Bureau of Safety and Environmental Enforcement
Oil Spill Preparedness Division
Remotely Operated Surface Vessel for Oil Spill Response

Final Report

May 2025

(Photo: OSRI, 2023)

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US Department of the Interior
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ABOUT THE COVER

Cover image by Pegau, OSRI. The in situ burn capabilities of the vehicle are tested at the Poker Flat Research Range.

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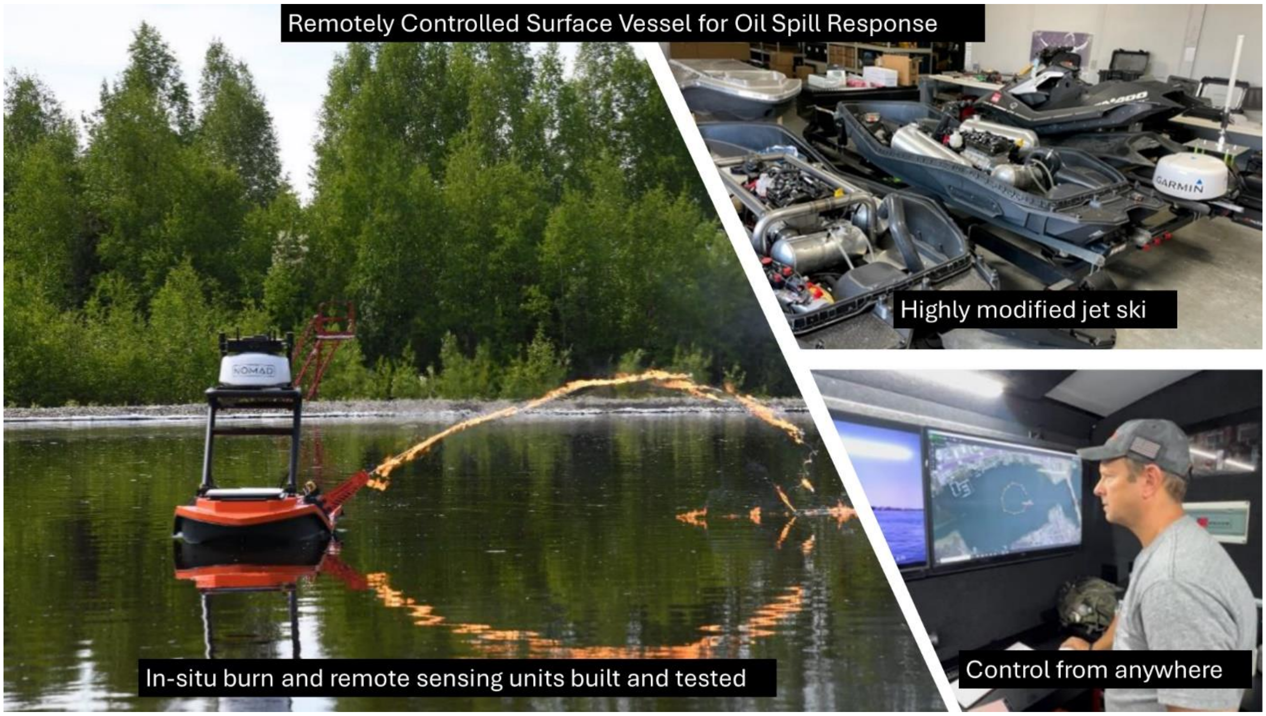
We would like to acknowledge the organizations that formed a Joint Industry Program to fund the development of this vehicle. Additional contributions and guidance on the project were received from the Oil Spill Recovery Institute, BSEE, ExxonMobil, North Caspian Operating Company, Shell, and Clean Caribbean & Americas.

GRAPHICAL ABSTRACT



EXECUTIVE SUMMARY

Spills may occur long distances from spill response equipment and personnel creating a need for a rapid response capability. It may also be risky to send personnel into the spill zone because of weather, sea conditions, or toxic fumes. The combination of these factors makes it desirable to develop new technologies that can be rapidly deployed, reach a distant spill, and reduce the risk to personnel. Small remotely operated or autonomous vehicles provide an opportunity to address the need for rapid response equipment while minimizing risk to personnel. In this Joint Industry Project (JIP) a remotely operated surface vessel for oil spill response was developed. The vessel has the capability to apply herders and ignite oil slicks in situ to provide response capabilities, and remote sensing capabilities that can reduce the need to send personnel into risky environments.

The development of this technology was overseen by a JIP. This JIP brought together a team of oil and gas industry, spill removal organization, government agency, and non-profit research and development partners to support the funding and provide design input into the creation of a means to provide a single platform for deploying herders and igniting oil slicks for in-situ burns. The partners included the Oil Spill Recovery Institute, BSEE, ExxonMobil, North Caspian Operating Company, Shell, and Clean Caribbean & Americas. The JIP partners agreed on the design concept, the selection of the build contractor, and provided input on the design as necessary. BSEE supported additional work to enhance the remote sensing capabilities of the vehicle.

