Summary Report

Aerostat-IC system extreme weather tests and demonstration at the USCG Oil-in-Ice III Exercise 2013.

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ABSTRACT

Inland-Gulf Maritime, LLC participated in the USCG Oil-in-Ice III Exercise during the week of February 18th, 2013 held at St. Ignace, Michigan by deploying and testing the Aerostat-IC aerial surveillance system which provided live imagery to various vessels taking part in the exercise at the Straits of Mackinac as well as to the station located at the St. Ignace "Little Bear" Arena(ICP).

During the exercise IGM was able to test the Aerostat-IC system operation in extreme weather conditions and learned a great deal about operating in high gusty winds and in an extreme cold weather environment. The extent to which mechanical and thermal wind currents affect the launch and retrieval of the aerostat confirmed that the launch and retrieval "set-up" are a key element for a successful operation. The "lessons learned" point toward having a dedicated and free roaming vessel dedicated to this task.

IGM also tested our newly developed and integrated **Long Range Video Communication (LRVC)** technology co-developed by IGM and L3 Communications to transmit video to the on shore ICP at St. Ignace, as well as to the USCG Cutter Hollyhock, the Icebreaker Tug Nickelena, and the Icebreaker Tug Erika Kobasic as well as to the Aerostat-IC ground control station located on the Barge where the Aerostat-IC platform was stationed.

Live video of USCG tactical operations including fire monitor enabled oil herding, skimming, fire boom deployment, and man overboard and ice rescues were sent from the Aerostat-IC aerial surveillance platform to the various vessels and the ICP. All video was also recorded by the control station on the Barge allowing review of the operations.

Acknowledgment

We extend our gratitude to the following organizations for inviting Inland Gulf Maritime (IGM) to participate in this exercise and for supporting and providing for our crew.

- Prince William Sound Science Center/ Oil Spill Recovery Institute
- United States Coast Guard Research and Development Center
- Station St. Ignace, USCG
- American Red Cross, St. Ignace, Michigan

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During the year 2012, Inland-Gulf Maritime, LLC set out to develop an aerostat based aerial platform which could carry surveillance payloads / sensors of up to 40 lbs to an altitude of at least 1000 feet, the outcome was the Aerostat-IC platform.

The AEROSTAT-IC system is a self-contained, compact aerostat platform and payload/sensor deployment unit which incorporates all the necessary components required to safely inflate, deploy and operate the lighter-than-air surveillance platform. It is designed to minimize the amount of time and resources required for the deployment and operation of the aerostat platform. This lighter-than-air platform is able to carry a diverse number of sensors or payloads of up to 40 lbs. ranging from cameras, communication relays, and atmospheric testing sensors among others to an altitude of up to 1000 feet.

The system utilizes a Launch and Retrieval System (LRS) which is comprised of small electrical winches located throughout the unit and controlled by a hand held controller. The LRS is used to take the place of additional operators during the launch and recovery phases by handling the 3 launch and recovery lines attached to the aerostat. The system also utilizes a main tether line which anchors the aerostat to the main base at all times and brings electrical power to the camera and down-link units and thus eliminating the need for heavy batteries.

The aerostat (balloon) is a kite-like semi-sphere aerostat with a volume of 1400 cu.ft. and an outer shell which protects it from the elements.

Six helium bottles of 300 cu.ft. each are housed within the unit and provide for inflation and servicing.

IGM tested the unit in fair weather conditions in the Gulf of Mexico but had yet to test its capabilities in extreme weather conditions found in the northern parts of the US, Canada, Alaska or the Arctic.

The USCG Oil-in-Ice exercise in northern Michigan presented IGM with the opportunity to test the system in an extreme weather environment and in real time while at the same time providing IGM the opportunity to test newly developed video transmit and camera control technology and demonstrate its capabilities to assist in coordinating oil spill response.

The following objectives were set by IGM during the preparation period before the USCG oil-in-Ice exercise:

(1) Identify, modify and enhance the existing Aerostat-IC system platform with the necessary upgrades to operate in extreme weather conditions.
(2) Integrate the Cloud Cap 200 Camera system and the newly developed RF Communications and Video Retransmit Equipment.

