRISTMAS TREE

The Christmas tree will be designed for our purposes by ANSON Ltd. Our specifications are:

1. Maximum depth of 4,000 meters

2. One 8 inch connection for the flexible riser, including a separate 2 inch intake for the de-waxing agent. The de-waxing agent must be taken and distributed among whichever of the ten pipelines are open.

3. Ten 3 inch pipelines to the hull penetrations, with a separate 1 inch line for the de-waxing agent. These pipelines must be allowed to be opened or closed by the ROV at any time.
FLEXIBLE PIPELINE

NKT Flexible pipe sizes go from 2.5 inches to 16 inches inner diameter and pressures go from 15,000 psi for the smallest to 4,000 psi for the largest. They will provide the flexible pipelines. The ten pipelines used to pump the oil from the hull penetrations to the Christmas tree will be 3 inches in diameter, with a pressure of 14,000 psi. It will also include an internal line (1 inch diameter) used to pump the de-waxing agent from the Christmas tree to the hull penetration valves. The de-waxing agent will be released near the end of the flexible pipeline, where it connects to the valve. It will include a one-way valve to prevent oil from entering the pipeline. The ten pipelines used to pump the seawater will be 5 inches in diameter. Flexible pipelines will be used for the entire connection system. Some advantages to using flexible pipelines are [1]:

- Purpose designed product optimized for each specific application
- A design that combines the flexibility of a polymer pipe with the strength and weight of a steel pipe
- Follows the natural contours of the seabed thus minimizing the susceptibility to free pipeline spans
- Minimization of external corrosion effects owing to encapsulation of the steel armour inside a continuous polymer outer sheath
- Accommodate misalignments during installation and tie-in operations
- Load-out and installation safer, faster and cheaper than any other pipe application

Retrievability and reusability for alternative application thus enhancing the overall field development economics and preserving the environment.
PIPELINE SUPPORT ROV, TOOLING

Several types of tooling will be needed to support the ROV pipeline operations. The following tooling will be supplied by Oceaneering Inc.:

1. ROVCON
   a. The Flexible Pipeline Pull-in sled
   b. 15 ton Pull Force
   c. Handles up to 10 in flexible lines
   d. Specially Modified for 4000 m

2. Linear Gate Valve Override Tool
   a. Actuating, Overriding and Locking Open Various Gate Valves
   b. Configured for ROV Operation by a Manipulator Arm
   c. Nominal Output Force Range of 25,000 to 110,000 lbs.

3. Hardline Cutter
   a. Capable of cutting 1-1/2 in Diameter Wire Rope
   b. Configured for ROV Operation by a Manipulator Arm

Figure 10: ROVCON tooling sled attached to a Work class ROV.

Figure 11: Gate Valve overriding tool.

Figure 12: Hardline Cutter.
RISER

Current riser technology is limited to 3000m. This affects the maximum operating depth of the oil recovery operations. 2H Offshore Engineering will provide the flexible riser with the following features:

1. Free Hanging Concentric Offset Riser
2. Threaded section connections for ease of installation and removal
3. High Strength Steel for acceptable strength to weight ratio
4. Flotation Support Structure to decouple surface motion of FPSO
5. Modular Design

Figure 13: Riser System.

Negotiations with 2H will be pursued to facilitate the development of a riser capable of reaching 4000m to increase the operating depth of the recovery operations. The riser needed for our purposes will have an 8 inch diameter and pressure rating of 10,000 psi. It will include small 2 inch internal line used to pump the dewaxing agent to the Christmas tree.
RISER REPAIR

The riser repair clamp, developed by Perry Slingsby Systems, will be lowered down in a tooling sled. To the right is a detailed figure of the repair clamp. The body, a hinged band clamp in super duplex steel, can handle a wide tolerance of diameters and variations in the riser shape and expansion and contraction variations.

Figure 14: Riser Repair Clamp.

MOPS

The oil recovery operations will be performed by the FPSO Ocean Producer operated by Oceaneering Inc. This ship’s design is based on a 77000-dwt tanker and has been specially converted to support offshore drilling and riser installation for deep-ocean oil fields. This vessel is capable of pumping from 15,000 to 25,000 barrels of oil a day, and has a storage capability of 500,000 barrels. The vessel is self-propelled, thus eliminating the need to tow a rig to the site.

