

# ENHANCED OIL SPILL SURVEILLANCE, DETECTION AND MONITORING THROUGH THE APPLIED TECHNOLOGY OF UNMANNED AIR SYSTEMS

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## ABSTRACT

*Many leading edge technologies that are conceptualized, developed, tested, refined and applied as military defense technologies evolve into useful applied technologies in other public and private sectors. Unmanned Air Systems (UAS) and the rapidly evolving Small Unmanned Air Vehicle (SUAS) are finding operational applications in scientific research, wildlife, law enforcement, security, natural disaster, and environmental surveillance, detection and monitoring. This paper will review the use of UAS in operational oil spill surveillance, monitoring and assessment.*

*UAS show particular potential for shoreline, coastal and inland surveillance and monitoring of remote areas with limited accessibility. Numerous international oil companies have sponsored UAV demonstrations focused on facility and pipeline inspection, surveillance and monitoring. Governmental agencies, including the U.S. Coast Guard and National Oceanic and Atmospheric Agency, have incorporated UAS into oil spill response exercises and test applications. Currently, many areas of high risk to pollution and high environmental sensitivity are monitored daily by costly manned aircraft surveillance; UAS can replace or augment these manned air vehicles, providing a cost effective alternative that also reduces human risks.*

*UAS technology is continually evolving to achieve broader application:*

- On-water launch and in-water recovery;
- Payload Integration – video, still daylight and nighttime IR imaging, image processing, and hazardous material air plume sensing and mapping;
- Command, Control and Communications (C-3) – real-time data link to the Incident Command Post;
- Platform Improvements – greater reliability, minimized size and weight, portability, longer operational flight time and extended range, and improved power sources;
- GPS positioning - pre-programmed flight patterns and break-away vectoring; and
- Simulation & Training - train effectively, maintain proficiency, and evolve tactics, techniques and procedures.

## INTRODUCTION

Rapid evolutionary changes and advancements in Unmanned Air System technology have been accelerated by military mission requirements and objectives of modern warfare. The authors of this paper would be remiss if we failed to recognize the important Research and Development roles of the world-wide Ministries of

Defense, the U.S. Department of Defense, Defense Advanced Research Projects Agency (DARPA), and the National Air & Space Agency (NASA) in advancing Unmanned Air System technology for force protection saving thousands of lives.

The definition of an Unmanned Air Vehicle (UAV) is an aircraft with no on-board pilot. Since 1849 when Austria attacked Venice using balloons carrying explosives, the concept of UAVs has been utilized. Lawrence Sperry's gyrostabilizer installed on a Curtis Bi-Plane in 1913 demonstrated the ability to steer a flying machine without an on-board pilot. Lightning Bug Drones, used during the Vietnam War, were a proven contributor in combat and successfully logged thousands of reconnaissance sorties that would otherwise have been carried out by piloted aircraft. UAVs can be remotely controlled or fly autonomously based on pre-programmed flight plans or more complex dynamic automation systems thus significantly reducing the human risk factor. Despite the long list of obvious advantages that UAVs (also termed Unmanned Aircraft, Remotely Piloted Vehicles, and Drone) offered, the most obvious benefit being no risk to a human operator. Despite the list of advantages for military communities a debate of manned vs. unmanned air vehicles has persisted over 70 years. Today that debate is over. As far as the Military world is concerned the debate ended over twenty years ago as the funding, development and acceptance of this reliable, survivable, and life saving technology has become commonplace in battlefield strategies. From battlefield assessment to providing troops situational awareness of what threat is around the corner, UAVs are at the front of the Global War on Terror.

The original UAV acronym has evolved to UAS for Unmanned Air System due in part to more technically sophisticated ground control systems, payloads, and other components. The term UAV still refers to the unmanned air vehicle component of a UAS. As with many leading-edge technologies, government funded defense and air and space R&D projects often produce equipment and systems that are commercially desirable and needed. The military tactical applications of today's UAS technology, ranging from passive surveillance and monitoring to weaponized surveillance, seek and destroy missions is the springboard for peacetime civil and commercial applications. UAS technology can and should be applied to peacetime public and private industry surveillance, detection and monitoring missions related to environmental protection, natural disasters and law enforcement. The application of UAS technology in oil and hazardous substance spill preparedness, detection, mitigation, containment, recovery, and cleanup is now available for enhanced, cost effective surveillance, detection, assessment, and monitoring.