(3) Test the newly integrated Aerostat-IC system modified for extreme weather environments in real time and in real extreme conditions during the USCG Oil-in-Ice Demonstration Exercise.
(4) Further demonstrate the ability to safely, effectively, and efficiently deploy, and operate the aerostat system with task specific aerial imaging and communications payloads in support of the USCG Oil-in-Ice Demonstration Exercise.
(5) Demonstrate the ability of the RF video transmit equipment to send imagery to other vessels and to an on-shore command center.
(6) Demonstrate the cost effectiveness of utilizing the Aerostat-IC system as an alternative aerial surveillance platform.

IGM participated in the USCG Oil-in-Ice III Exercise from the 18th - 22nd of February 2013 in St. Ignace, Michigan. There were two days of operations where the Aerostat-IC system was to be deployed and operated with specific tasks in support of the exercise.

BODY OF REPORT

Potential Improvements - Identification and Modifications to the Aerostat-IC platform

During the month of January IGM began identifying any potential improvements necessary to be made to the Aerostat-IC platform which could help enhance its operation in extreme weather environments. The following were identified and performed improvements to the Aerostat-IC system:

- Replacement of the main tether line to a lighter weight tether line in order to counter the potential extra weight of ice and or snow accumulation on the aerostat balloon during operation. The original tether line weighed 4.8 lbs/100 feet. The new and lighter tether line installed weighs 2.7 lbs/100 feet and incorporated two #20 WG to carry electrical power up to the payload/sensor. This helped increase the net-lift of the Aerostat-IC system by 21 lbs. This additional lift means that if snow was encountered during the operation, it would provide an extra 21 lbs to counter the extra weight from snow accumulation on top of the aerostat.

- Replacement of the Launch and Retrieval System (LRS) winches to models with higher strength in order to increase the safety factor during potential sustained high and gusty wind velocities.

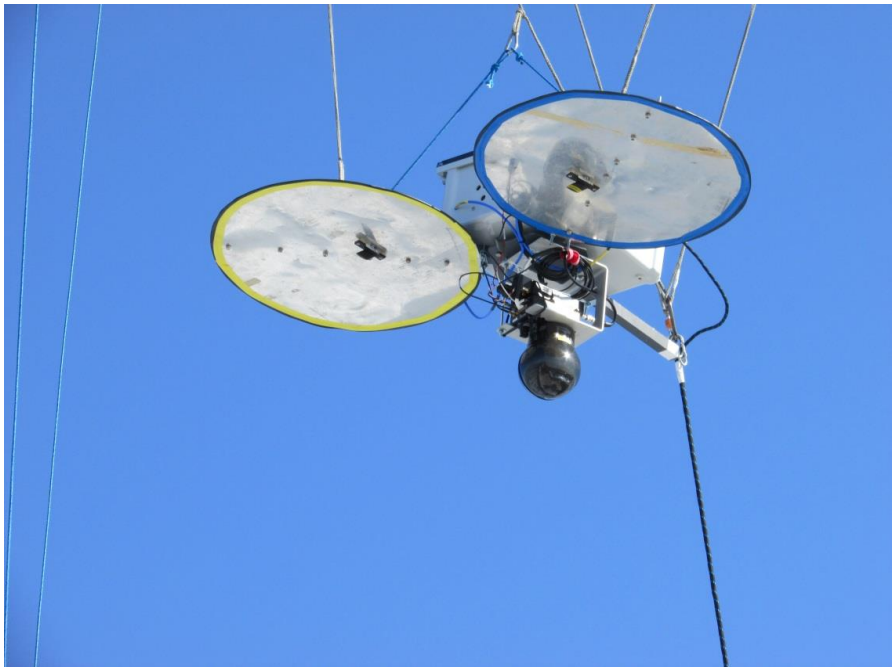
- Replacement of back-up batteries with High Cold Cranking Amps Batteries to ensure that the back-up batteries would be able to provide enough power to the main tether winch, the LRS and the payload in the event ground power loss. This would allow continuous operation of the system in case of a power loss was to occur during a critical assigned task and would allow for the safely retrieval of the payload/sensor and aerostat.

