SurfROVer: An ROV for Littoral Zone Survey Work

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***Abstract*—Powered umbilical ROVs have steadily increased in capabilities and utilization for applications in deep water where they can be readily "flown" to perform inspections and survey projects. But the littoral zone, where surf conditions, insufficient depth, and the hazards of shore proximity present special challenges, remains relatively unexplored.**

SurfROVer is a battery-operated crawler that is the latest in a line of special purpose ROVs designed by SeaView Systems (Dexter, Michigan, USA). SurfROVer is designed to be able to traverse from shore and into the surf zone targeting applications such as route surveys, Un-eXploded Ordnance (UXO) surveys, cable/pipeline tracking, as well as applications in otherwise impassible surf such as active surf bathymetry surveys.

Keywords—littoral zone, surf zone, survey, ROV, SurfROVer, UXO survey

I. Introduction

While many ROVs are powered via a high voltage umbilical, this approach has severe limitations for working in energetic surf conditions and is a source of potentially insurmountable electromagnetic interference that makes it impractical for some applications. By powering SurfROVer with battery bottles mounted near the axle height of the vehicle low on the frame, they contribute to the low overall center of mass for the vehicle and give the vehicle a very low electromagnetic noise floor that is very advantageous for survey work.

This paper will review the design considerations and resulting features as implemented in SurfROVer. Practical lessons learned from field testing, consideration for design revisions, as well as extended capabilities will also be presented. Finally, application possibilities for the vehicle will be explored.

II. Design Considerations

Some key design considerations that drove the vehicle design of SurfROVer included:

- Low and wide profile for maximum stability
- Low center of gravity with high mass for operation in energetic surf
- Four wide track drivers for good traction with low psi footprint
- High powered drive motor system for versatile payload or towing capacity
- Robust mechanical systems capable of withstanding the rigors of high surf
- High maneuverability
- Ease of deployment
- High bandwidth communications for live data feed from sensor payload
- Use of as many off-the-shelf components as practical to maintain low cost

In order to address these requirements, SurfROVer was designed around a hydraulic drive powered by a pair of off-the-shelf brushless DC electric motors. These can be readily controlled via the onboard electronics that are enclosed in a pressure compensated junction box designed by SeaView, which is similar to junction boxes developed for various other ROV projects.

The battery packs, comprised of individual lithium ion cells ganged into battery banks, were mounted into a circular configuration which could be reasonably efficiently fitted into the pressure cylinders mounted on the deck of the vehicle. A custom battery management system was designed to enable efficient charging of the batteries with minimal need for service to individual banks within the battery pack.

Depending on the application and deployment conditions, SurfROVer can be fitted with a GPS mast that enables precise geo-location via connection with a known-location base station that can be set up as part of the deployment process. Cameras mounted on the vehicle body or the mast enable an operator to have a real-time view from the vehicle which enables the vehicle to be operated from a control center that might be positioned remotely from the actual vehicle operation.

Fig. 1. SurfROVer's wide footprint and low center of mass ensure stability while the four-track caterpillar drivers enable good pulling strength.

Some figures of merit for SurfROVer are listed in TABLE I.