## BACKGROUND

Today's UAS are categorized by Tiers or Class. Unfortunately, there is no common language among groups that segregate UAS into one recognized Tier Structure. The Air Force UAS Tier is defined, in part, by the operational altitude and endurance of the UAS. The US Army's Future Combat Systems program separates UAS into a Class that reflects the Group it supports such as a Company or Brigade. The Navy and Marines have their own scheme to define a UAS Tier System. Since there is no categorization standard, Table 1 shows a representative sample of UAS in use today and places them in specific Tiers. The elements that define the appropriate Tier include size, weight, endurance, payload weight capacity, range and operational footprint.

The UAS listed in Table 1 are representative of the latest technology available today for Military applications. Systems like Raven, Dragon Eye, Scan Eagle, Hunter and Predator are significant contributors to the hundreds of thousands hours UAVs have flown in Afghanistan and Iraq.

**Tier I Micro/Small** – "Micro is the newest category for UAS denoting a UAS that is generally very small in size and weight making them extremely compact and easy to transport. A Micro UAS is an optimal solution when aerial reconnaissance is required but the desire is to be undetected. The limitations of Micro solutions are typically flight endurance and payload capacity. The Aerovironment Wasp, which evolves from the Black Widow UAV developed for DARPA, is a 1 Pound UAS with Day and Night sensor capability. This system, called BATMAV, is the first Micro UAS program of record with Department of Defense.

Small UAS range in size from 3 to 10 foot wingspans and will weigh from 4 to 14lbs. The Small UAS advantage over a Micro UAS is endurance, range and payload capacity. Simply stated the larger the aircraft the more it can carry in fuel (batteries or gas) and sensors.

Manual operation or GPS-based autonomous navigation is a common feature on Micro/Small solutions. Examples of 'Micro' are Honeywell's MUA and AeroVironment's 'WASP'. Examples of Small UAS are: AeroVironment's 'Raven', 'Puma', and 'DragonEye'; Elbit Systems' 'Skylark'; and Adaptive Flight's 'Hornet' helicopter. Photos Nos.1 and 2. show a micro 'Wasp' and small 'Puma'.

**Tier II Tactical** – Tactical UAS are larger aircraft with greater endurance and payload capacity. These two features often define when a Tactical UAS will be utilized. Tactical UAS are often integrated with Sense & Avoid (SAA) technology, whereby an aircraft can sense the location and relative motion of another aircraft and maneuver to avoid. Examples of mechanical launched UAS that have one foot in SUAS and one foot in Tactical UAS' are: Insitu's 'ScanEagle' and 'Insight', shown in Photo No. 3; Advance Ceramics Research's 'Silver Fox'; these UAS can be catapult launched and recovered by vertical catch wire or airfield grade ground landing. Evergreen Helicopters is operating a commercial 'Insight' UAS that includes a truck-mounted mobile command and control station and launch and recovery capability. A rapid deployment configuration UAS is under development by Evergreen Helicopters that will allow systems to be transported aboard a Boeing 747.

Tier I and II UAS are commercial multi-mission capable, cost effective systems well suited for use in maritime monitoring, oil spill surveillance, tracking and assessment, as well as other services such as pipeline monitoring, search and rescue, forest fire management, border security surveillance, traffic control, petrochemical industry support, maritime monitoring and environmental clean-up tasks.

**Tier III Tactical Plus** – Examples of Tactical Plus UAS are Northrop-Grumman's MQ-5B 'Hunter' and AAI's RQ-7 'Shadow',

shown in Photo No. 4. Both are designed to gather battlefield reconnaissance, surveillance, target acquisition, and battle damage information in real time using a multi-mission optronic payload, then relaying it via video link to commanders and soldiers on the ground.

**HALE (High Altitude, Long Endurance)** – The loftier HALE UAS generally fly above 60,000 feet and are designed to stay aloft for days or up to a week. Examples of Tier III HALE UAS are: NASA's solar-powered 'Helios' "flying wings" with a 247-foot wingspan, which in August 2001, reached 96,863 feet, over 2 miles higher than any plane had ever sustained level flight; Northrop Grumman's aviation gasoline powered 'Global Hawk' with a 3-day maximum endurance; and AeroVironment's hydrogen powered 'Global Observer' with a targeted maximum endurance of 7 days. AeroVironment's 'Global Observer' shown in Photo No. 5 is in the development phase. Global Hawk is the only unmanned aerial system (UAS) to meet the military and the Federal Administration Aviation's airworthiness standards and have approval to fly regular flights within U.S. airspace. Global Observer is in development to serve as High Altitude Long Endurance (HALE) UAS, able to provide long-dwell stratospheric capability with global range and no latitude restrictions. The HALE Global Observer UAS will operate on hydrogen fuel cells, with a planned flight time of up to 7 days, and can also be used as a broadband communications relay. Diagram 1. depicts the persistent observation and surveillance capability of the HALE UAS involving two UAVs relieving each other on station every seven days.