- Upgrade to the Emergency Deflation Device to reduce its weight and upgrade its casing to better protect it from extreme weather.

Selection and Integration of Wireless Technology for Video Transmission

IGM also researched new wireless technology to send video directly from the aerostat to the various vessels and command center. The following equipment was selected and integrated with the aerostat system:

- RF Compact Multi-Band Data Link unit
- RF Mini UAV Data Link unit
- RF Soldier ISR Receiver (SIR) Tactical Rover units
- RF Rover 6 Transceiver units



Demonstration of the complete system including video dissemination to various vessels and on shore ICP at the USCG Oil-in-Ice III Exercise.

IGM installed the video receiving network on all vessels and at the ICP location at the town of St. Ignace, Michigan.

The Aerostat-IC was selected to be positioned on a working Barge along with Hydro-Fire Boom deployment team and the Lamor Oil Recovery Bucket team, a large crane used for deployment and recovery of the Fire Boom as well as a warming cabin for the personnel operating the equipment on the barge.

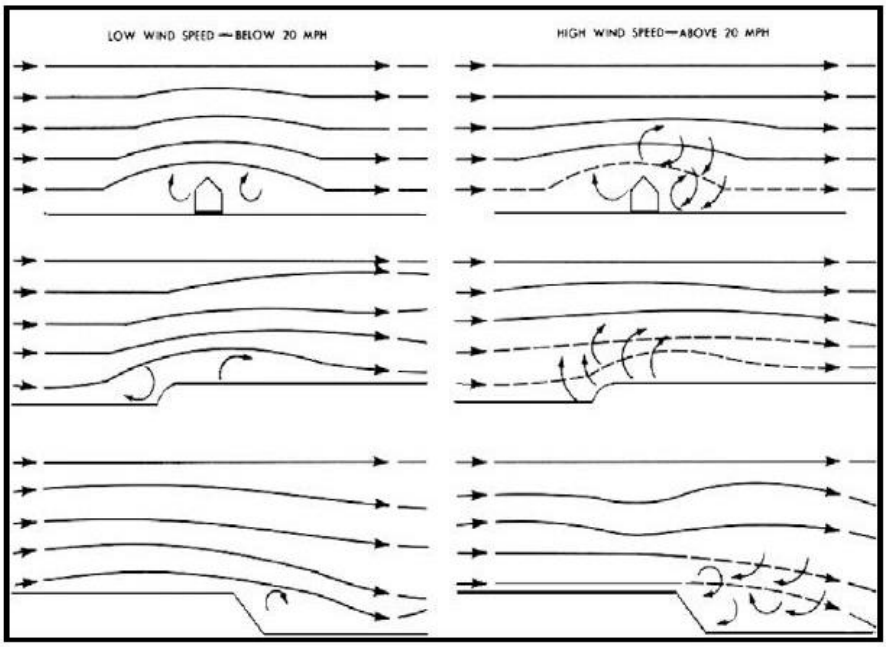
Due to space restrictions, the Aerostat-IC platform was positioned 6 feet from the warming cabin as the other areas of the barge were taken up by other equipment and operations.

On the first day of operation, the barge was positioned into a section of the ice at the Strait of Mackinac just east of the Mackinac Bridge. The Fire Boom was deployed first and then the Aerostat-IC system was to be deployed.

The IGM team set up and inflated the aerostat and as it is customary to determine safe and proper deployment of the unit, made three attempts to deploy the aerostat with the dummy payload. It is procedure to deploy a dummy payload to confirm proper line adjustment before the performance payload is launched. During this deployment the winds were gusting up to 34 kts, well within the systems limitations, however, after various adjustments to the flight lines without any improvement in the stability of the aerostat, it was determined that the instability to deploy was being caused by the wind turbulence wrapping around the warming cabin which was located upwind of the unit and causing

extensive currents of disturbed eddies. It was decided to abort deploying the aerostat as a safety measure.

The winds were recorded to be 15 knots with gusts up to 34 knots, however due to the mechanical turbulence being induced by the warming cabin in front of the system, it was estimated that the wind gusts were being intensified as well as the turbulence created by the cabin.
The diagram below illustrates the effect of wind behind an obstacle at low speed and at high speed:



Effects of wind turbulence caused by terrain and obstacles.