Figure 15: FPSO Ocean Producer
TECHNICAL BACKGROUND

OIL RELATED DATA

API Gravity - The American Petroleum Institute’s expression of the specific gravity* of crude oils and condensates measured at 60°F (16°C). The lower the API Gravity the heavier the oil.

API Gravity (in degrees) = (141.5/Specific Gravity)-131.5

- Heavy oil - API Gravity <25°
- Medium gravity oil - API Gravity 25°-35°
- Light oil - API Gravity 35°-45°
- Condensate - API Gravity >45°

* Specific gravity – ratio of the mass of a body to the mass of an equal volume of water at a specified temperature.

Viscosity - The internal friction due to molecular cohesion in fluids, which results in the resistance of a fluid to flow. It is measured in Poise (grams/cm/sec), usually expressed as centipoise. Viscosity is temperature dependent (higher temperatures, lower viscosity). Dissolved gas will also lower the viscosity of petroleum.

Cloud Point - the temperature at which turbidity is noticed in the crude oil due to the settling out of solid paraffin waxes. Wax-free oils show no cloud point.
Pour Point - the temperature at which a crude oil will no longer flow. Pour point is usually 2-5°C below the cloud point.

Asphaltene Content - Asphaltenes are the heavy molecular weight component of crude oils and sediment extracts that is insoluble in n-heptane. They consist of large polyaromatic ring structures linked by aliphatic chains or rings and functional groups and have molecular weights starting at about 150,000.

OCEANOGRAPHIC RESEARCH VESSEL

R/V Roger Revelle

![R/V Roger Revelle](image)

**R/V Roger Revelle**

- **Built:** 1996
- **Length:** 273'
- **Beam:** 52'5"
- **Draft (max):** 17'
- **Gross Tonnage:** 3,180 long tons
- **Displacement:** 3,512 long tons
- **Crew:** 22
- **Scientific berthing:** 37
- **Motors:** Two 3,000 hp Propulsion General Electric
- **Bow Thruster:** 1,180 hp Azimuthing jet
- **Propulsion:** Two 3,000 hp Z-Drive Lips
- **Water Capacity:** 12,000 gal
- **Fuel consumption:** 4,400 gal/day (transit)
- **Speed, Cruising:** 12 knots
- **Speed, Maximum:** 15 knots
- **Speed, Minimum:** variable to 0, any direction
- **Endurance:** 52 days at 12 knots (fuel)
- **Range:** 15,000 at 12 knots (fuel)
- **Fuel capacity:** 227,500 (planning)
- **Radio Call Sign:** KAOU
- **Laboratory Space:** 4,000 sq. ft
- **Main Deck Working Area:** 4,070 sq. ft
- **Freeboard:** 9 ft
- **Sewage System:** MSD
**Incinerator:** Yes    **Holding Tanks:** 5,100 gal

**Ownership:** Title held by U.S. Navy. Operated under charter agreement with Office of Naval Research.

**Navigational capabilities:**
- GPS Trimble Tansmon P-Code
- GPS Trimble NT 200 DGPS
- RADAR Sperry 3cm, 10cm
- ADU GPS Ashtech Attitude-sensing System
- Acoustic Positioning System Nautronix 916 SBL/LBL
- Fathometer Furuno FV 700 50 kHz
- Doppler Speed Log – ODEC 200 kHz
- Doppler Speed Log – EDO 600 kHz
- Dynamic Positioning – ROBERTSON
- ADF - SIMRAD Taiyo
- Gyro - Sperry MK 37 (2)

**Scientific Equipment**

**Permanent scientific equipment**

<table>
<thead>
<tr>
<th>EQUIPMENT</th>
<th>MFG/MODEL</th>
<th>FREQ kHz</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multibeam</td>
<td>EM120</td>
<td>12</td>
<td>150 deg swath, bathymetry &amp; sidescan</td>
</tr>
<tr>
<td>Sub-Bottom Profilers</td>
<td>Knudsen 320 B</td>
<td>3.5 / 12</td>
<td></td>
</tr>
<tr>
<td>ODEC Bathy 2000</td>
<td></td>
<td>3.5/12</td>
<td></td>
</tr>
<tr>
<td>Magnetometer</td>
<td>Geometrics G-886</td>
<td></td>
<td>Towed Magnetometer</td>
</tr>
<tr>
<td>XBT</td>
<td>Sippican MK 12</td>
<td></td>
<td>Digital</td>
</tr>
<tr>
<td>ADCP</td>
<td>RDI Narrowband</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td>RDI Broadband</td>
<td>150</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydrographic Doppler Sonar</td>
<td>50/140</td>
<td></td>
<td>Profiles to depth of 1,000 m with 15 m depth resolution</td>
</tr>
<tr>
<td>Underway Data System</td>
<td></td>
<td></td>
<td>Meterological/Sea Surface</td>
</tr>
</tbody>
</table>
Comm/Data Network