**MALE (Medium Altitude Long Endurance)** - Some Tier III MALE UAS are designed for primarily military but also non-military applications. Examples of military MALE are General Atomics Aeronautical Systems' 'Predator', 'Predator B' and 'Sky Warrior'. 'Reaper' is the newest military strike UAS that has the surveillance capabilities of a Predator, but can fly faster, at a higher altitude up to 50,000 feet and can carry almost 4,000 pounds of munitions. Endurance-wise, Reaper can carry about the same payload of a U.S. Air Force F-16 aircraft and stay aloft about eight times longer than an F-16.

The National Air and Space Administration developed 'Ikhana', a variation of Predator B UAS adapted for civilian missions. NASA's Suborbital Science Program will be its primary customer, using the vehicle for Earth science studies. Ikhana was deployed by NASA to assist in monitoring and tracking the October 2007 devastating wildfires in southern California.

## NON-MILITARY APPLICATION OF UAS TECHNOLOGY

The quest for commercialization of UAS' was begun prior to the recent surge in militarization of the UAS. In 1977, **Dr. Paul MacCready**, became internationally known as the "father of human-powered flight" when his Gossamer Condor made the first sustained, controlled flight powered solely by its pilot's muscles. Dr. MacCready was Aerovironment's founder and is considered a pioneer in solar-powered aircraft which evolved into a series of unmanned, solar-powered stratospheric aircraft and into today's HALE 'Global Observer' and Aerovironment's several micro and small UAS. Insitu's founder, Dr. Tad McGeer initially developed the UAV 'SeaScan' as a fishing industry prototype to assist the commercial fisherman in tracking tuna. 'Sea Scan has evolved into today's 'ScanEagle'. The 'Silver Fox' was originally developed by the Office of Naval Research to keep whales out of harm's way during naval exercises.

To many, the commercial or non-military world is an obvious segue for the expansion of UAV use. However, such a transition is not without challenges and there are expressions of concerns similar to those heard during the military's arduous acceptance of the technology. Nevertheless, UAS technology is capable of fulfilling

a broad spectrum of commercial missions and applications if the challenges, discussed later in this paper, are addressed. UAS with multi-mission functionality will be in high demand.

Non-military applications, both commercial and civil, include:

- **Homeland Security** - border patrol, coastal marine transportation, drug interdiction, high risk facilities (terrorist targets) and major event security surveillance.
- **Law Enforcement** - criminal activity surveillance, traffic control monitoring, emergency evacuation assessment, hostage rescue, crime scene investigation.
- **Natural Disaster** - early warning assessment and post-impact emergency response to hurricanes/typhoons, tsunamis, earthquakes, floods, and wildfires.
- **Marine Casualty** and response surveillance and monitoring.
- **Oil & Gas Industry** surveillance and monitoring of terminals, refineries, offshore E&P platforms, and pipelines.
- **Oil and Hazardous Substance** - spill surveillance, detection, monitoring both pre- and post-incident, including pre-impact assessment and natural resources damage assessment.
- **Wild Fire/Forest Fire** - monitoring & assessment.
- **Search and Rescue** - marine and terrestrial.
- **Wildlife** - monitoring of the migration, population count and assessment, rescue and rehabilitation.
- **Agriculture** - high valued crop surveillance, detection and monitoring.

#### How UAS Technology Might be Applied to Oil and Hazmat Spills

A review of the sequence of events and circumstances of a typical spill scenario will help determine how UAS technology might be applied to complement oil or hazardous substance spill response. Lake Maracaibo, in western Venezuela presents a good spill risk situation and realistic scenario for considering applied UAS technology. Lake Maracaibo is the largest lake in South America, approximately 180 km long, covering 13,210 sq km. For years, the Ministry of Energy and Petroleum (MINPET) and PDVSA have jointly sustained a policy and procedure of daily surveillance over flights for early detection of oil discharges into the water. This involves a piloted helicopter with a MINPET observer/evaluator making two to four day-time only flights over sections of Lake Maracaibo, each flight lasting up to two hours, every day, 365 days a year. These are routine surveillance flights for early detection of oil spills from the expanse of production platforms, underwater pipelines and vessels. These surveillance flights add up to over 1,400 manned flights, 3,000 flight hours, and hundreds of thousands of liters of fuel consumption. Were it not for the very low price of fuel in Venezuela, this would be a very costly surveillance program. Manned flights are restricted to day-time operations to minimize the human flight risk. Lake Maracaibo would be an excellent candidate for commercial UAS surveillance, detection and monitoring.

