UAS FOR MARITIME PATROL AND SECURITY CRAFT

It is estimated that patrol and security craft in the 10-70m size range will continue to serve the world’s Navies and Coast Guards in large numbers over the next 20 years. These platforms typically lack the sensor and operating range of larger ships, limiting their operational effectiveness. However, technological advances in UAS – specifically small and micro-UAS – promise to make the 10-70m patrol ships a more influential part of future fleet mix (see figure 1). This article reviews current trends in maritime UAS for smaller ships and craft.

EXCITING NEW ERA IN SIGHT FOR MARITIME UAS

The 10-70m segment will continue to be the largest segment of the global naval market in the coming two decades as measured by hulls in the water. AMI counts 3,596 10-70m hulls in service worldwide today, and forecasts at least another 1,600 new-build hulls in this segment will join fleets worldwide over the next 20 years (see figures 2-A and 2-B).

Current UAS would significantly extend intelligence surveillance and reconnaissance coverage, yet few are designed or offered to this important patrol and security craft market segment. Severe space restrictions and lack of flight decks typical of 10-70m craft have hindered adapting UAS for on-board operation.

A sea change is in sight for small shipborne UAS as increasing demand, emerging requirements, and new technologies are combining to increase options for operating UAS on 10-70m craft to facilitate local, real-time monitoring of maritime interests from even the smallest naval and security platforms. Successful UAS operations from patrol craft require an effective means of launch and recovery configured to the extremely limited space available. Space and crew limitations on 10-70m craft will likely require select crew members to double as UAS controllers and handlers.

Recognising this limitation, many companies are developing UAS features that require less manpower and operator training – autonomous take-off and landing, reprogrammable waypoint navigation, obstacle avoidance, and communications loss return-to-ship function. Airframe designs are increasingly compact and highly durable, enhancing UAS survivability necessitated by repeated hard net and water landings. UAS power systems are evolving with longer-life batteries offering hours of flight time now widely available.

Larger patrol ship designs such as Damen Group’s modular Stan Patrol 4207 and 4708 designs, DCNS’ mission-configurable GOWIND corvette or the inherently versatile PV 80 design from Germany’s Fr. Lürssen Werft offer a wider variety of flight deck options (see figure 3).

However, current sea-based UAS airframe and sensor options still cover relatively limited mission profiles, requiring Navies to weigh acquisition of more expensive multi-mission manned helicopters, or potentially greater numbers of less costly and versatile maritime UAS to achieve a platform mix that fully meets the sea-based mission requirement. For many emerging naval fleets, acquiring sea-based UAS that enhance the capability of current and future patrol vessels appears a matter of time, requirements definition, and available budget.

UAS PERFORMED IN PATROL CRAFT TRIALS

The Portuguese Navy conducted a series of concept demonstrations with sea-based UAS between 2003 and 2009. These trials sought a solution to improve the surveillance capability of its 27m “Argos” and 28m “Centauro” class fast patrol craft with a small UAS (see figure 4-A). Flying geo-referenced imaging missions, the UAS would provide real-time video transmission to the patrol boat. An initial search for existing suitable platforms proved fruitless, none meeting operational requirements for hard (controlled crash) landing, 32nm range, 1.8m maximum wingspan, 6kg take-off weight, and...
Figure 2-A: Miniature UAS can be easily deployed from the Multi Role Tactical Platform (MRTFP) range of fast attack craft built by the Turkish shipbuilder Yonca-Onuk, JV for Egypt, Pakistan, and Georgia (shown).

Figure 2-B: AUSTAL's 78.8m long MRV 80 (Multi Role Vessel) fits into the category of advanced multi-purpose vessel designs coupling high-speed and superior seakeeping performance with unparalleled deck space for small unmanned aircraft. (Photos: Courtesy of Yonca-Onuk; AUSTAL)

most importantly low cost. With no viable off-the-shelf military-grade solution available at the time, the Portuguese Navy tested a commercially available R/C aircraft trainer design acquired from Multiplex. Students and staff from the Portuguese Naval Academy extensively modified the aircraft. Video cameras, navigation, and flight stabilisation systems were installed and water sealed in the event of a sea landing. "We were aiming at producing a system for under €6,000", Victor Lobo, Director of the Portuguese Naval Research Centre, said. "We managed to get a working system, including airframe, motor, sensors, and control systems, for just over €3,000", he said.

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Advanced platforms like the PV 80 patrol vessel design Fr. Lüerssen Werft developed for the Royal Brunei Navy (pictured here is the first-of-class “Darussalam”) offer the possibility to deploy UAS capable of carrying area search radars for wider EEZ patrols. (Photo: Courtesy of Fr. Lüerssen Werft)

Figure 4-A: The Portuguese Navy tested a small commercially available R/C aircraft trainer design from one of its “Centauro” class coastal fast patrol craft.