Two prototype vehicles were developed. One focused on the in situ burn capabilities and the other with enhanced remote sensing. In addition to the in situ burn capabilities, the first vehicle carries a tethered drone with visible and infrared cameras along with vehicle mounted cameras, sonar, and radar that provide additional remote sensing capabilities. The second vehicle replaces the in situ burn capabilities with additional vehicle fuel to expand the range and the ability to mount and place sensors above and below the waterline. It has an integrated volatile organic carbon and other atmospheric gas sensors for site characterization. Multispectral cameras, combined with the infrared camera, provide additional abilities to estimate oil thickness. The intention is to develop “plug and play” packages such as the in situ burn and remote sensing packages onto a single vehicle platform, as needed.

Both prototypes are built around a heavily modified jet ski using a modular design that allows for rapid part replacement to simplify field repairs. The choice of a jet ski body provided a proven, durable hull and high efficiency engine. Based on vehicle specifications and testing during development it is expected that the vehicle can travel at speeds up to 50 knots for 4 to 8 hours depending on the fuel configuration. If not running at speed, it can loiter in an area for multiple days. The goal is to enable the vehicle to be launched from shore, vessel, or helicopter. It is small enough to fit into small cargo aircraft. This allows it to be rapidly transported and deployed in remote locations. It can then travel to a spill and provide in situ burn or remote sensing capabilities. The vehicle can move with the spill and provide continuous observations around the clock. The vehicles can be operated three ways: 1) locally using a small controller or laptop computer, 2) at greater distances using a cellular modem, or 3) from anywhere in the world using

satellite communications. The shipping trailer can be converted into a command trailer with multiple monitors and all vehicle communication equipment built into the trailer.

The herder-igniter package and jet ski were tested at the Poker Flat Research Range near Fairbanks, Alaska. The vehicle successfully deployed herders and ignited five burns over a four days of testing. The vehicle also demonstrated its ability to operate in shallow water as the test facility had a water depth of less than three feet. Further testing occurred off Galveston, Texas, where the long-distance control systems were tested along with the operational characteristics in open waters.

The result is a small, flexible vehicle that can be rapidly transported and deployed to a spill. Once on station an operator can commence in situ burn operations or conduct remote sensing for site characterization and spill monitoring.

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1 Introduction

Spills may occur in remote locations creating a need for a rapid response capability until full response operations can commence. It may also be risky to send personnel into the spill zone because of weather, sea conditions, or toxic fumes. The combination of these factors makes it desirable to develop technologies that can rapidly deploy and reduce the risk to personnel. Small remotely operated or autonomous vehicles provide an opportunity to address the need for rapid response equipment while minimizing risk to personnel.

An earlier Arctic Response Technology Joint Industry Program (ART JIP) investigated many aspects of spill response as applied to the Arctic environment. One of the tests in the ART JIP was to examine the use of chemical herders for in situ burns (Potter et al. 2016). In testing it became obvious that there was a need for new technology developed that combined the herder application with the ignition source to allow rapid response to offshore oil spills. This finding was the genesis of this Joint Industry Program (JIP) focused on combining the application of the herder and ignitor in a single platform that could be rapidly deployed to spills in remote locations.

This new effort began with a study sponsored by the Oil Spill Recovery Institute (OSRI) that examined the potential approaches to rapidly deploy systems that would combine the herders and ignitors needed for in situ burns. Two potential approaches were identified: (1) develop an ignitor that could be operated from a helicopter using an existing herder deployment system; and (2) develop a remotely operated surface vessel. Upon the completion of that study, this JIP was formed with OSRI as the administrative lead with contributions from the Bureau of Safety and Environmental Enforcement (BSEE), North Caspian Operating Company, ExxonMobil, Shell, and Clean Caribbean & Americas. Based on an initial analysis of options that was commissioned by OSRI, the JIP selected to build a remotely operated surface vessel (ROSV) for oil spill response. The concept was incorporated into a request for proposals and Tactical Electronics (TE) was selected to design and build the vessel.

During the ROSV development, it became apparent that the vehicle had potential to address other spill response needs, such as remote sensing. BSEE then expanded the scope of their work in the JIP to include the development of a ROSV that was designed to be a remote sensing platform.

To meet the needs of the program, the ROSV needed to be easily deployed in remote locations with limited logistics; have systems that were easy to work on in the field; be able to be remotely controlled at a variety of distances; and have the sensors necessary to safely operate the vehicle to allow careful applications of herders and ignite oil slicks. The vehicle needed to be small and light enough to transport in small cargo aircraft or carried on smaller response vessels and able to launch from land, boat, or helicopter to rapidly be deployed to remote locations. Building upon a proven and durable vessel design makes it easy to work on the system in the field due to its standard gas engine and modular design that allows parts to quickly be swapped. A vehicle controlled using a radio or satellite modems provides flexibility in vehicle operations. Several cameras, sonars, a radar, and a tethered quadcopter aerial vehicle provide the user with the inputs needed to safely operate the ROSV and conduct in situ burns efficiently.