With over 37,000 miles (60,000 km) of pipelines, two to ten-inches (5-25 cm) in diameter, crisscross each other over 5,100-sq. miles (8,200 square kilometers) of the lake bottom, an underwater pipeline rupture in Lake Maracaibo, Venezuela presents a very realistic scenario. In the event of a ruptured pipeline oil spill, aerial monitoring and tracking should continue throughout the source mitigation and response operations until demobilization.

#### Pre-Incident Surveillance and Detection

The use of a Tier I micro or mini-UAS equipped with forward and side mounted color video and Infrared (IR) pan and tilt, digital zoom cameras is capable of flying pre-programmed surveillance flight patterns over designated zones within a 10-15 km radius

from the ground control station on shore, on an oil platform or on a vessel. If a suspect oil leak is detected, the UAS can be released from the programmed search pattern and vectored to the suspect sight where it can loiter and video record the situation with the side-mounted color or IR camera, providing direct GPS position and visual information to the field control station and to an operations center ashore. A single trained operator of a two-man team is all that is required to review and assess the real-time information displayed. If the situation warrants an on-site confirmation by a human eye, a piloted helicopter with a trained oil spill evaluator can be dispatched to the GPS coordinate location.

There are situations and circumstances in which the proximity of oil handling operations, ship-to-ship/ship-to-shore transfers, or offshore exploration and production to coastal areas and marine sanctuaries would benefit from frequent surveillance and operational monitoring for early detection of oil discharge. The UAS technology affords a cost effective solution for frequent or even persistent surveillance of areas of particularly sensitive or vulnerable to oil spill damage; environmental or economic or historical antiquity. Examples are:

- Offshore oil exploration drilling in the Beaufort Sea, utilizing UAS to conduct surveillance of sea mammal activity in the area of exploration;
- Aerial surveillance of the Palm Island I and II and 'The World' developments in Dubai, United Arab Emirates (UAE) for early detection and protection from the impact of oil spills;
- Close to shore production operations off Bahia, Brazil;
- Ship-to-ship transfer operations in Singapore and Fujairah, UAE; and
- Future exploration and production off the east coast of Canada and the United States.

UAS technology might also be used for shore-side aerial surveillance and inspection of oil and petrochemical facilities, pipelines, and gathering and pumping stations. Both the Tier I (Micro-Small) and Tier II (Tactical) UAS technology could fulfill this mission with the Micro-Small UAS conducting shorter range, line of sight surveillance and inspection and the Tactical UAS conducting longer range and endurance surveillance and inspection of pipelines.

#### UAS Mission & Functions during Marine Oil Spill Response

Once an oil spill is detected, the UAS observations can assist in locating the source of the spill for determining the proper action required to mitigate the spill. A typical micro or small UAS will consist of two or three aircraft which provide the capability of back-to-back persistent monitoring 24 hours if desired with one vehicle in flight while another is in standby or being battery recharged or refueled.

UAS can become a versatile tool for oil and hazmat spill response. The Incident Command System or the National Incident Management System (NIMS) can easily integrate UAS into Command Post planning and operations. Diagram 2 shows the organizational structure of the Operations Section's Air Operations Branch and its Air Tactical and Air Support Groups. A UAS Coordinator can be readily incorporated into the Air Tactical Group. The UAS Coordinator would be primarily responsible for coordinating the UAS detection and monitoring missions. Alternatively, an assigned Helicopter Coordinator could also manage the UAS missions. In a major event which might involve air tanker fixed wing aircraft, helicopters and unmanned air vehicles, air space management and flight coordination is critical to safe flight operations.

Within the Planning Section, UAS assets are accounted for by the Resources, Situation and Environmental Unit Leaders. In the United States, the National Oceanic and Atmospheric Agency

(NOAA) provides the Scientific Support Coordinator (SSC) within the Planning Section. The SSC may have particular needs for UAS monitoring capabilities, and could either work closely with an experienced UAS Technical Specialist or NOAA could have their own personnel trained as a UAS Technical Specialist.