Hand-launched from the forecastle deck, the UAS was recovered by a nylon net strung over the patrol craft stern area (see figure 4-B). According to Lobo, after practice, the boat crew became quite proficient in setting up the landing net, eventually in less than five minutes. During the demonstration, over 100 successful recoveries were made with minimal disruption to shipboard operations, including use of the RIB. Flight tests were successfully carried out in weather conditions ranging from calm to heavy rain with high wind gusts.

According to Lobo, UAS interference with ship systems was a concern, although the UAS control system had no effect on patrol craft communications, navigation, and radar systems. “We were afraid of that, but everything worked perfectly”, he said. The demonstration’s high success rate validated the concept. The inherently buoyant UAS survived multiple net and sea landings without damage. Maritime air patrol missions have since been tasked to the Air Force, now using a land-based ‘Alpha-Extended’ UAS developed in part from the Navy’s research, Lobo explained.

In other small boat UAS compatibility trials, similar to the Portuguese Navy demonstrations, a Boeing/Insitu ScanEagle fixed-wing, miniature UAS was operated by contractors from a US Navy Mark V 25m craft in 2008 and 2011 (see again figure 4). During the 2011 exercise, ScanEagle’s ability to launch and recover on a small craft was validated although photos clearly show most of the open stern space was occupied by the UAS. A new Compact Launch and Recovery System (CLRE) intended for use on smaller naval vessels was tested in October 2011 (see figure 5).

UAS technology and advanced designs are now overcoming operational and performance constraints that previously restricted operations from small boats. New systems, many quite innovative, are making an appearance with more to be expected in the near future. While UAS mission payload is a critical factor, deck load, fuel type, and footprint limitations inherent to
The system was FQM-151.

Fig. 6: The AQUA PUMA miniature launched and recovered by hand, lands directly onto the sea surface. It is a next-generation FOM-151 POINTER, with the same form factor but increased endurance (1.5 hours) and enhanced sensor capability.

The system was successfully tested from HMAS "Armidale" for the Royal Australian Navy to explore adding a UAS capability to the Navy's "Armidale" class patrol boats.

(Photo: Courtesy of Royal Australian Navy/AeroVironment Inc.)

smaller patrol craft necessitate trade-offs between rotary-wing and fixed-wing UAS capability. Appropriate systems will offer lower cost, quick set up, reliable launch, and recovery in confined areas, and operate as organic patrol craft assets. The most successful will seamlessly extend surveillance while requiring no special actions on part of the patrol craft or crew to deploy, operate, and recover.

OPTIONS FOR MARITIME FIXED-WING UAS

A re-designed version of AeroVironment's fixed-wing electric WASP AE Micro Air Vehicle (MAV), the WASP III, is modified to operate in a maritime environment. With a wingspan of 72.3cm, the hand-launched air vehicle offers 50 minutes of flight time and 2.8m line-of-sight range, doubled by use of a direct download link (DDL) relay. For surveillance missions, the UAS has a modular payload capability. Operable from even the smallest craft, the system is recovered by deep stall or conventional recovery. To aid landing manoeuvres, the waterproof UAS is uniquely equipped with a forward-facing camera.

Also hand-launched and electric-powered, AeroVironment's PUMA AE has a longer two hour flight time and 15km range. The company's AQUA PUMA Small Unmanned Aircraft System (SUAS) completed sea trials with the Royal Australian Navy in 2007 (see figure 6). Larger than WASP, the PUMA is 1.4m in length with a 2.8m wingspan. Also waterproofed to survive recovery at sea, the PUMA lands automatically. Both are capable of autonomous operations sharing a small man-portable common ground control system. Eighteen nations outside the US have purchased AeroVironment's PUMA AE, WASP or RAVEN B small UAS.

Shipboard operations were taken into consideration when designing the flying wing-shaped RESOLUTION 3 UAS (see figure 7). Developed by Alaska-based Airborne Technologies Inc. (ATI), the system is used for maritime observation by the US National Oceanic and Atmospheric Administration (NOAA). Extensively launched and flight-tested in winds from 25-30 knots, the air vehicle has been operated from civilian and NOAA ships ranging in size from 10m to 80m. Made of molded composites and Kevlar, the electric-powered UAS weighs 3kg empty (with 7kg gross weight) and its centre section area is of roughly 40x61cm. Also recovered by sea landing, the UAS is launched by bungee or proprietary catapult system. Depending upon batteries, the system offers up to three hours endurance. The ground control station provides interactive moving map, real-time glass cockpit display, and a 3D synthetic flight view. The UAS can be equipped with a flexible sensor package capable of autonomously detecting and mapping objects on or near the water surface.