TABLE I. SEAVIEW SYSTEMS' SURFROVER SPECIFICATIONS

GENERAL	
Max Operating Depth	300msw
Dimensions (L x W x H)	2.6m x 2.0m x 0.8m
Weight (in air)	680+kg, depending on configuration
Ground Pressure	0.52 PSI/ 3.5 Kilopascals
Pull Force	500kgf
Battery Life	8-12hrs
Battery recharge time	8hrs
Speed (submerged)	~1.5m/s
Propulsion	Electro/hydraulic
Turning Radius	On-the-spot (without tow array)
OPERATING CONDITIONS	
Current Conditions	3 knot current regardless of incident angle
Bottom Type Environments	Range of soil types (sands, muds) up to 80kPa
Wave Action / Sea States	Up to 2 m plunging waves; Sea State 3
Traverse Capability/ Obstructions	Traverse capability for obstructions 0-20 cm above flat seafloor; barriers, troughs, macro-ripples, shell reefs; etc.
PAYLOAD CAPABILITY	
Payload Allocation	150kg+
Payload Volume/Hotel Space	~100 l
Payload Power	AC/DC voltages available
Platform Data	PTZ camera, 2xSD cameras, direction, velocity, roll/pitch/yaw, pressure depth, health status
Positioning	Desired RTK-DGPS; augment with IMU and USBL (tbd)
Payload Data Interface	10/100 Ethernet, RS232, RS485, TTL. Analog I/P. Digital I/O, Quadrature Encoder. Gbit Ethernet (optional)
TOPSIDE INTERFACE	
PC Interface	Windows control/display
Data Interface	Ethernet via tethered modem (e.g., FO-Ethernet modem)

SurfROVer was designed to be transported within a standard enclosed automotive trailer with enough additional cargo space to accommodate the ancillary electronics and control center setup including various power supplies, computers, and displays.

Fig. 2. The control trailer for SurfROVer enables full remote operation.

SurfROVer is also configured in such a way that it can be controlled with a standard video game controller without any of the additional electronics by attaching a control stub to the vehicle's interface port.

This makes deployment of SurfROVer possible from locations that are inaccessible by the control trailer. As long as the relatively robust and capable track system of SurfROVer is able to traverse the terrain to approach the deployment site, SurfROVer can be driven independently of the control trailer by a technician walking along with SurfROVer. This enables deployment in a variety of conditions that would be inaccessible if the control trailer needed to be positioned at the deployment site and facilitates easy deployment for many conditions.

III. FIELD TRIALS

Field trials of SurfROVer were conducted at a Great Lakes location and at the Army Corps of Engineers Field Research Facility at Duck, North Carolina.

For these trials, SurfROVer as fitted with a fiber-only umbilical interfaced via SeaView's SVS-109 fiber optic multiplexer that provided real-time control, communications and monitoring of the various cameras and sensors on the vehicle.

A mast mounted GPS system enabled precise geo-location of the vehicle at any time. The vehicle was fitted with pitch, roll, and yaw sensors as well as forward and reverse facing cameras all of which were fed back to the control both for real-time monitoring and for use in command and control operations for the vehicle.

For these trials, SurfROVer was towing the EM sensor array from White River Technologies Inc. The vehicle and tow sled configuration are illustrated diagrammatically in Fig. 3.

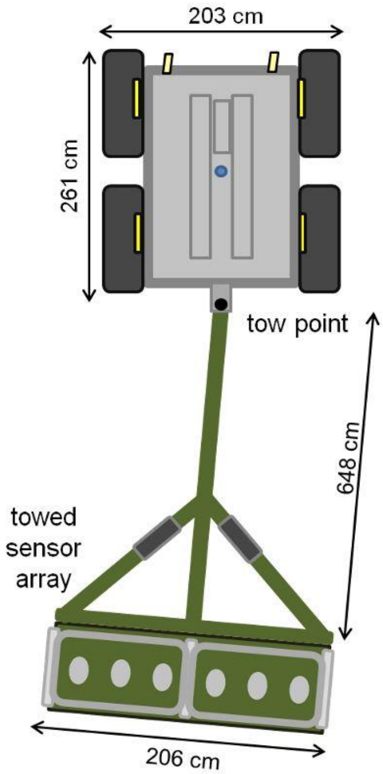

Fig. 3. Configuration of SurfROVer with towed EM sensor array. The blue dot at the center of the vehicle is the location of the GPS mast. An encoder at the tow point was used to monitor the angle of the sensor array relative to the vehicle orientation.