Within the United States, UAS could be sourced nationally through oil spill removal organizations (OSROs) who have UAS listed in their US Coast Guard Basic Ordering Agreement, or through other governmental services contracts. Sourcing UAS through national OSROs such as National Response Corporation and Marine Spill Response Corporation is possible. Oil companies may have service contracts in place with UAS providers. Accessing US manufactured UAS for international deployment may require US Department of State approval. UAS sourced from other country manufacturers for use in other countries may have fewer restrictions for international deployment.

The use of Tier I micro-small and Tier II Tactical UAS systems equipped with the right sensors could complement real-time surveillance, monitoring, mapping, and response to large oil spills on water and land.

- In the marine environments, the ability of frequent or persistent search and GPS positioning of oil patches allows operational vectoring of on-water mechanical oil containment and recovery resources for maximum engagement of the floating oil. This can be done throughout the 24-hour day using IR camera monitoring.
- When oil spill trajectory modeling is being used to assist in oil spill response planning and operations, UAS technology provides the capability of frequent and persistent tracking and mapping of oil migration. Real-time visual and positioning data of oil movement can be applied to the oil spill trajectory model for continuous refinement enhanced accuracy of oil movement projections.
- When surface or aerial dispersant application is involved in oil spill response, UAS technology could be utilized for vectoring a surface vessel or an aerial dispersant aircraft to an exact location. Similarly, a UAS could assist in post dispersant application assessment.
- UAS technology can also serve as a Shoreline Cleanup Assessment Teams (SCAT) tool in assessing shorelines prior to and after oil impact. This could be particularly helpful for coastal and shoreline areas that are inaccessible or have limited accessibility for SCAT Teams. When more than one UAS ground control station is available, a micro or small unmanned air vehicle can be operationally passed from one ground station to another, thereby expanding the geographical range of coverage
- Wildlife rescue and rehabilitation efforts could be assisted by UAS technology during identification of wildlife populations at risk and in the search for oiled birds and mammals. Rescue teams can be vectored to the location of oiled wildlife or areas where hazing should be conducted to keep wildlife away from the risk of oil contamination. The battery powered micro and small UAVs are quiet and impose the least disturbance to natural habitats during surveillance and monitoring operations.

UAS technology can enhance the safety of responders and reduces liability and risk during hazardous material spills. A UAV can be equipped with an air monitoring device to assist in the sampling for contaminated air and mapping airborne plumes of hazardous material.

### Incidents of National Significance

The occurrence of an incident of national significance involving national and regional commands could benefit from the mobilization and deployment of multiple Tier I and II UASs to cover the broader response area. In the future, there may also be the option

of deploying a Tier III High Altitude Long Endurance UAS to provide broad area monitoring and assessment whereby a UAS can loiter over a land or sea area for days or weeks at a time and transmit real-time data directly to national or regional command posts.

It is worthy of mention that the U.S. Coast Guard's Deepwater Program is the largest major acquisitions program covering a 25-year period and funding up to 24 billion dollars US. In addition to producing more than 91 new cutters, 195 new aircraft, and command, control, communications, computers, intelligence, surveillance and reconnaissance equipment, Deep Water includes two multi-mission UAS aircraft. One is the HV-911 Eagle Eye Tilt rotor VUAV, four of which may be carried aboard certain Coast Guard cutters. The program is currently under review. The other is a High Altitude Endurance (HAE) UAV equipped with high-resolution sensors – Electro-optic/Forward Looking Infrared (EO/FLIR), Synthetic Aperture Radar (SAR), Inverse Synthetic Aperture Radar (ISAR), and Generic Mapping Tools (GMT) - and having the capability to stay on station at altitudes of 50,000 to 65,000 feet. This is a strong indication of the U.S. Coast Guard's attention and commitment to modernization of their multi-mission surveillance, detection, monitoring, and tracking capability with zero liability to human life.

### Challenges of using UAV in Civil and Commercial Airspace

There are three significant challenges today confronting the UAS industry and its prospective civil and commercial clients.