Fig. 8: The ORBITER 2 UAS can carry a variety of optical payloads, including the M-STAMP EO miniature, lightweight, multi-sensor payload. Controp Precision Technologies specifically developed for use on-board SUAS.

(Photo: Courtesy of Aeronautics Defense Systems/Controp Precision Technologies)

According to Tim Veenstra, ATI's President, "the RESOLUTION aircraft and system was built with the understanding of expecting a high attrition rate in maritime operations. They are certainly not considered throw away but losing an airframe would not break the bank." Veenstra noted the target price for a complete system, including ground station hardware and software, two airframes, launcher, communications, and training, will range between US$65,000-85,000. A single replacement airframe cost is approximately US$15,000. The entire system is transportable in ruggedised cases similar in size to airline luggage. ATI is testing a new UAS sensor package that NOAA will use to search for debris from the 2011 Japanese tsunami possibly still circulating in the Pacific.
Intent on flying medium-range unmanned aerial reconnaissance missions from smaller patrol boats, the Israeli Navy in 2010 adopted the Aeronautics Defense Systems (ADS) ORBITER 2 UAS (see figure 8). With automatic launch by catapult for maritime missions, the UAS is fully waterproofed and floats with the aid of an airbag. After parachute descent and recovery at sea, the vehicle can be quickly returned to service. The system has a 3m wingspan and 9kg maximum take-off weight. Electric-powered, the ORBITER 2 has a 70-knot maximum speed. Endurance is four hours with range from 15 to 45nm. A handheld ground control station (GCS) displays real-time control and video. In data link configuration, the ORBITER 2 can operate beyond 43nm using auto-tracking directional communications.

Eyeing global opportunities, in 2011, a joint venture between ADS and Azerbaijan’s Defence Industry Ministry was formed to produce and market the ORBITER 2 beyond Israel’s traditional sphere of business operations. Another recent success in May 2012 saw Finland order 55 systems in a deal estimated to be worth €23 million. Meanwhile, the Israeli Navy is reportedly seeking a small UAS to equip its SUPER DVORA fast patrol boats, potentially launching the OBSERVER 2 positioned across from the stern area. Each system includes three flight vehicles.

In production since 2010, the Aerovisión-Thales Maritime FULMAR system is a relatively compact, medium-endurance UAS also featuring a flying wing design (see figure 9). The Maritime FULMAR is 1.23m long with a 3.10m wingspan. A two-stroke internal combustion gasoline engine propels the air vehicle at speeds from 60 to 150km/hr. Cruising for up to eight hours, 445nm can be covered with full payload. Recovered via sea landing on a pneumatic ski, the vehicle is fully waterproofed. A satellite radio beacon aids recovery location tracking. Equipped with redundant GPS and internal navigation, flight plans are reprogrammable while airborne. Security routines for forced landings due to communications or power failure are pre-programmed. The UAS is data-linked with its notebook PC-based control station for up to 55nm before switching to autopilot. From a distance to 28nm, the air vehicle can transmit real-time video at 2.4GHz. Two persons can prepare the control system, collapsible directional and video antenna, UAS, and launcher for flight operations in 30 minutes. For long-range missions, the GCS can be networked using TCP/IP at intervals of up to 55nm. THALES is marketing the UAS as a wholly European-developed maritime border security solution. The FULMAR is used by Malaysia for surveillance of the Malacca Straits.

**VTUAV OPTIONS**

Designed as a maritime VTOL UAS by the Spanish company Indra, the PELICANO was unveiled during flight tests in 2012 (see figure 10). With a length of 4m, the aircraft requires a small flight deck for operations. Capable of fully autonomous flight, the UAS can take-off and land automatically in bad weather. The UAS can carry EO, IR, light radar, and chemical/biological agent sensors. These components can be integrated with the launch vessel command system, extending patrol craft sensor range. Three to four air vehicles and ground control station comprise a complete system.

The PELICANO UAS could eventually be adopted by the Spanish Navy and operated from the new "Meteor" class OPV (Buque de Acción Naval Marítima or BAM) and Civil Guard maritime patrol boats. However, size constraints and a general lack of flight deck-equipped craft in the 10-80nm ranges will restrict widespread use of larger VTOL UAS such as Indra’s PELICANO and CybAero’s APID60 systems as well as Saab’s SKELDAR, Schiebel’s S-100 CAMCOPTER, and CASSIDIAN’s TANAN systems to a very few platforms. Smaller VTUAV providing less capability, yet able to operate from confined spaces in a maritime environment are beginning to enter the market.

