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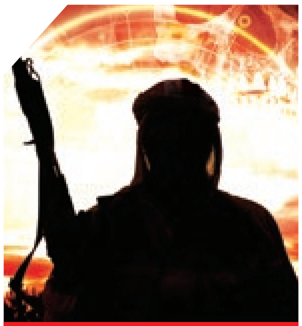

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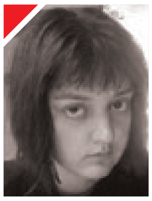

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Unmanned vehicles:
Enhancing security, rescue and natural disaster management capability

Last issue we brought you Part I which reviewed the current capability of robotic UGVs. Here follows Part II commencing at looking at the integration of UMVs into current manned maritime security and surveillance operations.

By
John **Cunningham**
and
Dr Pascual **Marques**

Nikola Tesla (1856-1943), inventor of the world's first practical remote-controlled unmanned vessel, was granted a US patent in 1898 for a 'Method of and Apparatus for Controlling Mechanism of Moving Vessels or Vehicles'. Tesla first demonstrated this rudimentary unmanned ship at an electrical industry trade show at Madison Square Garden in New York, using a large tank of water and radio for command and control. Nikola Tesla's 19th century vision is therefore considered the precursor of the 21st century unmanned maritime systems technology. Nonetheless, UMVs remains an emerging technology that faces numerous challenges that must be overcome for such vehicles to become commonplace in commercial and military applications; a particular challenge is the integration of UMVs into manned maritime security and surveillance operations.

UMV technology includes surface vessels, underwater submersibles and hybrid systems. These vehicles incorporate fully integrated sensors and payloads required to accomplish different missions. Contrary to the steady development of unmanned aircraft, UMV technology has had a slower progress. However, during the next decade, a significant increase in the application of UMVs is anticipated, where such vehicles will provide enhanced capabilities for commercial and governmental maritime operations.

Commercial applications provide services offered by contractors as part of business operations. In contrast, governmental applications are aimed to preserve public safety and security, provide response to different emergencies, and address issues of public and scientific interest. These remotely-operated vessels and submersibles are particularly desirable for hostile maritime environments that may include high threat regions or areas contaminated by nuclear, biological or chemical agents; in which deploying a crewed vessel is ill-advised. A key challenge for the global introduction of unmanned maritime technology is to coordinate efforts so that maritime operations integrate seamlessly into current manned maritime procedures and the operations are safe. An important aspect for successful manned-unmanned cooperation is the integration of UMVs into the global maritime communication environment so that the autonomous vehicles use the same communication equipment as manned vessels. Safe operation and traffic control of UMVs requires highly reliable radio communications between the unmanned vessel and the maritime control station, as well as satisfactory sense and avoid capability.

The world's military UMV market is evolving rapidly under the combined impact of changing maritime threats and significant technological advances. Specifically, current research and development (R&D) efforts aim to enhance capabilities in mine counter-measures, anti-submarine warfare, port and harbour security, counter-terrorism, and counter-piracy. The military, in particular, has special interest in the following R&D areas; harbour protection systems, systems integration, regulations for unmanned maritime vessels, modular lightweight minesweeping, and detection and management of buried and drifting mines.

Commercial UMVs also offer valuable support in humanitarian applications. Submergible vehicles can review port damage and help identify problems with movement of surface vessels used for transportation of vital equipment, food and medical supplies in areas affected by natural disasters.

UAV capability for security and natural disaster management

UAV technology provides unparalleled support in diverse public missions such as border surveillance and security, wildlife surveys, military training, weather monitoring, communications relay, law enforcement, environmental monitoring, agriculture aerial mapping and other. The main UAV applications are defence related, in particular Intelligence, Surveillance and Reconnaissance (ISR) patrols.

UAVs are also used for Chemical, Biological, Radiological and Nuclear (CBRN) detection, or simply those tasks considered too dangerous or politically challenging for manned aircraft to undertake.

UAVs are better suited than manned aircraft for 'dull, dirty, dangerous'. UAS are preferred over manned aircraft because of the lesser risk of losing human lives and the greater confidence in mission success. In fact, unmanned vehicles have better sustained alertness over humans during dull operations. Typically, 'dull' operations require more than 30 or 40 hours of continuous surveillance. Such tasks can be automated, often only requiring human oversight rather than direct and continuous control. Unmanned aircraft are also the ideal choice for operations in 'dirty' environments that are hostile to a manned aircraft and its crew; for example, flight into nuclear clouds after bomb detonation. Small unmanned aircraft are used by fire brigades for reconnoitering fires in inaccessible locations or where smoke and flame makes human presence hazardous.