#### 1. Federal Aviation Administration (FAA) and Equivalent International Agency Policies

The integration of UAS technology into the NAS is a challenging task for many reasons. The FAA is responsible for the air safety of all personnel and aircraft operating within US air space. Safety of personnel is also a first and foremost precept of all emergency response personnel in the oil spill sector. The FAA is working on a policy that is applicable to UAS and which will hopefully take into account a policy that differentiates between the different UAS tiers. The policy for UAS operations is one, complicated in part by the diverse capabilities and size of different platforms. Another reason is the inability of all UAS to satisfy Sense and Avoid (SAA) requirements. All would agree that for a UAS that operates at altitudes commonly used by manned aircraft SAA is mandatory. Special interest groups will also have a voice in how quickly UAS solutions become daily participants in Civilian Airspace. Organizations such as Airline Owners and Pilots Association (AOPA) simply do not want UAVs in "their airspace" and they lobby the FAA hard to prevent their use. When a Police Department in North Carolina wanted to utilize a Small UAS the AOPA lobbied the FAA to prevent its use. (<http://www.aopa.org/whatsnew/newsitems/2006/060215uav.html>).

In the United States, the current FAA policy is that no person may operate a UAS in the National Airspace System without authorization in the form of a COA (Certificate of Authorization). A COA will only be issued to a Federal or State Agency, and only authorizes UAS operations at specific location. For non-government entities (UAS manufacturers) an Experimental Certificate (EC) is required for any flights in civil airspace. This would include UAS demonstrations for promotion or marketing purposes.

In time, hopefully sooner than later, the FAA will create policies to regulate the different UAS tiers. In October 2007 FAA's John Hickey, FAA Director of Aircraft Certification, made a presentation to the AIA Subcommittee titled *FAA's Program Plan for Unmanned Aircraft – Impact of Shifting Priorities*. FAA stated that while they are re-prioritizing to focus on small UAS, they have limited staffing resources resulting in the inability to keep pace with demand and reducing its throughput of COA's and

Experimental Certificates in the future. The UAS program plan cites Small UAS and Restricted Policy Development as a Priority 2 issue that will begin in 2010. The message to Congress and the UAS community is that the FAA's lack of resources, constrains the FAA's ability to support UAS Policy Development in a timelier manner.

UAS Industry leaders believe that policy and guidelines should consider the Class of UAS, its capabilities, its record of performance and safe operation, mission requirements that mirror the capabilities of the UAV, and certified operators that meet FAA requirements.

The success of first responders in a crisis situation is based upon having the latest information and establishing and maintaining communication and coordination with all parties involved in the "Response". Safety for all personnel involved is the number one priority at all times day or night. There is high probability that proven UAS solutions involving controlled Certified Operators will contribute to increasing safety and reducing human risk to first responders when natural or man-made disasters occur.

## 2. Spectrum Issues for Commercial UAV Use

Obtaining control and video downlink channels for a UAV are critical in order for UAV's to be used for commercial purposes. The facts and issues include:

- Video channels, in particular, take up a large amount of bandwidth that will be challenging to obtain. A minimum of about 6 MHz of spectrum between about 400 MHz and 3 GHz is needed to control a single small UAV and downlink reasonable quality video.
- The military has allocated government frequencies for military UAV usage that they may allow for some civil applications such as disaster management. Use of these frequencies, however, is solely up to the discretion of the military.
- The FCC and International Telecommunication Union (ITU) are responsible for commercial frequency allocation and have not allocated sufficient spectrum for long-range control or video UAV use. Remote controlled aircraft frequencies won't handle video and are prevented from long range use.
- While there are frequencies that do not require licenses that are usable by UAVs under certain circumstances, these frequencies are not protected. Depending on who else is using them, unlicensed frequencies may be unusable or unreliable at certain times, in certain locations.
- Long-range usage of unlicensed frequencies may be quite challenging. There are many current frequency users - satellite industry, entertainment broadcast, cell phone, microwave communications, etc. - that also want the suitable spectrum and would like to prevent new applications from entering the competition for frequencies. These current users have or will put up a strong political opposition that the UAV industry must counter. A solid front and participation by UAV manufacturers, operators, and users, will be essential for spectrum to be allocated for UAV use.

Realistically, the goal should be to obtain 2 to 3 channels worldwide that can be shared by UAV users.

## 3. UAVs Liability versus Manned Aircraft:

Today technology on a manned Boeing 747 enables a take-off, controlled flight and landing from New York to Los Angeles without a pilot ever touching the controls. Today, technology on a UAV enables a take-off, controlled flight and landing from the United States to Australia. Which is safer? Which aircraft is more reliable? Which is more likely to have a Catastrophic Event?

