23083 Hwy. 190E
P.O. Box 898
Robert, LA 70455 USA
Phone: (985)350-6299
e-mail: info@seatrepid.com

Expanded Description of Rope/Riser Crawler

ABSTRACT

A semi-autonomous [tetherless] or tele-operated [tethered] subsea inspection vehicle intended for mechanically crawling the moorings and risers of moored structures comprising (1) a means of mechanically propelling the vehicle along the mooring and/or riser through its entire length, (2) an adjustable latching mechanism so as to allow for varying diameters of structures, (3) a spring-loaded clasp for attaching/detaching to/from the structure, (4) a ring of cameras and sensors that allow close, detailed inspection of the circumference of the member, characterizes its structure/integrity and allows measurement of its diameter, (5) a means of high-density digital capture of sensor data aboard the vehicle, (6) a means of acoustically communicating with and tracking the vehicle, (7) a means of positively uncoupling the vehicle should power or communications with the vehicle be lost, (8) a means of attaching/detaching the vehicle to/from the structure with a remotely operated vehicle using manipulators and/or a purpose-built docking mechanism, (9) 3-axis gyro, magnetometer, accelerometer for sensing vehicle orientation, (10) pressure-sensing depth gauge, (11) Acoustic Positioning System with modem for vehicle location and remote communication, (12) Distance Encoder for measuring distance traveled along surface of structure, (13) “Bump” sensor for direction change at bottom, (14) Batteries for locomotion, manipulation and control, (15) Strobe light (for recovery at surface), (16) Internal Video and Data Capture (Compact Flash or other high density media), (17) Sacrificial deployment weight (concrete or other environmentally-friendly substance) for buoyancy control, (18) Activated remote release as well as manual manipulator release for dual means of detachment from the wire, (19) OD (Outer Diameter) measurement capability through pixel counting, (20) Syntactic foam buoyancy (overall positive buoyancy), (21) Easy access to the video and data capture card, (22) Batteries to be charged in housing with housing easily detachable from vehicle.

CONCEPT OF OPERATION (CONOP)

A. Operators aboard a vessel of opportunity attach one or more crawler vehicle assemblies to a deployment line (or “fixture”), and hang it over the side of the boat for easy access via Remotely Operated Vehicle (ROV).

B. An ROV pilot, also aboard the vessel, navigates the ROV to a crawler vehicle (still mounted on the fixture), and grapples it with either the ROV’s manipulator arm or a purpose-built docking mechanism.

C. Within approximately the first 100 feet of the surface, biological growth on the lines precludes attachment of the crawler; therefore, the ROV pilot would use the ROV's own cameras and sensors to perform the riser/mooring inspection. Immediately below the depth where most surface biological growth subsides, the ROV clamps the inspection crawler vehicle onto the line. On the vehicle, a compliant casing as well as a system of wheels or tracks would surround the cable so as to maintain traction, assure positive locomotion along the line and keep the vehicle from falling off of the mooring/riser.

D. Under normal operation, the vehicle would stay in the attachment position until its operator commanded it to descend.

E. Upon acoustic command, the vehicle would crawl or coast down the line with the operator tracking its position acoustically. A sacrificial ballast weight attached to the bottom of the vehicle would aid its descent and act as a shock absorber upon bottom contact, should the vehicle contact debris or the bottom. The secondary function of the high-speed travel down the line is for macro viewing of the line at higher speed as well as clearing the line of any light marine growth or debris before the detailed inspection commences upon ascent.

F. After traversing as far as possible down the line, the operator would acoustically command the vehicle to drop the weight (thus making the vehicle slightly buoyant so as to increase climbing efficiency) and crawl back up the line. The vehicle could run either tethered or untethered. In the tethered configuration, video feedback would be immediate. In the untethered configuration, the vehicle would experience less drag, and multiple vehicles could crawl the structure(s) simultaneously with less chance of entanglement.

G. On board the vehicle, video from each of a ring of cameras surrounding the line is simultaneously recorded and time-stamped (and/or transmitted in the tethered configuration) as the vehicle runs back up the line. Also, data from any further on-board sensors will be captured during the inspection transit of the line. During the ascent, the operator is able to monitor the crawler's position and status, and issue commands [if necessary].

H. When the vehicle returns to its starting depth, it automatically stops recording video/data and holds position. The ROV pilot then retrieves the vehicle from the line and re-attaches it to the deployment/retrieval fixture.

I. The crew retrieves the fixture from the water.

J. The crew removes one or more crawlers from the fixture.

K. The crew changes recording media and batteries, as necessary. The process is then repeated for the other lines on the platform.