2 ROSV Development

The ROSV is built upon a commercial jet ski body. The jet ski was selected because of its proven durable hull and simple-to-maintain, efficient propulsion system. The jet ski was then heavily modified to support remote operations. A modular design was used to allow simple replacement of components when troubleshooting.

2.1 Base Vehicle

The in situ burn and remote sensing prototypes both begin with the same base vehicle. The steering was removed to allow integration of the remote-control systems. The top cover and seating were replaced with a cover designed to allow access to systems and provide a mounting point for equipment to be carried by the ROSV. The engine was wrapped in a cage that provided the strength to allow the vehicle to be lifted by a helicopter or boat (Figure 1). An alternator was added to supply the electricity needed to operate the tethered observation platform (TOP) and other electronics. A pair of batteries were installed to provide additional power if needed (Figure 2). Communication systems include wireless mesh network radio interface, long-range coded orthogonal frequency-division multiplexing radio, cellular modem, and Starlink satellite modem. Navigational gear includes a complete Garmin navigation package with two sonar sensors (depth sounder, scanning sonar), chart plotter with auto pilot, and radar antenna (Figure 3). The radar dome is installed on a retractable mast that can be lowered for shipping or raised to gain greater range. There is a 360° camera mounted below the radar, forward looking camera, underwater cameras, and visible and infrared cameras on the TOP. The rear deck has been expanded to provide additional buoyancy and space for the tethered observation platform (Figure 3).

A cargo trailer was modified to serve as a shipping container and command center (Figure 4). The modifications include providing climate control, installing antennas to connect with the ROSV, adding several monitors for viewing information from the vehicle, providing a table and seating, and adding storage areas for tools and spare parts. The trailer can easily accommodate up to four people as a workspace.

Fig. 1 Vehicles in various state of completion
The bottom left vehicle has a lifting cage mounted around the engine. On the top left is a hull with the new top installed. Bottom right is a unit prior to the cage installation and the original vehicle top is behind it. (Photo: Tactical Electronic, 2022)

Fig. 2 Forward internals
The forward section includes all of the electronic controls, electrical fuses and switches, and batteries on either side of an eight-gallon fuel tank. (Photo: OSRI, 2023.)

Fig. 3 Top view
The white plate on the bow is the antenna for the Starlink satellite communications. The radar dome is in the raised position showing the radar antenna and other communication antennas mounted on it. On the stern is the platform for the TOP. (Photo: Tactical Electronics, 2023.)

Fig. 4 Shipping and command trailer
The cargo trailer set up as a command and control center. The table folds up and chairs are removed to convert to a storage trailer. (Photo: OSRI, 2023.)

The general characteristics of the vehicle are provided in Table 1. These include that the vehicle is 0.9 m tall, 1.2 m wide, and 3 m long. It weighs 200 kg dry and 400 kg fully loaded. It has a polytech hull that is used because of its strength and resilience. The top is a coated aluminum cover with watertight access ports. It has a 90 horse-power vortex engine with a jet drive. The vehicle can run at a top speed of 25 m/s. At top speed the vehicle is expected to use 9 liters per hour. At idle it burns approximately 1 liter per hour. The amount of fuel storage depends on the configuration (30-110 liters). The vehicle has a 0.3 m draft allowing it to operate in shallow waters and rivers.

Table 1 Vehicle Characteristics

Dimensions	H 0.9 m x W 1.2 m X 3 m
Dry Weight	200 kg
Loaded Weight	400 kg
Hull	Polytec 2.0
Deck	Aluminum with Cerakote finish
Draft	0.3 m
Engine	90 HP Rotax 900 ACE 4-Stroke
Top Speed	25 m/s
Fuel	30-110 L Gasoline
Fuel Use	9 LPH at top speed
Electrical	2 – 100 Ah Lithium Batteries
Communications	Starlink Satellite, Multi-Cell Modem, WiFi, Long-range UHF
Auxiliary Inputs	USB, RS232, RS485, Ethernet LAN
Cameras	Above and Subsurface, 360° Deck, Multispectral
Radar	Garmin – 0.2 m Radome, Chart Plotter with Autopilot
Sonar	Garmin – up to 60 m depth
Range	Up to 800 Km depending on configuration and speed
Loiter	Up to 7 days

The tethered observation platform is a water-proofed quadcopter tethered to the vehicle (Figure 5). The tether provides power and data transmission and is spooled in and out by a winch in the vehicle. The maximum altitude is 30 m. The TOP is carried on a deck that folds out from the stern of the ROSV. It is designed to be launched and retrieved from the water surface. Once aloft, it is programmed to follow the vehicle. Because it receives its power from the vehicle, it can stay aloft as long as the engine is able to keep the batteries charged but is designed to land if power is lost. It is unable to stay aloft without the power from the vehicle.