'Dangerous' operations typically involve reconnaissance over enemy territory that can result in loss of human lives, thus UAS are preferred. Unmanned aircraft can conveniently replace different dangerous ground tasks, such as convoying of tactical supplies and sweeping for improvised explosive devices. There are high expectations for the growth of the civil and commercial UAV market. Emerging civil applications of UAVs are inspection of terrain and buildings, coast guards duties, border patrols, rescue operations, police work, fisheries protection, pipeline survey, disaster and crisis management, search and rescue, environmental monitoring, and forest fire fighting.

Characterised by comparatively silent flight and small dimensions, UAVs cause less disturbance of the scene being surveyed. The unmanned platform usually provides a big picture of the scene instead of visual limited recording from ground level. Commercial UAVs are designed to perform missions at a lower cost and ecological impact than a manned aircraft equivalent. Thus, the desire for endurance in many UAVs demands high aerodynamic and fuel efficiency.

Multi-mission diverse-payload vehicle

An example of a multi-mission UAV recently introduced into the commercial market is the MA THOR by Marques Aviation. The MA THOR is a high-wing twin-boom inverted-v-tail unmanned aircraft. It is a versatile vehicle used in missions as diverse as remote sensing and mapping, land and maritime border patrol, sea and land search and rescue, long endurance military reconnaissance, surveillance of oil and gas installations, inspection of natural disasters, ecological work, and fire fighting. The vehicle uses a modular fuselage configuration to accommodate a diversity of payloads for different missions; electro optical and infrared cameras, gyro stabilised daylight and low light cameras, laser designator, range finder, miniature aperture radar, radar altimeter, automatic video tracker, nuclear biochemical sensors, meteorological appliances, laser detector tracker pod, and ejectable items such as chaff, leaflets and flares.

Additional payloads can be installed in the UAV including mine detection equipment, electronic warfare systems, SIGINT, and scientific sensors. Larger, more sophisticated payloads can also be carried aboard for day and night, maritime surveillance and search and rescue operations like the FLIR systems, UK Mountain, coastal and firefighting operations often present adverse meteorological conditions and strong winds. However, enhanced aerodynamics and flight stability principles in the MA THOR allow the UAV to complete its assigned surveillance tasks in demanding flight conditions.

Homeland security

Unmanned observation systems fulfill civilian tasks related to homeland security such as border protection and control, monitoring the coastline, and providing security for large public events.

At present, the US Customs and Border Protection (CBP) agency employs six Predator UAS in support of border operations on the southwestern and northern borders of the US. In Europe, the Swiss company RUAG has used a ranger reconnaissance UAV since 2006, to monitor the Swiss border. Border protection involves monitoring a very large area during an extended period of time. For this reason, medium-altitude long-endurance (MALE) UAVs are the most suitable systems as they can remain airborne and operate ten times longer than a manned helicopter. It has been estimated that a single MALE UAV is capable of carrying out long endurance monitoring mission, which would otherwise require ten helicopter missions.

The European agency Frontex is responsible for fostering cooperation between EU member states in border security. Frontex recognises the need to relentlessly monitor the southern border of the Schengen area along the northern coasts of the Mediterranean. This is necessary given the unpredictable political climate in North Africa.

Recently, United Kingdom police authorities have introduced small and medium-size UAVs in their operations. These unmanned systems replace expensive helicopters, and provide reconnaissance and enhance security at large events, such as the sporting events during the 2012 Olympics.

Natural disaster management

Natural disasters encompass forest fires, floods, earthquakes and violent storms in which UAVs can help monitor and analyse the situation. UAVs support search and rescue operations when looking for survivors of shipwrecks, aircraft crashes or victims buried in alpine avalanches. Thermal cameras make continued search and rescue activity possible at any time of day or night in snow avalanches. ABC accidents and oil spills are other types of disasters in which unmanned systems are preferable.

The UAS Ikhana was used in 2007, for reconnaissance during the large forest fires in California. In forest fire operations, characterised by conditions of poor visibility due to the smoke, the thermal imaging sensors aboard the UAV communicate the exact coordinates of the flames to fire-fighting aircraft to more accurately release fire retardant. In such disastrous events, UAVs have capability to obtain

The unmanned aircraft overflew the damaged areas relentlessly for 14 hours to monitor the situation. High-resolution images transmitted by the Global Hawk made it possible to locate usable takeoff and landing areas of helicopters and relief aircraft.

images at a higher resolution than those of satellites and therefore, relay useful information for the firefighters in real time. However, the greatest advantages of UAS for support in forest fire operations are their high endurance and the minimal risk to pilots.