The pilot of the 747 and the UAV Operator (often a pilot) are both experts in the safe operation of their aircraft. In the event of an incident, the 747 pilot will react to an alarm or incident and attempt to normalize the operation of the aircraft. He has the benefit of the latest technology and the ability to seek advice and help from Air Traffic Controller and others on the ground. Similarly, the UAV operator has the same resources, plus the advantage of broadening the level of assistance by using a telephone. We could go on with situational comparisons, but the fact is that UAVs are as safe as manned aircraft and qualified UAV operators as competent in safe operation of their aircraft as pilots are with theirs.

The manned or unmanned aircraft systems in use today in Military operations are both designed to meet the same levels of reliability and safety as noted in Table 2 - Comparative Reliability and Ground Safety Risks, reflects design criteria for Acceptable Cumulative System Risk. The European Aviation Safety Agency (EASA) created the criterion for this analysis. As noted in the comparative assessment, the Raven SUAS has similar or in the same flight risk classification of both flight proven commercial (747) and military (combat aircraft). Raven's comparative risk shows many magnitudes greater reliability than the comparative risk of current day air travel of 1 flight death per 70 million flights. This is based on the current statistical passenger mortality risk per million flights. (ref: [Aero Safety World November 2007 issue "Measure for Measure"](#)). The aircraft listed in Table 2 follow the same design criteria with regard to safety, control and reliability. Accidents, catastrophic or not, are generally caused by pilot/operator error, training or maintenance issues. They are not the result of inherent flaws in the design of the aircraft. Aircraft landings, takeoffs, flight, weather, population density, and aircraft serviceability/maintainability are among those things considered in the overall analysis. The Raven UAS, the most deployed UAS in the world today, is included in this analysis with the Global Hawk and Predator aircraft. With over 5,000 Raven's provided to Coalition Forces, 'Raven' has the highest rating for reliability and ground safety of the UAS solutions in service today.

## International Traffic in Arms Regulations (ITAR)

Many countries have developed UAS'. Without question the United States is a leader in UAS development at all levels. In the U.S. UAS technology is listed as a munition and as such it is included under the ITAR restrictions. This restriction means that some of the UAS solutions listed in this document would not be available for response/service in countries other than the U.S. without an export license from the U.S. State Department.

## CONCLUSION

The deployment of Unmanned Air Systems for oil and hazardous substance spill surveillance, detection and monitoring could add a versatile capability to spill response effectiveness. The UAS does not replace but rather augments manned aircraft, reducing human risks and providing a cost effective capability that provides real-time or near real-time information to the command post and field responders. As UAS technology continues to evolve and be refined, it will offer broader applications that can enhance oil and hazmat spill response effectiveness by providing:

- Rapid and frequent or continuous aerial surveillance and monitoring throughout a spill area;
- On-land and on-water launch with land and in-water recovery;
- Payload Integration – video or still daylight and nighttime IR imaging, image processing, and hazardous material air plume sensing and mapping;
- Command, Control and Communications (C-3) – real-time data link to the Incident Command Post;

- Continuing UAS Platform Improvements – greater reliability, minimized size and weight, portability, longer operational flight time and extended range, and improved power sources;
- GPS positioning - pre-programmed flight patterns and break-away vectoring; and
- Simulation & Training during oil spill drills and exercises - train effectively, maintain proficiency, and evolve tactics, techniques and procedures.

The oil and gas, and spill response community should take advantage of UAS technology and incorporate it into spill response tactics and strategies.

**BIOGRAPHY**

**JOHN ALLEN** is Senior Vice President for Business Development for SEACOR Environmental Services International Ltd. (SESI) and is based in Metro Washington, DC. He first joined National Response Corporation (NRC) in 1992 and in 1996 he began expanding services internationally with the formation of International Response Corporation, precursor to SESI. Before

joining NRC, he was an independent logistics and emergency response consultant to government and industry, prior to which he served as a career Surface Warfare and Special Operations officer in the U.S. Navy specializing in diving & salvage, and expendable ordnance management. Mr. Allen holds an MPA degree from George Washington University, Washington, DC and BSc from University of Windsor, Windsor, Ontario, Canada, and is a graduate of the Industrial College of the Armed Forces, National Defense University.

**BRIAN WALSH** is Business Development and Marketing Manager of AeroVironment (AV) Unmanned Air Systems. He joined AV in 2004 and is responsible for the Small UAS Marketing strategy for both the Military and Commercial initiatives. Prior to his current assignment, Mr. Walsh was the Director of Sales & Marketing for IQstor Data Solutions headquartered in Southern California. Mr. Walsh is a frequent speaker on the benefits for UAS technology Beyond the Military, specifically for First Responder applications. Since joining AV, Mr. Walsh has played a key role in developing the AV UAS brand into the largest provider of Small UAS solutions in the world today.