Fig. 5 Tethered Observation Platform
The tethered observation platform includes a waterproofed quadcopter that is powered through a tether to the vehicle. A winch on the vehicle allows the tether to be extended or retracted. (Photo: Tactical Electronics ,2023.)

2.2 Software

To enable the vehicle to be operated remotely, a software package had to be developed to allow all functions to be operated from either a handheld controller or via communications with a computer. On the vehicle, data from the sensors are collected on a computer functioning as a centralized message queuing telemetry transport (MQTT) broker. It gathers information from the Garmin, autopilot, ethernet systems, cameras, and other sources and each source has a management system that translates its primary function into a common language used on the vehicle. Data are transferred to and from the vehicle through a virtual private network (VPN). Network routes are selectable between cellular, Starlink, and mesh radios.

A web-based dashboard provides a display to view and control the state of the vehicle (Figure 6). Data from various sensors is visible and the software allows for the control of various actuators and relays using graphical user interfaces. The dashboard has several pages that allow viewing information from the cameras, sonar, GPS, and radar systems and controlling all aspects of the vehicle and tethered observation platform. Control of the vehicle drive functions, such as steering and speed, run through the autopilot system on the vehicle. The software supports this function using remote control functions similar to those found on the handheld controller. Control is accomplished through a touch screen or a mouse.

Data from a user's sensor is viewed through the dashboard and the data is accessed off the control computer system.

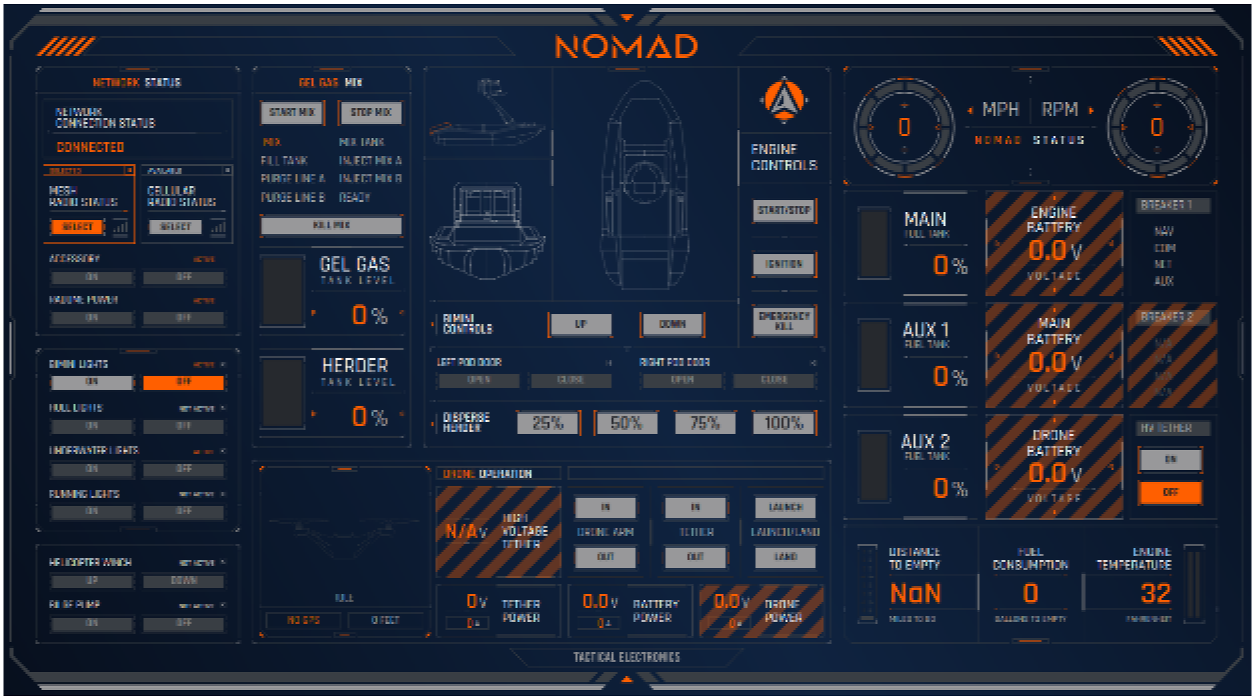

Fig. 6 Dashboard
The vehicle status and operation of many features is controlled through a web-based dashboard. (Photo: Tactical Electronics, 2023.)

The handheld controller (Figure 7) connects to the vehicle through a mesh radio link.

Fig. 7 Handheld controller
The handheld controller allows operation of the various functions of the vehicle. Data from the different systems on the vehicle can also be viewed on the screen. (Photo: Tactical Electronics, 2023.)