After the Indian Ocean Tsunami of 2004, the Heron MALE-UAS assisted in locating victims buried in rubble. In 2008, the West Midlands Fire Service (WMFS) in the UK employed the Incident Support Imaging System (ISiS) to observe a fire at a university. The ISiS, which uses a German md4-200 UAV, provided the firefighters with thermal imagery of the development of the fire on the roof of the building, thus minimising the risk to the firefighters. High endurance is also an important asset during flooding events. UAS can continuously gather information about the evolution of the flooding as it evolves, during the day and at night. Flyover inspections of dikes can be conducted at regular intervals and critical points. The ability to quickly provide information about the scene is essential in catastrophe management, so that the population can be warned early and evacuated.

Following the devastating earthquake in Haiti in 2010, a Global Hawk was assigned its first disaster relief missions in the Caribbean. The unmanned aircraft overflew the damaged areas relentlessly for 14 hours to monitor the situation. High-resolution images transmitted by the Global Hawk made it possible to locate usable takeoff and landing areas of helicopters and relief aircraft. The Fukushima Daiichi nuclear power plant suffered substantial damage following the earthquake and tsunami in Japan in 2011. A high-altitude long-endurance (HALE) UAV glided over the power plant to take pictures of the building using high-resolution infrared sensors. The HALE vehicle showed disaster response teams that overheating was occurring inside the nuclear station. Later the vertical-takeoff-and-landing (VTOL) UAV RQ-16 T-Hawk was deployed at the reactor site to relay real-time images of the damaged facility.

During search and rescue missions in maritime accidents on the open ocean, medium and high-altitude UAVs with high endurance and capability to monitor large areas are decisive. Therefore, UAS represent an important support tool for natural disaster management due to their instant availability, autonomy and endurance.

In summary, ARGUS Robotics (USA) addresses the ever-increasing need to improve security methods that prevent IEDs, car bombs, and nuclear/biological/chemical devices being used against military personnel and civilian targets. The highly-adaptable multi-mission UGVs designed by ARGUS Robotics support a wide range of uses such as generator power, lights, security sensors, camera systems, and debris removal during severe natural disasters such as earthquakes, hurricanes, and tsunamis.

The fully robotic ARGUS UGVs also assist humanitarian demining work. A dual set of controls, manual and robotic, provides support for wounded soldiers, whereby amputee soldiers can control the vehicle's function from their wheelchair. Contrary to the steady development of unmanned aircraft, UMS technology has experienced a slower progress.

However, a significant increase in the application of UMSs is anticipated during the next decade. These surface and submersible maritime vehicles provide enhanced capabilities for commercial and governmental maritime operations. Governmental applications aim to preserve public safety and security, and provide response to different emergencies. Remotely-operated vessels are particularly desirable for hostile maritime environments, or areas contaminated by nuclear, biological or chemical agents; in which deploying a crewed vessel is ill-advised. A key challenge for the global introduction of unmanned maritime technology is the integration of UMSs into current manned maritime procedures so that the operations are safe.
UAVs also give support in a large variety of Government and civilian missions, such as border surveillance and security, weather monitoring, communications relay, law enforcement, environmental monitoring, aerial mapping, firefighting, and others. UAVs have typically been assigned the 'dull, dirty, dangerous' missions in order to minimise human exposure to hazards. An example of a multi-mission UAV recently introduced into the commercial market is the MA THOR by Marques Aviation. ■

About the Authors

John Cunningham is the Owner and Founder of Area Reconnaissance Ground and Urban Support Robotics (ARGUS), USA. John received his BS degree from West Virginia University in Mining Engineering and MS Degree from Marshall University in Technology Management-Manufacturing. For 24 years John oversaw design and manufacturing of thousands of wheeled and tracked commercial construction vehicles for domestic and international markets. The US Department of Defense approached John requesting commercial vehicles to be made in both manual and robotic functions for anti-IED efforts. Such vehicles were quickly made and exceeded all key point parameters. From this request a series of vehicles have been designed on a common platform to meet a wide range of security and humanitarian needs around the world.

Dr Pascual Marqués is the Owner and Executive Director at Marques Aviation Ltd (UK) and the International Director (United Kingdom) of Unmanned Vehicle University. Dr Marqués is an expert in Aerodynamics and Flight Stability. At Marques Aviation Ltd he oversees the design and manufacture of novel fixed-wing and rotor unmanned aircraft developed by the company. Dr Marqués acts as the Chair for the World Congress on Unmanned Systems Engineering (WCUSEng) and the International Aerospace Engineering Conference (IAEC). He is also the Editor-in-Chief of the International Journal of Unmanned Systems Engineering (IJUSEng). Dr Marqués regularly lectures in Aerodynamics and Numerical Analysis at Unmanned Vehicle University where he is a member of Faculty.

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