Fig. 4. SurfROVer operating in the littoral zone

During field trials, track logs were stored showing the track of the vehicle as well as pitch and roll in surf conditions. For purposes of this testing, the vehicle was operated in passes parallel to the beach and thus subject to wave impacts on the side of the vehicle and towed sensor array. This was deemed to be the worst-case scenario and thus the best test of vehicle stability. Fig. 5 shows the pitch, roll, and yaw record for the vehicle and sensor array. In practice, the sensor array tended to be swept by passing waves which can be seen in the sizable variations in Sled Yaw angle in the figure.

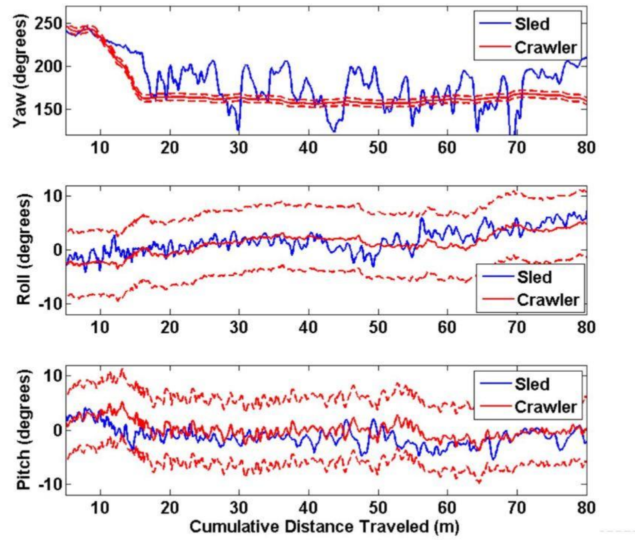

Fig. 5. Yaw, roll, and pitch angles for SurfROVer and the towed sensor array.

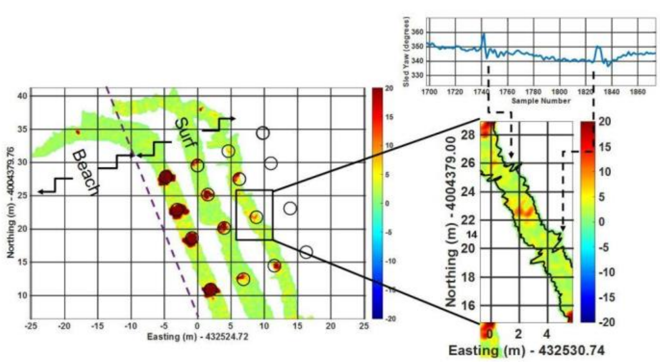

Fig. 6. EM sensor output for a series of passes being towed by SurfROVer. The insets show detail of the indicated track along with sensor output when crossing over a test target that was implanted in the surf zone.

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IV. DESIGN REVISIONS

Among the design features that were reconsidered in light of the field trial results were:

- Optional RF vehicle control depending on application. The fiber umbilical was determined to represent a potential source for mechanical failure that could be avoided for many applications and replaced by RF control. This is expected to be more reliable and less labor intensive by eliminating the line handling and surf exposure of the fiber umbilical.
- System power control enhancements: The power demands of the drive motors were such that they could potentially overdrive the conservative power limits built as a safeguard in the system. To overcome this issue, the system is being fitted with a power reset
- The EM noise environment, while good, was not ideal. In order to address this, modifications are underway to improve the isolation of the sensor array electronics
- The improved isolation of the EM sensor array is expected to allow for good sensor performance even with the sensor located closer to SurfROVer. This is expected to make a shorter tow bar and thus smaller profile for wave impacts and consequent improved stability to the combined SurfROVer-array system.

In conclusion, SurfROVer has been found to be a useful tool for surf zone survey work that would be otherwise difficult or impossible to access. In addition to opening the possibility for a range of surf zone surveys including UXO, bathymetry, and real-time storm dynamics, extensions to SurfROVer are expected to enable full autonomous operation for some missions.

Acknowledgment

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References

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