Computer System | SUN Enterprise
450 Servers (2) | 200Gbytes Disk: CD-ROM, DAT and Exabyte Tapes

Work Stations | UNIX and PC | Numerous in Labs

Printers/Plotters | Laserjet/Color Inkjet

Bioanalytical Lab with precision temperature control. Refrigerator and freezer walk-in chambers for sample storage/preparation. Use of isotopes is prohibited in ship's laboratories. Isotope isolation vans are available by request. Other equipment and technical services available on cruise-specific basis.

**Vans:** Numerous van placement locations on main deck, 01 level port side and forward on 02 deck.

**Communications:** INMARSAT satellite voice and data, VHF, HF radio, SSB voice and TELEX.
**In-port San Diego phone number:** (858) 534-1647
**INMARSAT phone number:** 011-872-336780030 or 011-872-336780020
**INMARSAT fax:** 011-872-336780031 or 011-872-336780021
INMARSAT area code is 872 when ship is in Pacific; other codes are 871, 873, or 874 for east Atlantic, west Atlantic, Indian Ocean.

**Support Equipment**

<table>
<thead>
<tr>
<th>EQUIPMENT</th>
<th>LOCATION</th>
<th>SWL (At Sea)</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>North America Heavy Crane</strong></td>
<td>Main Deck Starboard Quarter</td>
<td>5,000 lbs.</td>
<td>Trawl/Dredge Capable</td>
</tr>
<tr>
<td><strong>North America Heavy Crane</strong></td>
<td>01 Level Port Frame</td>
<td>5,000 lbs.</td>
<td></td>
</tr>
<tr>
<td><strong>HIAB Crane</strong></td>
<td>Main Deck Port Quarter</td>
<td>2,000 lb.</td>
<td>Relocatable</td>
</tr>
<tr>
<td><strong>HIAB Crane</strong></td>
<td>02 Level forward</td>
<td>2,000 lb.</td>
<td>Relocatable</td>
</tr>
<tr>
<td><strong>A-Frame</strong></td>
<td>Stern Centered</td>
<td>18,000 lb.</td>
<td></td>
</tr>
<tr>
<td><strong>Hydro Boom</strong></td>
<td>Starboard Side Frame</td>
<td></td>
<td>Provision for 3 Sheaves</td>
</tr>
<tr>
<td><strong>Portable Cranes</strong></td>
<td>Various</td>
<td></td>
<td>Contact MarFac for Info</td>
</tr>
<tr>
<td><strong>Mooring Capstain</strong></td>
<td>Main Deck Aft</td>
<td></td>
<td>Relocatable</td>
</tr>
<tr>
<td><strong>Instrument Well</strong></td>
<td>Staging Bay</td>
<td></td>
<td>24&quot; Dia</td>
</tr>
</tbody>
</table>
### Workboat

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Uncontaminated Seawater</strong></td>
<td>All Labs</td>
</tr>
<tr>
<td><strong>Seismic Air Compressors</strong></td>
<td>Engine Room</td>
</tr>
<tr>
<td><strong>Deck Boltdowns</strong></td>
<td>Main/01/02 Decks, All Labs</td>
</tr>
</tbody>
</table>

### Winches

<table>
<thead>
<tr>
<th>TYPE</th>
<th>CABLE</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Markey DUTW 9-11 Traction</td>
<td>15,000 M 3x19 9/16&quot; Trawl</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10,000 m .680 EM or F/O</td>
<td>F/O Over Stern Only</td>
</tr>
<tr>
<td>Markey DESH 5</td>
<td>10,000 m .322 CTD</td>
<td>Can be configured as Hydro</td>
</tr>
<tr>
<td>Markey DESH-5</td>
<td>10,000 m 3x19 1/4&quot; Hydro</td>
<td>Can be configured as CTD</td>
</tr>
<tr>
<td>Portable</td>
<td>Various Sizes and Lengths</td>
<td>Contact MarFac for Information</td>
</tr>
</tbody>
</table>