On day two, the Aerostat-IC unit was repositioned on the opposite end of the barge away from the warming cabin, the flight lines were adjusted to the original settings and a test flight was performed utilizing the dummy payload. The test flight, after relocating the system to the other end of the barge away from the warming cabin, was successful.

Next step was to deploy the payload carrying the Cloud Cap 200 Camera and the RF Video transmission equipment as normal. The system was deployed first to an altitude of 750 feet to ensure that the video was being received at the Incident Command Post (ICP) in St. Ignace, located approximately 5 miles to the north. Video was received by the USCG Cutter Hollyhock, both of the Icebreaker Tugs and in the ICP as well as on the Aerostat-IC ground control (the Barge). The payload was then lowered to an altitude of 500 feet for operations. Connectivity to the ICP was maintained for the duration of the exercise from this altitude.

During the day, the Aerostat-IC performed tasked as specified by the Coast Guard, as following;

- Monitoring and recording the simulated oil (peatmoss) herding operations

- Monitoring and recording the simulated oil (peatmoss) recovery operations by the Lamor Oil Recovery Bucket team and transmitting the live video to the ICP at St. Ignace.

See still pictures taken from the Aerostat Platform at 500 feet below:

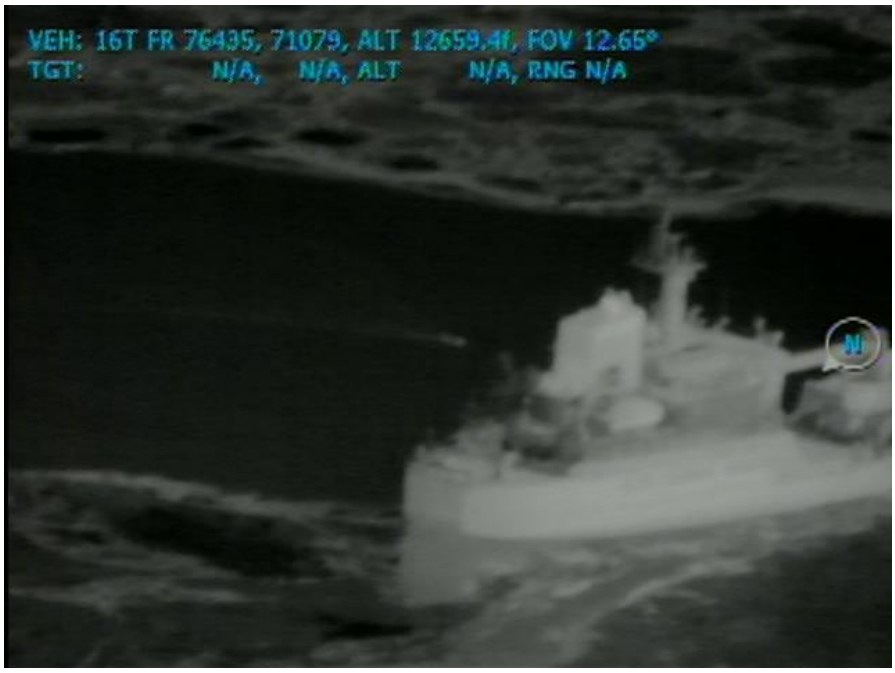
View from Aerostat-IC of Recovery Operation

View from Aerostat-IC of Herding Operations

Tests were also performed to determine if the Aerostat-IC aerial surveillance system could assist the Captains of the herding and recovery vessels with situational awareness when performing their respective operations and to enable effective navigation of the vessels in regard to the herding and recovery exercises. It was proven that providing the real time video feed to the wheelhouse, focused on the bow of the barge enabled the Captain to better facilitate skimming operations by keeping the operators in position.