2.3 In situ Burn Vehicle

The design is based around the original requirement that the vehicle carry enough herder and ignitor to treat five areas before the vehicle needs service. The in situ burn vehicle adds pods on either side of the vehicle to deploy chemical herders and provide ignition using gelled gasoline. The vehicle has a 30-liter tank for gas to make gelled gasoline, another 30-liter tank for the gelled gasoline, and a third 30-liter tank for the herder. Pods on either side extend out and herders are pumped out through a nozzle. Having pods on both sides of the vehicle provides redundancy in the ignition system. The piping and nozzle for the gelled-gasoline ignition system also is fed through the same pod as the herder system (Figure 8). The prototype vehicle has an internal mixing system to combine the components necessary to create gelled gasoline. The mixture is then stored in another tank in the vehicle. Testing of the gelled gasoline mixture indicates that it is stable enough to mix before the vehicle is deployed. Using a premixed gelled gasoline would reduce the complexity and weight of the vehicle. It would also allow more gasoline to be carried for operating the vehicle and thus giving it greater range and operating time.

In operation, a pod door is opened and the nozzles are activated to dispense the herding agent and the gelled gasoline. The amount of the herding agent per linear meter is altered by the user to apply an optimal amount. The gelled gasoline is pumped out in a stream that lands on the water several feet away from the vehicle (Figure 9). The stream of gelled gasoline is ignited using a butane torch. The butane bottle is carried on top of the vehicle and is piped to the end of the gelled-gasoline nozzle. An electronic ignitor is used to ignite the butane, which in turn ignites the gelled gasoline. The gelled gasoline burns for several seconds allowing it to ignite an oil slick of appropriate thickness. Targeting the exact placement of the ignited gasoline is done using the TOP to provide an aerial view of the oil and vehicle, remotely steering the vehicle, and controlling the pump. A video from the aerial perspective of this operation can be viewed at https://youtu.be/a396EPpBJng.

Fig. 8 Herder and ignition port
The herder and ignitor port in the open position. The yellow arrow points to the herder nozzle. The large round nozzle with two smaller nozzles inside is for the gelled-gasoline ignition system. The tanks are inside the vehicle. The yellow bottle on top is for butane which is used to ignite the gelled gas. (Photo: OSRI,2023.)

Fig. 9 Ignition using gelled gasoline
Gelled gas is pumped out a pod on the side of the vehicle and ignited using a butane torch. The gelled gasoline then lands several feet from the vehicle. (Photo: OSRI,2023.)

2.4 Remote Sensing Vehicle

The remote sensing version of the vehicle also begins with the base design but adds additional sensor capabilities to enable it to deploy a wide range of sensors that may be of interest during spill response. A Honeywell AreaRAE gas detector is mounted in the stern of the vehicle (Figure 10) with an intake tube that runs up the retractable mast to minimize the possible collection of exhaust gasses. The sensor monitors the levels of volatile organic carbon, lower explosive limit, carbon monoxide, oxygen, and hydrogen sulfide. This suite of measurements covers the basic gasses monitored for site characterization to determine if the region is likely to be safe to work in or requires additional personal protective equipment.

Fig. 10 Gas detection system
An AreaRAE gas monitoring device mounted in the stern of the vehicle. It pumps air through a tube that goes up the radar dome mast. (Photo: Tactical Electronics,2023.)

To allow the vehicle to be a testbed for sensors under development, hydraulic arms are mounted on each side of the vehicle (Figure 11). These arms fold out and down allowing sensors to be placed up to 0.4 m below the waterline. Sensors can also be placed on the bimini frame to allow them to be elevated to 1.2 m in the air. The vehicle can provide 12 V DC power and has ethernet, USB, and WIFI communication capabilities for incorporating the data stream from the instruments. The arms fold the sensors along the side of the vehicle for transportation.

Fig. 11 Hydraulic arms for deploying instruments
The sampling arms with one in the down position and the other extended to the side. (Photo: Tactical Electronics,2023.)

The last modification is the addition of a multispectral camera to the TOP. It is desired to have the ability to determine the oil thickness and after reviewing results of testing (CRRC et al. 2023) and discussions with several people, the decision was to select an Altum-PT five-wavelength multispectral imaging camera with synchronized infrared (IR) camera (Figure 12). The system also provides a pan-chromatic video camera. The application of visible and IR measurements has been used for oil thickness measurements (Svejkovski et al. 2012, Garcia et al. 2019) and this approach was judged to be the most mature for estimating oil thickness. The project only dealt with integrating the camera on the vehicle and the TOP and providing access to the data. It did not provide an algorithm for converting the camera signal to oil thickness.