L. If the ROV drops the crawler vehicle from its manipulator before positively securing the crawler to the line, the operator communicates acoustically with the crawler vehicle instructing it to drop its ballast weights in order to assume a positive buoyancy for ease in retrieval (with use of its acoustic positioning beacon and strobe light for easy location) by the ROV for re-ballasting then reattaching to the line.

M. If the crawler vehicle becomes lodged on the line, the ROV can locate the crawler vehicle acoustically (via acoustic transponder) as well as visually (via strobe light) in order to move the crawler over the obstruction or to retrieve the vehicle to the surface.

N. If the crawler vehicle malfunctions, the vehicle can either be retrieved by the ROV or the operator can acoustically instructs the vehicle to drop ballast then release its spring-loaded clasping mechanism thus allowing the vehicle to float to the surface for visual retrieval. If the vehicle completely loses power, the fail-safe mechanism on the clasp will default to an "unclasped" status thus detaching the vehicle from the line and allowing it to float to the surface where it can be retrieved visually (with use of its onboard strobe light).

COMPRISING COMPONENTS

Aboard the vessel:

– A command shack for the ROV and crawlers (not depicted)
– A deployment mechanism for the ROV (not depicted)
– A deployment mechanism for the crawler deployment/retrieval fixture (Figure 7)

Fig. 1a.

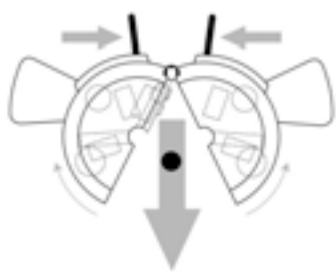

Fig. 1b.