### SIDE SCAN SONAR

**KLEIN SONAR SYSTEMS**

**SYSTEM 3000**

**SONAR SYSTEM**
### TOWFISH:

<table>
<thead>
<tr>
<th><strong>Frequencies:</strong></th>
<th>130 kHz and 445 kHz</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Transmission Pulse:</strong></td>
<td>Tone Burst, operator selectable from 25 to 400 usec. Independent pulses for each frequency</td>
</tr>
<tr>
<td><strong>Beams:</strong></td>
<td>Horizontal:</td>
</tr>
<tr>
<td></td>
<td>- 100 kHz 1 degree.</td>
</tr>
<tr>
<td></td>
<td>- 500 kHz 0.2 degrees</td>
</tr>
<tr>
<td></td>
<td>Vertical:</td>
</tr>
<tr>
<td></td>
<td>- 40 degrees</td>
</tr>
<tr>
<td></td>
<td>Tilt:</td>
</tr>
<tr>
<td></td>
<td>- 5, 10, 15, 20 or 25 degrees down</td>
</tr>
<tr>
<td><strong>Expected Sonar Range:</strong></td>
<td>100 kHz: to 450 meters</td>
</tr>
<tr>
<td></td>
<td>500 kHz: to 150 meters</td>
</tr>
<tr>
<td><strong>Depth Rating:</strong></td>
<td>1,500 meters standard.</td>
</tr>
<tr>
<td></td>
<td>Options: 3,000 meters and 6,000 meters</td>
</tr>
<tr>
<td><strong>Tow Speed:</strong></td>
<td>2 to 5 knots typical, 13 knots maximum</td>
</tr>
<tr>
<td><strong>Multiplexer:</strong></td>
<td>T1, 1.5 MB/sec.</td>
</tr>
<tr>
<td><strong>Construction:</strong></td>
<td>Advanced towbody design, stainless steel</td>
</tr>
<tr>
<td><strong>Size:</strong></td>
<td>122 cm long, 8.9 cm diameter</td>
</tr>
<tr>
<td><strong>Weight:</strong></td>
<td>25 kg in air</td>
</tr>
<tr>
<td><strong>Sensors:</strong></td>
<td>Compass, pitch, roll, sensor</td>
</tr>
<tr>
<td><strong>Options:</strong></td>
<td>- 2 Depth sensors 300, 1500 p.s.i.</td>
</tr>
<tr>
<td></td>
<td>- Positioning Responder</td>
</tr>
<tr>
<td></td>
<td>- Magnetometer interfaces</td>
</tr>
<tr>
<td><strong>TRANSCEIVER PROCESSOR UNIT (TPU)</strong></td>
<td></td>
</tr>
<tr>
<td>-------------------------------------</td>
<td>---</td>
</tr>
<tr>
<td>Operating System:</td>
<td>VX Works with custom application</td>
</tr>
<tr>
<td>Basic Hardware:</td>
<td>19 inch rack mount, VME bus structure.</td>
</tr>
<tr>
<td>Sonar Data Digitization:</td>
<td>12 bits/sample 24 kHz sample rate-per channel.</td>
</tr>
<tr>
<td>Outputs:</td>
<td>100 Base-Tx, Ethernet LAN</td>
</tr>
<tr>
<td>Navigation Input:</td>
<td>NEMA 0183</td>
</tr>
<tr>
<td>Power:</td>
<td>120 watts @ 120/240 VAC, 50/60 Hz</td>
</tr>
<tr>
<td>Size:</td>
<td>13.2 cm H x 54.8 D x 19 inch rack mount</td>
</tr>
<tr>
<td></td>
<td>3.5 in H x 21.5 in D x 19 in W</td>
</tr>
<tr>
<td>Weight:</td>
<td>12.7 kg</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>WORK STATION DISPLAY AND CONTROL UNIT (WDCU)</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating System:</td>
<td>Windows NT, 2000</td>
</tr>
<tr>
<td>Sonar Software:</td>
<td>SonarPro</td>
</tr>
<tr>
<td>Size:</td>
<td>19 inch rack mount x 18 cm H</td>
</tr>
<tr>
<td>Monitor:</td>
<td>SVGA 17 inch standard, other monitor sizes available, 2nd system monitor optional.</td>
</tr>
<tr>
<td>PC Based System:</td>
<td>Latest Pentium Based PC Technology</td>
</tr>
<tr>
<td>Data Storage:</td>
<td>Latest Internal hard drive technology, optional devices available.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>TOW CABLES:</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Klein offers a selection of coaxial, Kevlar reinforced, lightweight cables, double armored steel cables, and interfaces to fiber optic cables. All cables fully terminated at the towfish end.</td>
<td></td>
</tr>
</tbody>
</table>
SUB-BOTTOM PROFILER