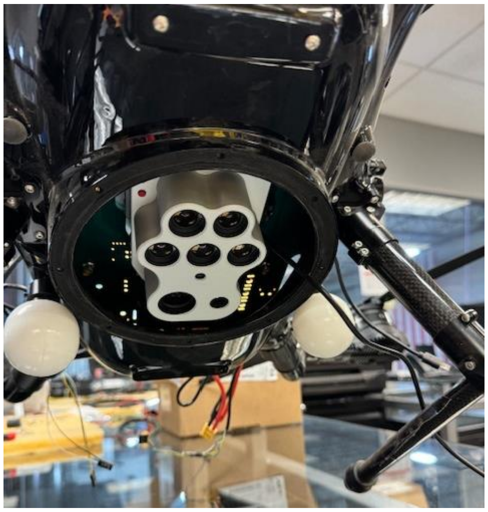

Fig. 12 Multispectral camera
The multispectral camera installed in the TOP quadcopter. (Photo: Tactical Electronics,2024.)

2.5 Operations

Detailed information on particular aspects of operation can be found in the operations manual that comes with the vehicle. This section only covers the high-level version of operations.

The basic operations are to:
1) Launch the vehicle in the water and shut the breakers for the electrical systems.
2) The emergency stop needs to be set to the operating position.
3) The handheld controller needs to be powered up and then wait for the vehicles video to display on the controller to show the vehicle and controller are connected.
4) At this point, the engine can be started and the vehicle can be operated.
The controller allows control of all of the vehicle functions.

Setup of the command trailer involves wheeling the vehicle out of the trailer and configuring the trailer for its command functions. This includes setting up the antennas and source of power, setting up the computer system, fold up the workbench and set up chairs. The vehicle can then be launched and started as described above. The trailer gives the opportunity to view multiple data streams from the vehicle. The vehicle can be operated using a controller and the keyboard. It can be programmed to follow a path autonomously by programming a path into the autopilot.

The operation of the vehicle can be shifted from the handheld controller and a remote location. This can be done by pushing the auto button on the handheld controller or at the remote site. The auto button is a toggle switch. Hitting it a second time switches operation back to the handheld controller.

A video of the setup and operations can be found at
https://www.youtube.com/watch?v=zze1l3Igdg4.

3 Testing

The components of the ROSV and the completed ROSV have undergone a series of tests to demonstrate that the vehicle can conduct the intended in situ burn and remote sensing operations.

3.1 Local testing

All the subsystems underwent a series of tests at Tactical Electronics' facility in Broken Arrow, Oklahoma and Keystone Lake just outside of Tulsa, Oklahoma. The vehicle was tested after each phase of development to ensure all systems operated as expected and modifications were made to reach the simplest and most reliable design. These tests were as simple as ensuring that the hydraulics would open the pod doors or move the sampling arms and as complex as ensuring that the kill button on the controller could rapidly stop the vehicle (Figure 13).

Fig. 13 Local testing
Local testing ran the gamut from ensuring the pod doors would open and the butane lighter operated, rolling the vehicle on its side to ensure no water entered and the vehicle would right itself, to running the vehicle at speed to ensure proper operation and that the kill switch would stop the vehicle. (Photo: Tactical Electronics,2022.)

3.2 Poker Flat Research Range

The in situ burn vehicle was brought to the University of Alaska, Poker Flat Research Range in June 2023 to test the ability to apply chemical herders and ignite crude oil on water. This testing was focused on the confirming the function of the vehicle as a whole and not designed as an in situ burn test or a test of the chemical herder, so the environmental factors that might be used to examine in situ burns was not documented.

The facility has a 100 m x 100 m freshwater test basin that provides a large enough area to be able to release a sample of oil, apply chemical herders, and ignite the resultant slick. A 5 m by 5 m frame was placed in the center of the basin and 37 liters of Alaska North Slope crude oil was poured into the frame and allowed to spread for 5-10 minutes. Once the oil had spread the vehicle would go around the frame applying the chemical herder (ThickSlick 6535) at an approximate rate of 3 ml/m of vehicle travel. Once that was completed the frame was lowered to release the oil and the slick was allowed to thicken as the herders acted on the oil. Once the oil had contracted the ROSV was used to ignite the slick (Figure 14). A typical burn used two liters of gelled gasoline and lasted one minute. Once a burn was completed, the residue was collected using a boom and removed using absorbent pads.

The tests were designed to demonstrate that all of the vehicle systems could operate properly. The purpose of the tests was to ensure that the vehicle was able to apply the correct amount of herder to get the slick to contract and that it could be controlled well enough to ignite a small slick. They were not designed to provide detailed information on vehicle operations, the efficiency of in situ burns, or the herder capabilities.

Over four days there were five burns conducted. There was little wind, so it was possible to conduct the burns without concern that the slick would reach the side of the test basin. Because of the high fire danger in the surrounding area, extreme caution was necessary. Because of the time needed to clean the basin, two tests were the maximum that could be achieved in a day. A visitor's day occurred on day four. People were invited to attend either in person or virtually. The basic vehicle operations were described, a burn conducted, and then the top removed from the vehicle to allow a walk-through of the various vehicle components. Approximately twenty people attended in person and over one hundred attended virtually. A recording of the session can be viewed at https://www.youtube.com/watch?v=fla-7WMh04U. The comments of attendees were complementary and positive. Discussions with the observers also pointed out that there may be more applications for the remote sensing vehicle and the importance of thinking of that version's capabilities.