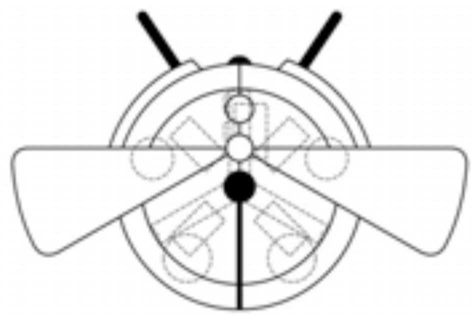

Fig. 2

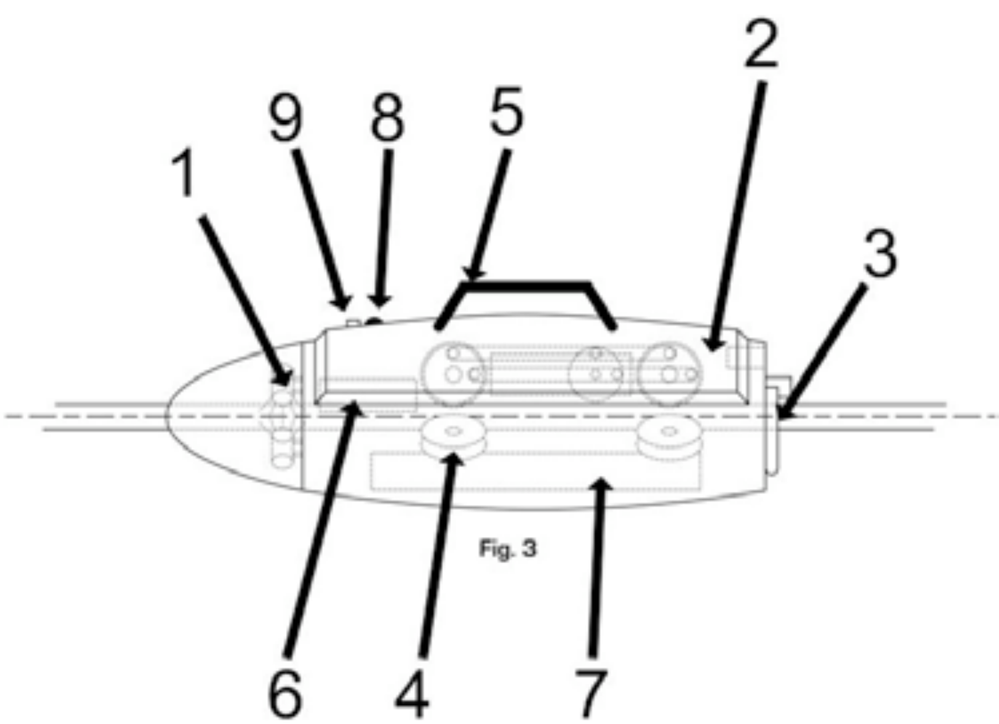

Fig. 3

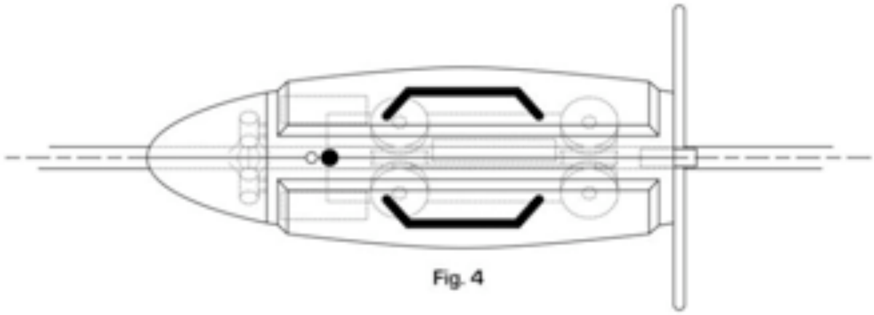

Fig. 4

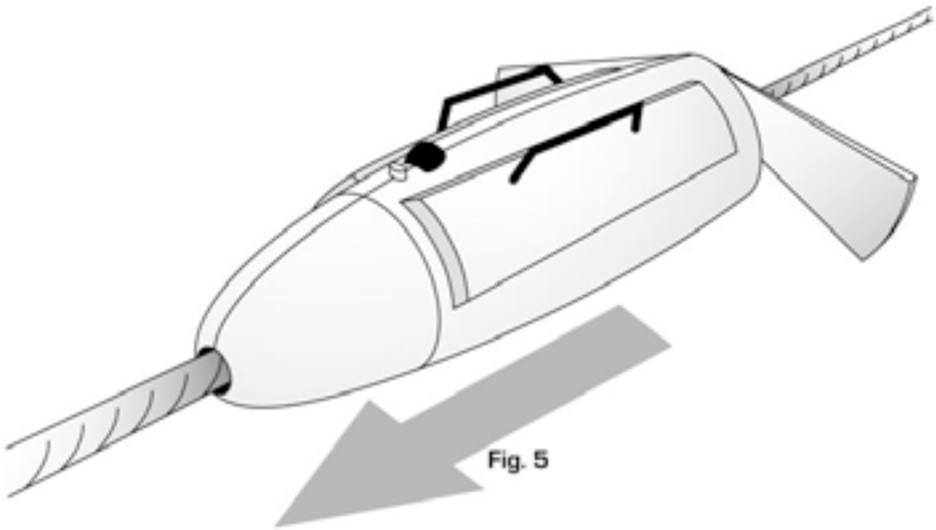

Fig. 5

<u>On the crawler:</u>

– Multiple cameras that would be positioned so as to surround the line and give a complete view of its circumference when attached to the line (Figure 3 – Item 1)
– Variable intensity lights co-located with the cameras on camera ring (Figure 3 – Item 1)
– A float block to provide buoyancy to the vehicle (Figure 3 – Item 2)
– A sacrificial weight to dynamically change the crawler's buoyancy (Figure 3 – Item 3)
– One or more tracks or wheels to drive along the line (Figure 3 – Item 4)
– A compliant clamping mechanism that would allow the vehicle to be passively attached to and detached from the line, while maintaining a sufficient clamping force to afford the wheels or track(s) traction (Figure 3 – Item 5)
– A navigation package including: a depth sensor, a magnetometer, and an inertial measurement unit (Figure 3 – Item 6)
– A battery pack to power the vehicle (Figure 3 – Item 7)
– An acoustic locater beacon/modem to track and communicate with the vehicle (Figure 3 – Item 8)
– Electronics housing(s) for enclosing the above-listed components (Figure 3 – Item 6)
– A strobe light for locating the vehicle visually should it become detached from the line (Figure 3 – Item 9)
– A downward-looking camera capturing a macro view of the mooring/riser and surrounding environs on the downward-facing end of the vehicle (Figure 3 – Item 10)

<u>Between the ROV and the vessel:</u>

– A tether over which power, command and telemetry data, and video data are sent, which can also be used to assist in deploying and recovering the vehicle (not depicted)