GeoPulse
Boomer/Sparker
Profiling System

Introduction

The GeoPulse boomer system is widely accepted by the marine geophysical community as the best option for high resolution, deep penetration profiling in both deep ocean and shallow coastal environments. Industry proven, with thousands of kilometres surveyed, GeoPulse offers a flexible high resolution solution. The system provides up to three times the acoustic energy of conventional profiling systems while operating in very shallow water and in high noise environments. The surface towed acoustic source is easy to deploy and the on-board units are compact and easily installed. For surveys where even greater penetration is required, the GeoPulse Multi-Electrode Sparker Array may be used in place of the Boomer plate, but at the expense of some trade-off in resolution.

Basic System

- GeoPulse 5420S Solid State Power Supply
  The GeoPulse 5420S employs a solid state high voltage switching device which offers significant advances over the older technology, including higher efficiency, very high reliability and excellent repeatability. The GeoPulse 5420S is controlled entirely from the front panel, making it very easy to operate, and incorporates the high level of safety features you would expect from a GeoAcoustics product.
- A specially designed Power Cable is used to connect 5420S to the source.
- An acoustic source which can be either a Boomer plate (Model 5813B) mounted on a Catamaran (Model 5812A) or a Multi-Electrode Sparker Array.
  The GeoPulse sound source produces a high energy pulse by the action of a unique vacuum controlled electromechanical “plate”. The vacuum controls the degree of damping and ensures a repeatable, high energy signature. The characteristic output of the sound source gives much improved resolution over conventional systems and up to ten times the seabed penetration of standard “pinger” profiler systems.
- GeoPulse Receiver (Model 5210A), usually with a Swell Filter Option fitted.
  The Receiver unit receives the acoustic return from the hydrophone. It combines in one compact and easily operated unit, the essential processing and control functions for analogue data enhancement and simple interface to any industry standard graphic recorder.
- GeoPulse Hydrophone (Model 5110A)
  The GeoPulse hydrophone array receives the returned signals. The hydrophone contains twenty elements and is designed for maximum durability in offshore conditions.

Features

- Deep penetration in wide variety of sub-bottom structures.
- Easy to operate and install.
- Good shallow water performance.
- Deployed by one-two people.
- Proven offshore track record.
- Higher source levels enable operation in water depths to 500m.
- Ragged and reliable.
- Good performance in high noise environments.
- Cost effective solution.

Expected Penetration from GeoPulse™
**Specifications**

**Receiver Model 5210A**

- **Amplifier:** Differential common mode rejection: 100 dB at 60Hz. Sensitivity 30µV RMS in, produces 1V RMS out at 90dB total gain with TVG.
- **Signal to noise:** 20dB at 100dB gain 1kHz centre frequency and 1kHz bandwidth.
- **Coarse gain:** 40dB maximum.
- **Fine gain:** 0 – 30dB in 3dB increments.
- **Filter:** Low pass and high pass, active type. Maximally flat, 24dB/octave minimum roll-off, 0 gain, 0.02kHz to 15kHz adjustable in 3 octave increments. Knobs interlock to prevent overlap.
- **TVG:** Dynamic range: 30dB. Rate: approximately flat to 30dB in 14ms. Manual delay: vernier adjust from 1 to 14ms with multiplier of x 1, x 10, x 100 and internal select of x 1000.
- **AGC:** Attack and decay adjustable from 30μs to 250ms. Range: 20dB. Power: 115/230VAC ± 10% (internal switch selectable), 47 to 65Hz, 45W.
- **Environmental:** Operational: -5 to 50°C, Storage: -15 to 85°C.
- **Dimensions:** 45.7cm (L), 43.2cm (W), 17.8cm (H), 12kg.