As an additional test to the oil-in-Ice drill, the USCG requested aerial surveillance with the Aerostat-IC system to locate and track a man overboard. The USCG deployed 2 rescue swimmers into the cold water next to the USCG Cutter Hollyhock (approximately 2 miles from the Aerostat-IC barge), the Aerostat-IC aerial surveillance system was able to locate and track the swimmers with both EO (electro optical) and IR (infra red) capabilities.
See still pictures below:

View from the Aerostat-IC of the USCG swimmer with EO and IR



The exercise for the Aerostat-IC system concluded with the USCG deploying personnel to walk on the ice and requesting for the Aerostat-IC aerial support to monitor the ice walkers during their rescue simulation of a person breaking through the ice. By switching back and forth from EO to IR, the operator could confirm that the number of people he was seeing with the IR corresponded with the picture being provided by the EO function and thus always keeping track of the correct amount of personnel out on the ice.
See still picture below:

View from Aerostat-IC of the USCG ice walkers on IR and EO

EVALUATION

Selecting System Location

IGM has determined that due to the lessons learned concerning mechanical turbulence effects on the deployment of the aerostat, that additional testing is required to determine what considerations must be taken into account when selecting an operational area for the unit.

However, it was confirmed that the operational personnel could stay within the footprint of the unit during the complete set up, deployment and operation of the Aerostat-IC system while on the barge.

Inflation process

The IGM team found that inflation in extreme weather environments requires more extensive preparation and coordination between the operational personnel plus enhanced training techniques. The inflation process needs to be further simplified to reduce the amount of time that the operational personnel are exposed to the extreme cold weather environment. Our proposed solution is to pre-pack the aerostat envelope in a launching jacket that protects the material and also "sets" it up for rapid inflation.

Deployment of the aerostat in high and gusty winds in comparison to calm conditions without obstacle created mechanical turbulence.

The IGM team learned that the effect of mechanical turbulence greatly affects the launching and recovery process, making it difficult to maintain the aerostat's stability. Effects of mechanical turbulence awareness will need to be incorporated into the training program and needs to be considered with selecting the operational site for the system.

Locating the unit on a working stationary barge with other spill response equipment and obstacles proved that it was not always possible to deploy the aerostat into the prevailing wind, this issue could be solved by locating the aerostat on a boat which can maneuver into the wind for launching and retrieval of the aerostat platform.

New Launch and Retrieval System (LRS) winches performance in comparison to the previously installed Trac LRS winches.

The LRS winches performed well, they seem to be a little slower than the previous LRS winches, but this did not affect the performance of the system.

There was a definite improvement on how much the tether line bowed as the aerostat gained altitude, a indication that there was indeed less weight from the main tether line. The original line weighed 4.8 lbs per 100 feet of tether line and incorporated four #20 WG wires, while the new line weighed in at only 2.7 lbs per 100 feet and due to the payload upgrade, it only required two #20 WG electrical wires.

New Payload deployment in comparison to the normal payload deployed in the past.

The payload utilized for this USCG exercise was a newly developed and integrated payload which proved to be bulkier and difficult for one person to handle. The size and weight of the payload and sensors would need to be reduced if there is a necessity to operate above 750 feet. The payload weighed in at 29 lbs complete with the video transmitting equipment, this surpassed the 22 lbs from the previous payloads tested, however, the video control, quality and range of transmission were greatly

improved.

Down-linking of video to the control computer at the Barge.

Control and command of the camera as well as video worked well, GPS signal was not received, this was determined to be a hardware problem.

Down-linking of video to the USCG Cutter Hollyhock.

Video was received with good quality and at a distance of approximately 2 miles from the Aerostat-IC payload. Maximum range of video transmission utilizing the normal vessel receivers was not tested at this time.

Down-linking of video to the on-shore command center.

Although the ICP was located behind a small hill in the town of St. Ignace, at 500 feet of altitude the Aerostat-IC was able to transmit and the ICP was able to receive the video real time. The ICP was located 5 miles from the Aerostat-IC aerial system. Maximum range of the video transmission to the on shore ICP was not tested.

Camera control utilizing Radio Frequency (Wireless) Technology

The camera was able to be fully controlled with no delay utilizing the Radio Frequency (wireless) communication equipment.

Ability of the Aerostat-IC system to locate and track man overboard in icy conditions using EO and IR technology.

The Aerostat-IC camera was able to locate and track the coast guard swimmer with both EO and IR capabilities.