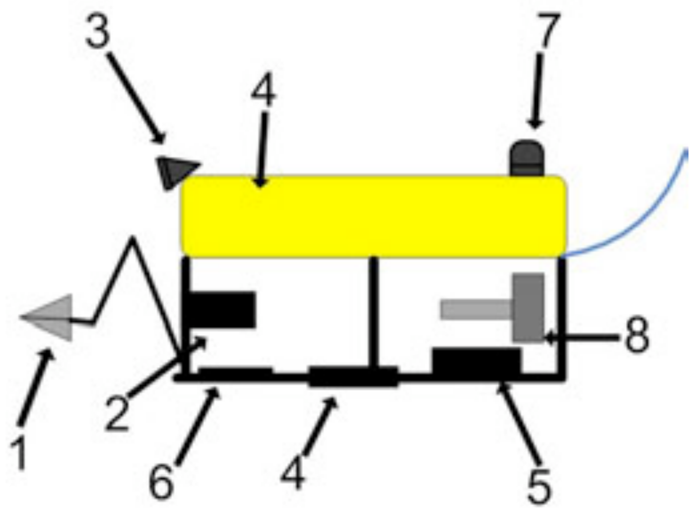

Figure 6

<u>On the ROV:</u>

– A manipulator capable of attaching and detaching a crawler from the line(s) to be inspected (Figure 6 – Item 1)
– Video cameras (Figure 6 – Item 2)
– Variable intensity lights (Figure 6 – Item 3)
– A float block and weights to provide vertical stability to the vehicle (Figure 6 – Item 4)
– A power conversion system to develop working voltages from the high voltage present on the tether (Figure 6 – Item 5)
– A navigation package including: a depth sensor, a magnetometer, and an inertial measurement unit (Figure 6 – Item 6)
– An acoustic locater beacon/modem to track the vehicle (Figure 6 – Item 7)
– Electronics housing(s) for enclosing the above-listed components (Figure 6 – Item 5)
– Thrusters to provide locomotion for the vehicle once submerged (Figure 6 – Item 8)

<u>Between the crawler(s) and the vessel:</u>

– An acoustic link, allowing the crawler to be tracked and command/telemetry data to be communicated (not depicted)
– Optionally, a tether over which video data can be sent for real-time monitoring (not depicted)

GRAPHICAL PRESENTATION OF THE CONOP

The crawler vehicle is placed on a deployment rope in series for multiple simultaneous placements of vehicles on multiple moorings/risers. The deployment rope/fixture (with multiple vehicles attached) is hung over the side, below keel level, for easy access by ROV. The crawler is installed upon the mooring or riser (Figure 7 and Figure 8) with a standard ROV using either a manipulator or a specialized docking station.