**Solid State Power Supply Model 5420S**

- **Dimensions:** 60 cm (W) x 41 cm (D) x 39 cm (H).
- **Weight:** 83kg.
- **Energy Storage:** Capacitor C1 C2 C3 15µF 25µF 25µF.
- **Charging Power:** 910W Max.
- **Environmental:** Operational: 0 to 50°C, Storage: -15°C to 65°C.
- **Connections:** Power In: 25A 3 pin panel mounted. Power Out: HV panel mounted connector with safety interlock.
- **Key Input:** CMOS/TTL & optical fibre on front panel.

**Sound Source Model 5813B**

- **Source Level:** 227dB re 1µPa @ 1m at 280 joules.
- **Pulse Length:** ~0.2ms.
- **Max. Input Energy:** 280 joules.
- **Max. Input Voltage:** 48V.
- **Weight:** 12.5kg.
- **Dimensions:** 38.3cm (W) x 41.5cm (D) x 4.3cm (H).

**Multi Tip Sparker**

- **Energy Level:** 150 to 500 watt-sec (60 Tips).
- **Repetition Rate:** 150 to 1000 watt-sec (144 Tips).
- **Dimensions:** 60 Tips x 20 (H) x 5 (W) x 100 (L), 144 Tips x 20 (H) x 5 (W) x 226 (L).
- **Weight:** 6kg (60 Tips), 8kg (144 Tips).
- **Max. Towing Speed:** 5 knots.

**Hydrophone Model 5110A**

- **Elements:** 20.
- **Sensitivity:** -202dB re 1V/µPa.
- **Response:** 4805dB from 5Hz to 3kHz, +2dB – 10kHz.
- **Preampifier:** Gain: +24dB. Power: 9-12VDC @ 4mA. Response: 5Hz to 20kHz + 1dB.
- **Dimensions:** 2.5cm (Diameter) x 7.6cm (L).
- **Weight:** 12kg.
- **Hydrophone array:** Breaking strength: 45kg.
- **Cable:** Length (5110A-16A): 60m.

**Catamaran Model 5812A**

- **Surface tow with 2 towing/steering lines.
- **PVC Floats with stainless steel frame.
- **Speed:** To 5 knots.
- **Size:** 132cm (W) x 87cm (D) x 28cm (H).
- **Weight:** 26kg.

**Receiver Model 5210A Options**

The Preamp Power Supply is a plug-in option to the 5210A. The unit also contains an output current sensing circuit so that, if an overload occurs, it can drive external LEDs to show supply status.

**Output:** voltage 0 (off), 6, 8, 12 or 24 VDC ± 0.5 VDC, switch selectable, current 30mA maximum overload protected.

The Model 5212A swell filter is a field installable option for the model 5210A. It can be used either in situ or with tape recorded records for post processing of data to remove the effects of vessel or hydrophone vertical motion on sub-bottom data.

- **Maximum frequency:** 7.5 or 15kHz (switch selectable)
- **Bottom averaging time:** 2-40 seconds
- **Operation modes:** 1) manual signal gate, 2) automatic tracking
- **Signal gate – return to manual with bottom signal loss.
- **Maximum Heave:** Approx ± 5.5m
- **Maximum Memory:** 960ms at 7.5kHz, 480ms at 15kHz
- **Depth Resolution:** Approx 8cm
- **Maximum Depth:** (without key delay) approx 720m at 7.5kHz, approx 360m at 15kHz.

*Specification sheet subject to change without notice.*

*9-Boomer-6900-A 01/2001*
The Kommandor Subsea is a fully redundant DP class II ROV Support Vessel (ROSV). The vessel is the world's first purpose-built ROSV. The vessel has continually proved to be a safe and adaptable solution to clients' varying requirements in all subsea survey, inspection and light construction tasks on a global basis.

The ROSV Kommandor Subsea incorporates a 4m x 4.2m moonpool which, together with a Subsea 7 designed cursor beam fetch mechanism system, provides the safest and most efficient method for the launch and recovery of the permanently installed hybrid Pioneer Remotely operated Vehicle (ROV), significantly improving the weather capability of the vessel.

A Seaeye Bover ROV system is also permanently installed onboard the vessel and is held on an A-frame launch and recovery system situated on the port side of the main deck area. Both systems are controlled from the online room located within the main accommodation area.