Ability of the Aerostat-IC system to locate, track and monitor ice walkers with EO and IR technology.

The Aerostat-IC camera was able to locate and track the coast guard ice walkers with both EO and IR capabilities, switching between EO and IR permitted the camera operator to confirm that the number of people on the ice being shown on the normal video was indeed the same using the IR function and thus being able to keep an accurate head count throughout the exercise.

CONCLUSIONS AND FUTURE WORK

Conclusions

Many lessons were learned during this project and several ideas for enhancing the performance and efficiency of the system also surfaced thanks to the ability to test the system in a real extreme weather environment. One of the main lessons learned during the course of this project was the immense effect which mechanical turbulence can have on the stability of the aerostat during the launch and retrieval periods.

Other important lessons learned include:

- The fact that operations for inflation, launch and retrieval of the Aerostat-IC system in extreme weather conditions require more time, coordination and efforts on behalf of the operators.
- With the newly integrated technology it was possible to send video directly from the Aerostat payload to various vessels within a 5 mile radius of the working aerial platform and to the command center on shore as long as line of site with the receiver can be maintained.
- Video provided by the Aerostat-IC system can be utilized by the captains to enhance their situational awareness and to maneuver herding and recovery vessels during operations.
- IR as well as EO capabilities of the Aerostat-IC system can be utilized to locate, track and monitor man overboard or to assist in ice rescue operations.
- The Aerostat-IC system was able to provide the required aerial coverage of the events of the USCG Oil-in-Ice III exercise and perform the specified tasks at a fraction of the cost of traditional air support and thus also reducing the human risks associated with traditional aerial coverage in extreme weather environments.
- It is important to establish a chain of command on who would mainly be directing what and where, when it comes to providing the aerial coverage. The camera operator has to be focused on the task at hand and not with conflicting instructions as to where to point the camera for viewing during the exercise.
- The final lesson learned was the realization that if dealing with a wide spread spill/response where working vessels are a wide distance apart, it may be beneficial to mount the Aerostat-IC on an independent vessel which can be relocated to assist where and when needed at different working parts or operations for the oil response / recovery and or search and rescue working out of the range of the camera system.

Future Work

With the lessons learned during the USCG Oil-in-Ice III Exercise, several a new ideas for enhanced and improved performance of the Aerostat-IC aerial surveillance system have been discovered and IGM will begin exploring a new approach in order to improve the system, having it work more efficiently

and improve performance in extreme weather environments and to meet a wider range of customers' needs.

IGM believes that the system performance can be greatly improved with the capability to transmit the video to a range of over 75 miles. This would entail re-designing the aerostat fabric (balloon) to act as a parabolic base for the transmitting antennas. Incorporating this into the aerostat fabric may prove to be the solution to extending the range while at the same time keeping the size and weight of the sensor/payload to a minimum.

One of the challenges to be able to transmit video over a long distance is that the receiving unit and the transmitting unit must have line of sight. Line of sight can be improved by increasing the altitude at which the aerostat operates, however, the higher it operates, better quality camera and zoom capabilities are required. IGM will continue exploring various types of gimbals in order to find a good balance between higher altitude, payload weight and quality of the video.

Another improvement which IGM will explore is the ability for multiple video feeds to be received by the on-shore command center simultaneously and thus improving the flow of information received which will assist the command center personnel in higher quality and quicker decision making.

The system can also benefit by the ability to control the payload/sensor from multiple vessels by creating a virtual switch which can allow not only for the interested parties to have control of the camera during a specific task, but also to create a redundancy or back up in case that the main sensor/payload command computer or system fails.

Along with aerostat material tests, IGM would like to perform material strength tests and material brittleness in even colder environments.

IGM will also continue to work on the redesign of the Aerostat base platform to reduce its footprint, the way it is secured to the vessel thus eliminating trip hazards, the aerostat inflation chamber and enhancement of the LRS system to prevent the handling line clips from catching or tangling.

Perform research and development of a new type of aerostat balloon which would improve on the accumulation of snow on top and thus improving its operational efficiency.

Test the unit in real time to further understand the limitations and effects of mechanical turbulence.