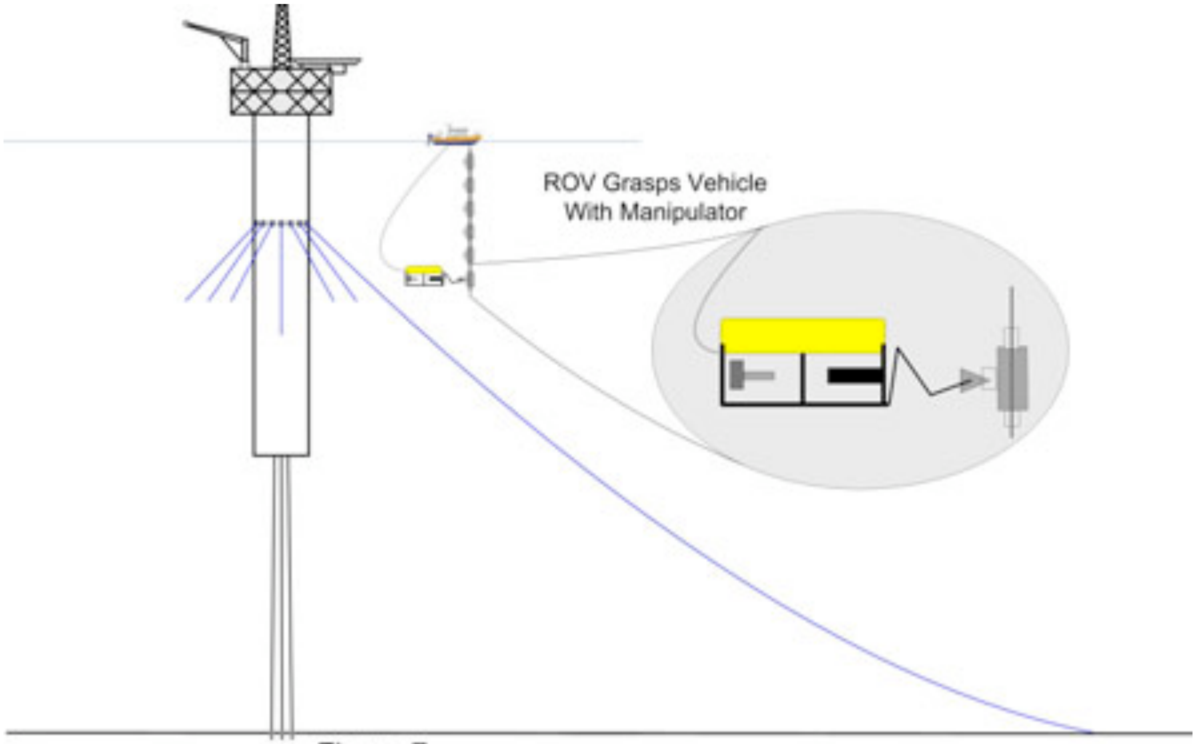

Figure 7

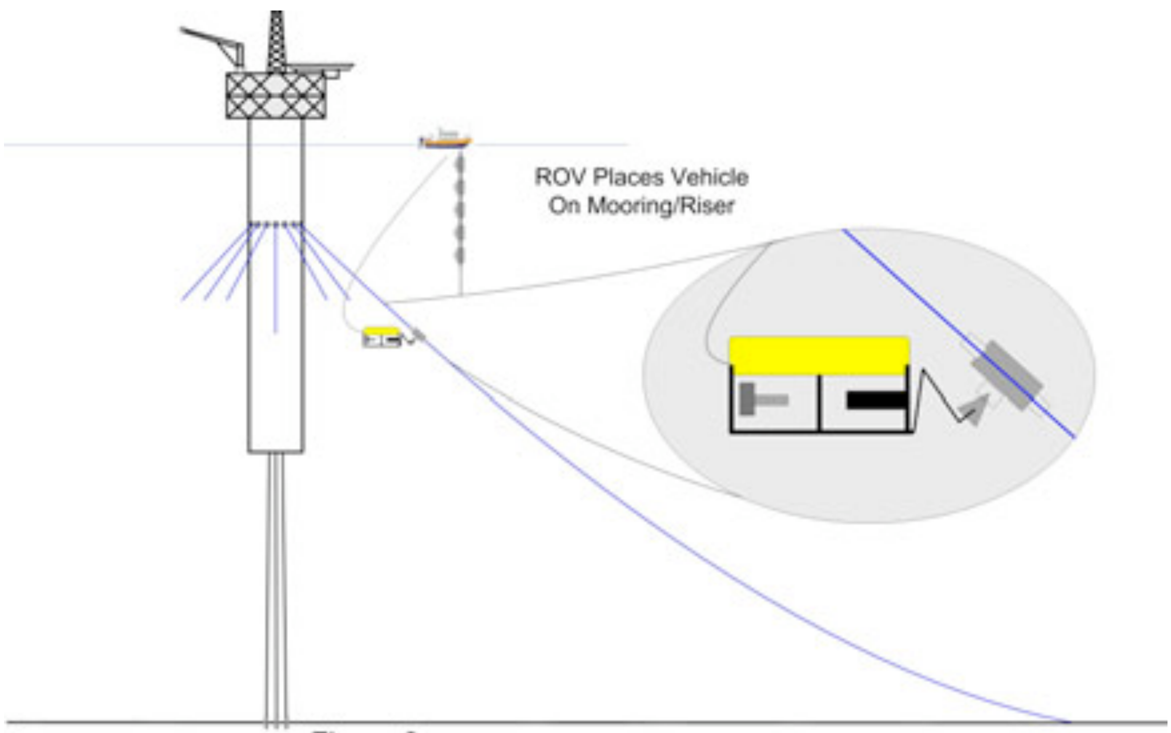

Figure 8

Once the vehicle is established on the mooring or riser, the acoustic modem awakens the vehicle for diagnostics (Figure 9).