There were two notable issues during this test. During test 2 the ignition mechanism failed, and the unburned oil that had been herded had to be cleaned (Figure 15). Trouble shooting identified the failure as a broken component on a circuit board. That board was replaced, and two successful tests were conducted on day three. The testing procedure was changes so that the ignition system was tested before pouring crude oil. The other issue was getting the TOP to fly at the proper altitude. This appeared to be an issue with the GPS altitude signal. Because of the issue with the TOP and a desire for a larger payload for the remote sensing vehicle, the decision was made to rebuild the TOP system to address those two issues. For the tests at Poker Flats, an untethered drone was flown to provide the aerial imagery necessary to properly navigate the vehicle and conduct the burns.

These tests also allowed us to test some of the design issues that needed to be addressed early on. Most notably, the original design mixed the gelled gasoline on board, which requires a fair number of parts. There is an “A” and “B” chemical that is mixed into the gasoline sequentially at specific amounts and times. This produced the gelling consistency needed for applications. This required two small tanks for each chemical with two separate pumps and regulators. Since the gelled gasoline is stable for a few days, it is possible to mix the gelled gasoline before deploying the vehicle. Premixing the gelled gasoline simplified the system, decreased vehicle weight, and allowed for more fuel for the engine to be carried.

Fig. 14 Overhead view of oil in the test frame

Clockwise from the top left. The view from a drone showing the oil spread within the test frame and the vehicle applying chemical herder. The contracted slick. Applying gelled gasoline. Note that the frame is 5 m on a side, which provides a scale for the distance the gelled gasoline was applied. (Photo: Tactical Electronics,2023.)

Fig. 15 Cleaning oil from the test basin
At the end of each burn the test basin a boom was used to collect any residual oil. That oil was then collected using absorb pads and bagged for disposal. (Photo: OSRI,2023.)

3.3 Galveston Bay

In August 2023 the ROSV was taken to Galveston Bay to run through a series of exercises designed to test the various control mechanisms. This included local control using the handheld controller, control from the shipping and command trailer via cellular data, and from the development center in Oklahoma via satellite (Figure 16). The ROSV was also programmed to follow a preset path using the autopilot function in the GPS software.

The ROSV was launched from shore and followed in a chase boat to approximately two miles offshore using the handheld controller.

The shipping and command trailer was set up in the parking lot near the launch site. It took approximately 15 minutes to unload the trailer and set it up as a command center. The air conditioning was able to maintain a comfortable temperature despite the air temperature being over 100 degrees and up to ten people in the trailer.

Once on station, a cellular communication link was established between the trailer and ROSV. The connection was found to be stable and consistent over the two hours of testing using this system. It was possible to send all the live video feeds and data over the connection without any disconnects. The control of the vehicle was then shifted from cellular to satellite communications from the command trailer. Performance was initially very good but during a set of tests it was found that the video feed began to stutter. Control and data streams remained uninterrupted. Testing showed that the issue was the low placement of the satellite receiver allowing it to be blocked by the radar system. The plan is to move the satellite receiver to the top of the radar mast to prevent further shadowing by the radar system.

During this time, the autopilot was programmed to have the vehicle run specified tracks to determine the ability of the system to run to a location automatically. Several different maneuvers were programmed into the autopilot to test the ability to follow a track and confirm proper steering. The autopilot was programmed using both cellular and satellite communications with no problems observed with either approach.

Control of the vehicle was then shifted to the Tactical Electronics' facility in Oklahoma. As expected, the satellite control was not dependent on the location of the command facility and no issues were observed when controlling the ROSV from a long distance.

Fig. 16 Galveston Bay tests
Clockwise from the top left. The vehicle in Galveston Bay, controlling the vehicle with the handheld controller, the view from the forward-looking camera on the vehicle, controlling the vehicle from the command trailer, and the path followed by the vehicle over a track programmed into the autopilot. (Photo: Tactical Electronics,2023.)

4 Outreach

One goal of the JIP was to ensure feedback on the design was received throughout the development process. Various members of the JIP gave presentations at oil spill related conferences (Table 2). Information on the ROSV was also provided in general presentations to other interested audiences.

Table 2 Presentations on the ROSV

Year	Conference
2021	Oil Spill Response Technology Workshop
2021	Alaska Forum on the Environment
2022	Norwegian Oil Spill Preparedness and Response Webinar
2022	International Oil Spill Science Conference
2023	Clean Gulf
2024	International Oil Spill Conference

Oil spill removal organizations were consulted throughout the testing. Alaska Chadux and Oil Spill Response Limited had personnel attending throughout the Poker Flats testing. During the Poker Flats testing a visitors' day was held in which over 20 people attended in person and over 100 virtually. Personnel with Marine Spill Response Corporation supported the testing in Galveston Bay. The vehicle was available to view during the Clean Gulf meeting and the International Oil Spill Conference.