The vessel can easily be re-configured according to requirement and has previously been utilised as a platform for the simultaneous operation of three workclass ROVs. A hydraulic crane is fitted to the main deck with an SWL of 5t @ 14.5m, together with a stern mounted hydraulically powered A-frame with an SWL of 10t, suitable for both acoustic survey requirements including ROV operations or, with the inclusion of a suitable winch, for light installation operations.

The ROSV Kommandor Subsea offers an extremely cost efficient and flexible solution for many subsea tasks and, through continual upgrade and improvement, offers the highest standards of safety and technologically advanced systems available in the industry.
kommandor subsea

**Dimensions**
- Gross tonnage (Oslo 1969 Convention): 1573t
- Length overall: 68.50m
- Length BP: 62.40m
- Beam moulded: 11.50m
- Deadweight: 340t
- Depth to lower deck mid: 4.10m
- Depth to main deck mid: 6.60m
- Draft loaded: 4.05m
- Cruising speed: 11 knots

**Fuel Consumption**
- Economical: 10kts - 7.0 MT/day
- DP mode: 6.0 MT/day
- Flag: Bahamian
- Built: 1986, Denmark

**Capacities**
- Fuel oil: 272m³
- Luboil: 10m³
- Ballast water: 500m³
- Fresh water: 164m³
- Fresh water generators:
  - One reverse osmosis plant: 18m³ / day
  - One evaporator plant: 2m³ / day

**Power Supply**
- Two Deutz generators, type BA 12M 816U each developing 474kW @ 1800 rpm, coupled to 593kW Ares type A350 M alternator.
- Two Cummins generators, type KTA 38G3 each developing 840kW, coupled to Stamford 300kVA alternator.
- One Cummins generator type M1A 655 coupled to Stamford 304kW alternator (harbour generator).

**Thrusters**
- Hunssted type, two bow and one stern each driven by 405kW electric motor, nominal thrust 6000kg each.

**Dynamic Positioning**
The DP control system is a dual computer Kongsberg Simrad SEPS.

**Accommodation**
- Total persons: 44
- State cabins: 4
- Single: 4
- Double: 18
- Hospital: 1

**Classification**
- Lloyd's Register # 1001 A1, Offshore support vessel, UMS LMC.
- DP (AA) notation for world-wide trading.

**Helideck**
- Approved for up to Super Puma 332L/Beall 214S1

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**Communications Equipment**
- Shipmate NCG 300A Navtex
- Furuno DFFAX 207 weather fax
- Furuno PC-1500-IT GMDSS radio installation
- Two Furuno FM-8500 VH DSC terminals
- Two ICOM IC-A200 airband transceiver
- Nera Saturn V Marine Inmarsat terminal
- Inmarsat KU band terminal, data and voice channels

**ROV Systems**
- One Pioneer Workclass ROV
- One Observation Class ROV

**Navigation Equipment**
- Three Robertson RGC II gyrocompasses
- AP-99 autopilot
- Magnetic compass
- Furuno type FF 1510 mark II radar
- Furuno type FR 2110 radar
- Ben ALS48 speed log
- Furuno FE-860 echo sounder
- GPS receiver Furuno GP80
- Seapath 200 GPS heading reference system

**Reference Systems**
- Simrad HiPap, two x Sercel NR233 DGPS receivers, Bandak mark nine Tautewire, Seapath 200 GPS heading reference system, Fan Beam interface only.

**Working Deck**
- Main deck aft total: 320m²
- Cargo hold storage space: (130m² under hangar)
- Crane:
  - OMCV 1400-5-14.5 HL hydraulic crane situated on aft deck, port side. Working capacity SWL 5t @ 14.5 mts.
  - A-frame:
    - Hydraulic powered with local control.
    - Width: 5.1m
    - Height: 7.0m
    - SWL 10t, removal stern rail to accommodate larger items.

**Winches**
On forecastle deck one hydraulic anchor winch Norwinch type 2MA 34 with electric driven pump and one hydraulic transponder deployment winch.

**Propulsion**
Two Leroy Somer type 4010 electric motors each 665kW @ 1800rpm each driving Hunssted CP propellers @ 240rpm in conjunction with two schilling type rudders.

**Other features**
- 33kHz and 210 kHz survey echosounders
- 8m extending Sonardyne transducer pole for deployment of a variety of survey sensors through 14-inch diameter gate valve.

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For further information see www.subsea7.com or contact your regional office.