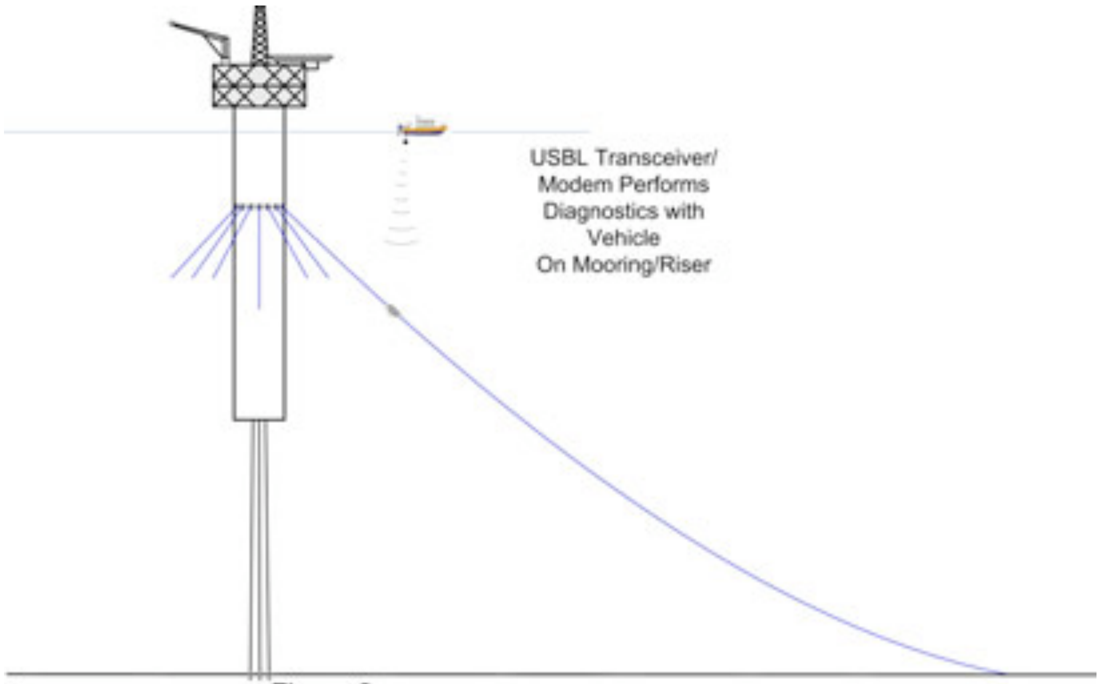

Figure 9

Upon successful diagnostics check, the vehicle is commanded to release its clutch allowing the vehicle to freefall to the bottom of the mooring or riser (Figure 10) while being tracked from the surface via acoustic positioning.

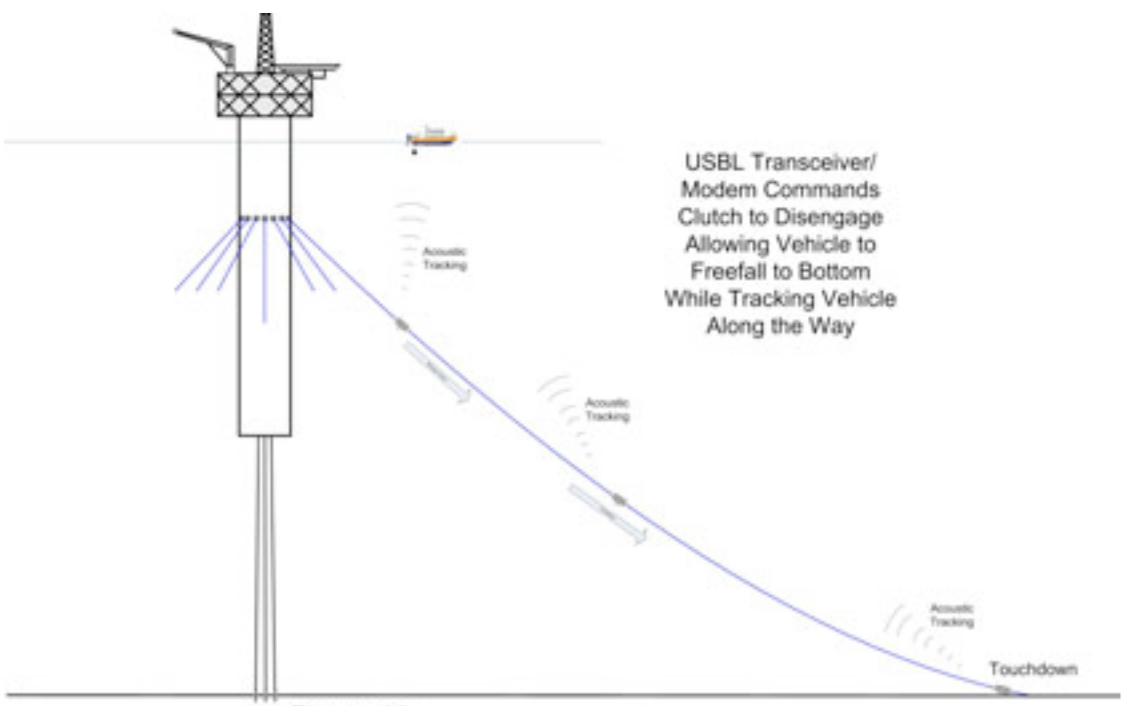

Figure 10

Once successfully landed on bottom, the vehicle senses touchdown via a “bump” sensor allowing the vehicle to engage its clutch upon the mooring/riser then shed its sacrificial clump weights (Figure 11) so as to render the vehicle positively buoyant.