TABLE 1: UAV TIER STRUCTURE

Tier	UAV	Weight	Endurance	* Payload	Range (Communications)	
I (Micro- Small)		Wasp	.95 lbs.	40 min	<100 gm.	5km
		Puma	12 lbs	3 hrs	2 lbs.	10 km
		Skylark I	12 lbs.	2 hrs	2.2 lbs.	10km
II (Tactical)		Silverfox	27 lbs.	8 hrs	5 lbs.	36 km
		San Eagle	38 lbs.	15-20 hrs	13 lbs.	100 km
III (Tactical Plus)		Shadow	585 lbs.	12-14 hrs	91 lbs.	125 km
		Hunter	1600 lbs.	21 hrs	200 lbs.	250 km
III (MALE) (HALE)		Predator	2250 lbs.	>24 hrs	450 lbs.	Global
		Global Hawk	22,000 lbs.	34 hrs	2000 lbs.	Global

PHOTO NO. 1 – TIER 1 SMALL/MICRO UAV ‘WASP’



The Wasp MUAS is a small, portable, reliable, and rugged unmanned aerial platform with a wingspan of 72 cm and a weight of 430 grams.

PHOTO NO. 2 – TIER 1 SMALL UAV ‘PUMA’



Puma UAS is easy to deploy and recover for persistent low-altitude surveillance; wingspan of 8.5 feet, this light-weight, hand-launched UAS provides aerial observation at line-of-sight ranges up to 10 kilometers

PHOTO NO. 3 – TIER II TACTICAL ‘INSIGHT’



‘Insight’ SUAS is launched with a compressed gas catapult and recovered by a vertical catch wire device. Wingspan is 3.11m, maximum takeoff weight 20 kg. System can include a truck-mounted mobile command and control station and launch and recovery capability.

PHOTO NO. 4 TIER III TACTICAL PLUS



Shadow 600 supports military requirements in several U.S. allied nations, operating in diverse and rigorous climate and terrain conditions.

PHOTO NO 5. – HALE “GLOBAL OBSERVER”



Global Observer is the latest development in High Altitude Long Endurance (HALE) UAS, which will be able to provide long-dwell stratospheric capability with global range and no latitude restrictions.

Diagram 1. Operational Concept of the HALE UAS



PHOTO NO. 6 TIER III MALE 'PREDATOR'



Predator series UAS' have operated on five continents worldwide as well as over three of the world's oceans.

PHOTO NO. 7 US COAST GUARD TIER III TACTICAL UAV



HV-911 Eagle Eye Tiltrotor

Diagram 2. Operations Section of the Incident Command System (ICS)

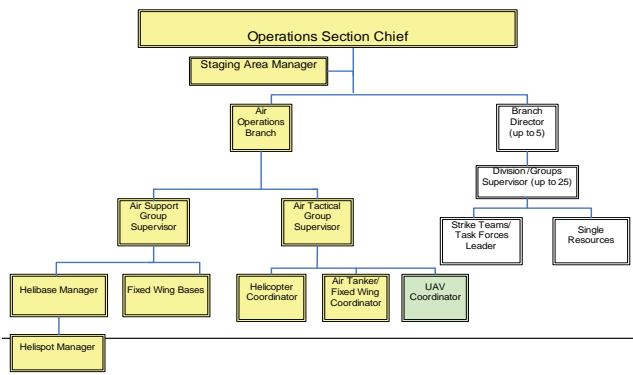


TABLE 2. - COMPARATIVE RELIABILITY AND GROUND SAFETY RISKS

Global Hawk	HALE	2.5 E-5 @	7.6 e-12 @	0.00000000007600
Predator	MALE	5 E-5 @	4.3 e-11 @	0.00000000043000
Boeing 747	747	9.5 E-7 @	3 e-15 @	0.000000000000003
Combat Aircraft	Fighter	1 E-5 @	9 e-13 @	0.000000000000900
Raven	SUAS	5.5 E-5 #	6 e-11 @	0.00000000060000
<p>@ Derived estimates – Based on data from the Proposed EASA Advance-Notice of Proposed Amendment (A-NPA No. 16-2005)            # Raven Catastrophic Probability</p>				