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Gaspar
Tel: +994 12 929000 Fax: +994 12 929600

Gulf of Mexico
Tel: +1 713 829 4600 Fax: +1 713 829 4612

Norway
Tel: +47 51 63 71 00 Fax: +47 51 63 71 01

West Africa
Tel: +231 10 411 0083 Fax: +231 10 412 5091

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The Hercules is a development of the highly successful Clanman deepwater drill support ROV system and is the latest workclass vehicle designed and built by Subsea 7, featuring many in-house developed technical innovations together with industry leading components.

The vehicle has a 120hp hydraulics system and is rated to 3,000msw. Together with four axial and four vertical thrusters, the vehicle is highly manoeuvrable and extremely proficient when operating in high current conditions an ability further enhanced by the addition of a Tether Management System (TMS). A through-frame lift capability of three tonnes @ 4g (equivalent to four tonnes @ 3g) allows the deployment and operation of large, skid-mounted tooling packages.

A triple wire-armoured lift umbilical is used to transmit data and high voltage electrical power to the vehicle. Fibre optic technology is used for data and video transmission allowing the system to be interfaced to a wide range of tooling equipment and survey sensors.

3000m depth rating

3 tonne through frame lift @ 4g

120hp capabilities
HERCULES

SPECIFICATIONS

Dimensions & Weights
- Length: 2400mm
- Width: 1950mm
- Height: 2050mm
- Weight (in air): 2750kg
- Through frame lift: 3000kg
- Payload: 150kg
- Depth rating: 3000msw

Propulsion System
- Shaft power: 120hp
- Hydraulic power: 100hp
- The vehicle is propelled by eight proportionally controlled thrusters providing the following:
  - Forward: 705kgf
  - Vertical: 456kgf
  - Lateral: 705kgf
- Thruster Configuration: Four horizontal vectored, Four vertical vectored

Optics & Lighting
- Format: SVHS or VHS
- Provision for six cameras
- All cameras with focus controls, two with zoom control Fibre optic video transmission
- 16 in, 6 out S-VHS compatible video switcher (surface)
- Light output (available):
  - 4 x 500W variable intensity standard fit of eight 250W diffused lights

Control & Sensors
- Auto heading
- Auto depth
- Auto altitude (with optional altimeter fitted)
- Pitch & roll

Indications/Sensors
- Pod vacuum and temp
- Hydraulic pressure
- ROV & TMS mux status
- Water ingress
- Depth
- HPU motor temperature
- Status of each analogue and digital signal

Manipulators
- Seven function (standard)
  - Schilling: T3/Conan
- Five function (standard)
  - Schilling: Rigmaster

Vehicle Control System
- Subsea 7 control multiplexer communicating through Subsea 7 fibre optic interface. Data I/O to surface control multiplexer through serial link to control computer system (PC). Fibre optic interface multiplexes control mux comms plus 7 RS232/RS422/TTL serial links at up to 500 Kbaud onto 2 optical fibres. Data I/O at ROV control mux through parallel expansion bus to expansion PCBs.

Multiplexer Telemetry I/O (ROV Pod)
- Digital inputs: 48
- Digital outputs: 48
- Analogue inputs (12 bit resolution): 48
- Analogue outputs (12 bit resolution): 48
- Relay control outputs (digital): 12
- Solenoid valve driver outputs (digital): 48 (24 double acting valves)

Telemetry I/O (control console)
- All channels can be monitored and controlled via serial communication from the ROV control computer

Control Computer I/O
- Digital inputs: 144
- Digital outputs: 96
- (inc 48 solenoid valve status indicators)
- Analogue inputs (12 bit resolution): 20
- Analogue outputs (12 bit resolution): 8

Gyro Compass System
- Model (standard): Oceantics ROV-FOG
- Accuracy: Typical ±0.5° x Secant latitude
- True north-seeking fibre optic gyro compass
- Model (option): Bendix King KCS305
- Accuracy: 2°

Locating System
- Various sonar system options
- Transponder/responder

Optional Tether Management System (TMS)

Perry
- Height: 2.080m
- Diameter: 1.83m
- Weight: 1725kg (air)
- Tether capacity: 200m

Slingsby
- Height: 2.10m
- Diameter: 2.00m
- Weight: 2300kg (air)
- Tether capacity: 250m - 300m

Electrical Supply Requirements
- 440-480Vac three phase
- 60Hz