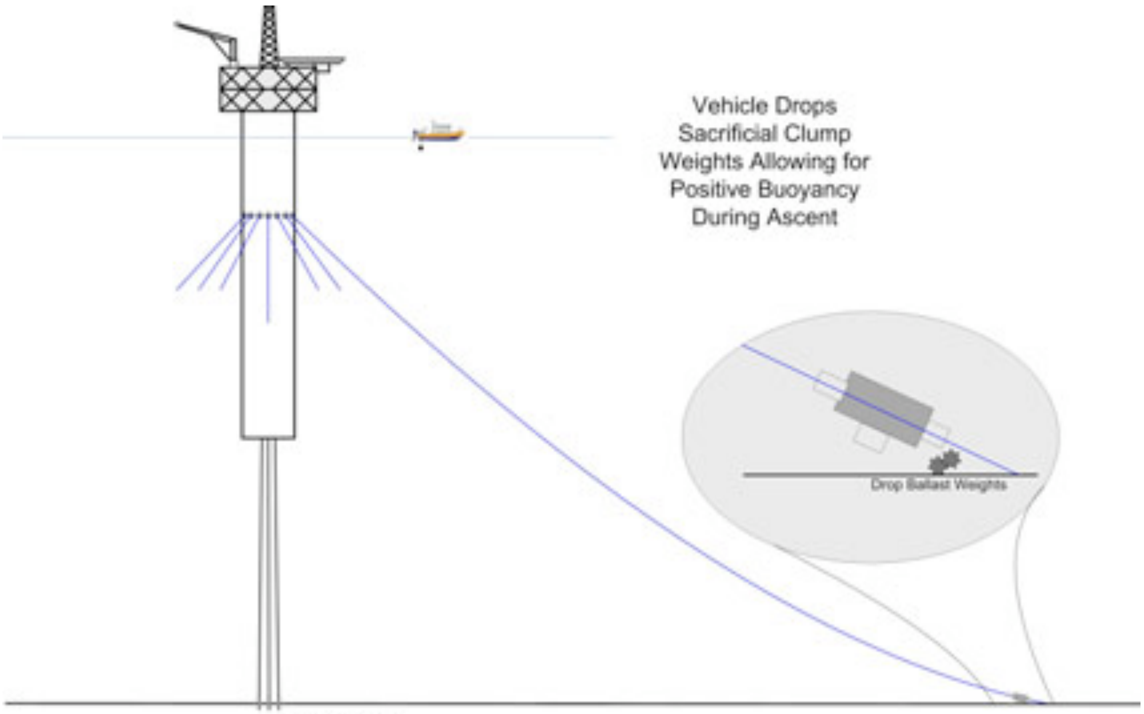

Figure 11

Once the vehicle's clutch is engaged and the clump weight is shed, the drive motor begins the vehicle's locomotion towards the surface at a fixed rate allowing for even video and sensor coverage of the mooring/riser (Figure 12). The vehicle's progress is acoustically tracked during inspection to note any discrepancies in movement as well as locating the vehicle should it become snagged.

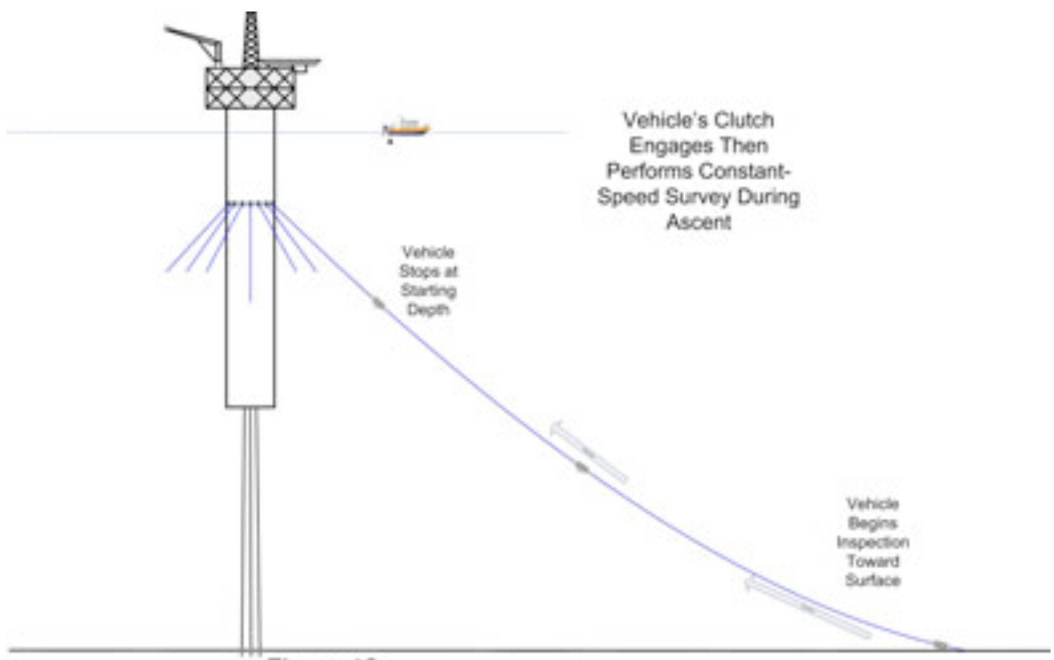

Figure 12

Once the vehicle senses its start depth, the drive motor will stop thus allowing the vehicle to be retrieved with the ROV (Figure 13) for vehicle maintenance and data retrieval.