A video of the Poker Flats visitors' day presentation is available at
https://youtu.be/Px7RorCO768?si=7GbL0D4MZAlU7391

A shorter presentation with highlights of the build and testing can be seen at
NOMAD: OSRC Stage 2 - YouTube

A manuscript on the development and testing of the ROSV is available from the 2024 International Oil Spill Conference.

5 Conclusions

Through the combined efforts of industry, government, and non-governmental organizations we have developed two prototype remotely operated surface vessels for oil spill response. These ROSV are small enough to be carried to remote locations. They are fast enough that they can rapidly reach a spill. They can provide in situ burn and remote sensing capabilities. They also loiter in an area allowing active tracking of a spill. The remote sensing capabilities are designed to identify areas with the thickest oil and ensure the area is safe for responders to enter.

6 Recommendations

Further testing of the vehicle is recommended. The vehicle operation should be tested over a wider range of sea states or other potential operating environments, such as rivers. While it is unlikely to be able to test the deployment of herders and ignition, the full remote sensing vehicle operations can be tested. The vehicle deployment and recovery from a vessel needs to be demonstrated. The vehicle should be tested to determine its range and how long it can remain operating before needing service. The remote sensing version of the vehicle should be tested to ensure all of the specialized components (gas sensor, deployment arms, multispectral sensor) on the vehicle function as intended. It would be best to test the vehicle in an area with oil, such as around an oil seep, to enable testing in a realistic manner.

Premixed gelled gasoline should be used instead of incorporating a system to mix gelled gasoline on board. This will greatly simplify the in-situ burn system and provide extra space for additional engine gasoline or sensors.

Continue to look at new designs of the tethered observation platform that could either increase its payload, increase the altitude it can operate at, or decrease its size. The TOP would also benefit from the reduction in size/weight of sensors to be carried.

A larger vehicle with more payload and larger engine is now available and should be considered as an upgrade to the base platform. The larger vehicle provides space for additional fuel, greater buoyancy, and space for mounting additional systems in the future. One potential addition is a winch system that can deploy instruments down several meters.

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8 Abbreviations and Acronyms

ART JIP	Arctic Response Technology Joint Industry Program
BSEE	Bureau of Safety and Environmental Enforcement
GPS	Global Positioning System
IR	Infrared
JIP	Joint Industry Program
ROSV	Remotely Operated Surface Vessel
OSRI	Oil Spill Recovery Institute
TE	Tactical Electronics
TOP	Tethered Observation Platform

Appendixes

Appendix A: Technical Summary

REPORT TITLE: Remotely Operated Surface Vessel for Oil Spill Response Volume Number: Subtitle

CONTRACT NUMBER(S): 140E0119P0019

FISCAL YEARS(S) OF PROJECT FUNDING: 19-24

CUMULATIVE PROJECT COST: 508569.13

COMPLETION DATE OF REPORT: 23 September 2024

BSEE COR(S): Karen Stone, Jay Cho

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KEY WORDS: Remotely Operated Surface Vessel, Surveillance, In situ Burn

* The affiliation of the Principal Investigators(s) may be different than that listed for Project Manager(s).

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Department of the Interior (DOI)
The Department of the Interior protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors the Nation's trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities.

Bureau of Safety and Environmental Enforcement (BSEE)
The mission of the Bureau of Safety and Environmental Enforcement works to promote safety, protect the environment, and conserve resources offshore through vigorous regulatory oversight and enforcement.

BSEE Oil Spill Preparedness Program
BSEE administers a robust Oil Spill Preparedness Program through its Oil Spill Preparedness Division (OSPD) to ensure owners and operators of offshore facilities are ready to mitigate and respond to substantial threats of actual oil spills that may result from their activities. The Program draws its mandate and purpose from the Federal Water Pollution Control Act of October 18, 1972, as amended, and the Oil Pollution Act of 1990 (October 18, 1991). It is framed by the regulations in 30 CFR Part 254 – *Oil Spill Response Requirements for Facilities Located Seaward of the Coastline*, and 40 CFR Part 300 – *National Oil and Hazardous Substances Pollution Contingency Plan*. Acknowledging these authorities and their associated responsibilities, BSEE established the program with three primary and interdependent roles:

- Preparedness Verification,
- Oil Spill Response Research, and
- Management of Ohmsett - the National Oil Spill Response Research and Renewable Energy Test Facility.

The research conducted for this Program aims to improve oil spill response and preparedness by advancing the state of the science and the technologies needed for these emergencies. The research supports the Bureau's needs while ensuring the highest level of scientific integrity by adhering to BSEE's peer review protocols. The proposal, selection, research, review, collaboration, production, and dissemination of OSPD's technical reports and studies follows the appropriate requirements and guidance such as the Federal Acquisition Regulation and the Department of Interior's policies on scientific and scholarly conduct.