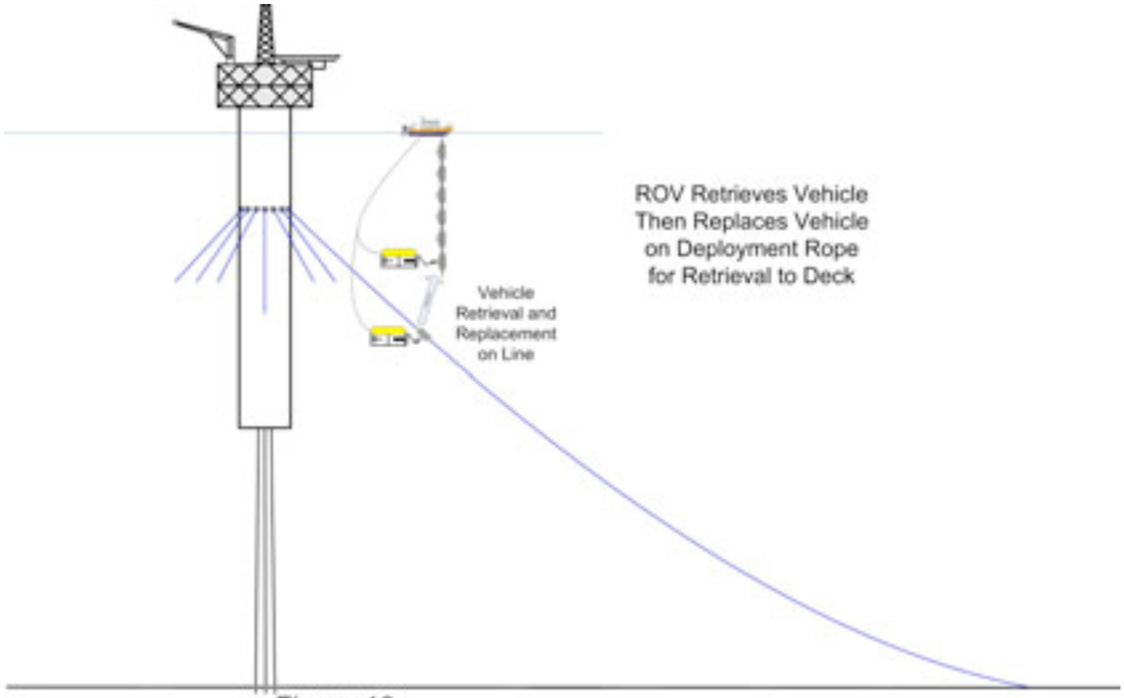

Figure 13

I claim:

- The process of a mechanical means of crawling a mooring and/or riser of a floating platform by use of a semi-autonomous vehicle commanded from a remote platform either acoustically or via tether to the surface.
- The mechanism for crawling moorings and/or risers of subsea structures via a direct physical attachment to the object with locomotion via a wheel or tracked guide.
- A method of inspecting moorings and/or risers via a ring-mounted camera array whereby high-resolution imaging can be achieved and high-accuracy diameter measurements can be taken.
- A method of buoyancy control whereby sacrificial ballast weights are dropped with use of a crawling vehicle along a mooring/riser of a subsea structure.
- A means of mechanically propelling the vehicle along the mooring and/or riser through its entire length with:
- An adjustable latching mechanism so as to allow for varying diameters of structures
- A spring-loaded clasp for attaching/detaching to/from the structure
- A ring of cameras and sensors that allow close, detailed inspection of the circumference of the member, characterizes its structure/integrity and allows measurement of its diameter
- A means of high-density digital capture of sensor data aboard the crawler vehicle
- A means of acoustically communicating with and tracking the crawler vehicle
- A means of positively uncoupling the vehicle should power or communications with the vehicle be lost
- A means of attaching/detaching the vehicle to/from the structure with a remotely operated vehicle using manipulators and/or a purpose-built docking mechanism
- A 3-axis gyro, magnetometer, accelerometer for sensing crawler vehicle orientation
- A pressure-sensing depth gauge for determination of crawler vehicle depth below the surface of the water

- An Acoustic Positioning System with modem for vehicle location and remote communication
- A Distance Encoder for measuring distance traveled along surface of structure
- A “Bump” sensor for direction change at bottom and shock absorption
- Batteries for power the locomotion, manipulation, telemetry and control of the crawler vehicle
- A Strobe light (for visual recovery at surface or subsea)
- An Internal Video and Data Capture (Compact Flash or other high density media)
- A Sacrificial deployment weight (concrete or other environmentally-friendly substance) for buoyancy control
- An Activated remote release as well as manual manipulator release for dual means of detachment from the wire
- An OD (Outer Diameter) measurement capability through video pixel counting
- Syntactic foam buoyancy (for overall positive buoyancy)
- Easy access to the video and data capture card
- Battery packs to be charged in housing with housing easily detachable from vehicle