Released commercially in January 2012, the Pulse Aerospace PA-01 VAPOR electric unmanned helicopter system is such a system. Less than 1.4m in length, excluding rotor, the PA-01 weighs 6.3kg. Built to industrial and military standards, an aluminum and carbon fibre chassis protect internal components. A variety of high-definition optical sensors, including laser radar (LIDAR) and IR, can be mounted to the UAS TASE 150 series gimbal. The system has a 45-minute flight time and offers re-programmable, autonomous operations with a choice of two control suites. Multiple modes, including a point-and-click, map-based, GCS software package and manual line-of-sight control, can be used. Navigation is redundant, using both GPS and the GLONASS receiver. The helicopter UAS system is transported in compact hardened containers.

[Ed.: Another example is Oto Melara’s TRP5 IBIS mini-UAS (see figure 11). Oto Melara cooperated with Céline Avio to develop this small
Fig. 12: Using a heavy fuel or gasoline-powered engine, the V-BAT drone has a 90km/hr dash speed, 400nm range, and is fully autonomous (figure 12-A). Figure 12-B shows an aerial picture taken by a BAT drone. Showing an LCAC and a variety of military vehicles on the beach. (Photo: Courtesy of MLB Company)

electrically powered VTUAV, which the company claims is virtually silent and has a negligible IR signature because of the lack of a combustion engine or high-temperature exhausts or fumes. Payload capacity is quoted at 3kg.

**MARITIME-CAPABLE HYBRIDS**

A number of innovative designs combining the benefits of VTOL and conventional flight are emerging. The capability to transform from vertical to horizontal flight can provide greater range, speed, and flexibility for the naval customer. In pursuit of such a capability, the Office of Naval Research (ONR) teamed with AeroVelo Corporation to develop the FLEXROTOR VTOL UAS. Lifted vertically by an oversize propeller and once airborne the FLEXROTOR drone transitions to cruising flight mode, relying on conventional aircraft-type wings for lift. A specialised autonomous Automatic Servicing Platform (ASP) used for take-off, landing, maintenance, and storage was developed as a separate Navy initiative. Requiring approximately half the deck space of current UAS, smaller US Navy ships could deploy the hybrid. The UAS has a 3m span, 80km cruise speed, and 40 hours endurance. Using the ASP, all operations can be conducted autonomously. In April 2012, the ONR funded the second developmental phase intending to upgrade propulsion systems to enable landing in strong crosswinds. At less than 25kg, the UAS falls into a weight class allowing operation by enlisted sailors without special rating.

**The Recovery Issue**

Keeping a firm hand on the terrorist and piracy plague will be highly dependent upon modern UAS technology. The security community sees their employment (be they either used by port authorities or even regular Coast Guards) as an effective measure to fight against disorder at sea. At-sea patrols can be ideally carried out by employing small sensor-equipped UAS operating in cooperation with seagoing patrols in coastal waters and harbours, near or at critical chokepoints, along major streams, or on the high seas. The lack of proper recovery systems aboard naval ships for fixed-wing UAS could have been the principal reason for the lack of a sound shipborne fixed-wing UAS. Their secure landing and recovery aboard naval vessels is often seen by the maritime community as the decisive factor to select a shipboard UAS system for their ISR needs. Some existing fixed-wing UAS have clearly demonstrated their capability to land on small-deck ships. One such example is the SILVER FOX close in UAS originally developed by Advanced Ceramics Research (ACR), which was purchased by BAE Systems in 2009 (see figure 15). The air vehicle is a gas-electric-powered unmanned system with eight to 10 hours endurance, weighing about 11 kg. It is catapult-launched and recovered by a net.

A problematic example may be US Navy's RQ-2B PIONEER UAS, which is recovered onboard a surface ship via vertical nets into which the air vehicle is landing (crashing) at a speed of nearly 70 knots, thus commonly damaging the vehicle or its avionics. During recent operations, there were incidents during which the air vehicle did not manage to hit the net. Such an air vehicle coping with turbulence effects behind a ship's superstructure and high sea states will not be able to hover above a surface warship's small deck like a naval helicopter or even a rotary-wing UAS. Therefore, a vehicle capable of thrust-vectoring or slowing down to helicopter-like speeds is needed to solve the problem. But rotary-wing or helicopter UAS were often seen as problematic due to their inherent instability and relatively high risk of exposing their rotor blades to shipboard personnel.

Source: Stefan Nitschke

Fig. 13: Ruggedised and weather-sealed, the Aeryon SCOUT micro-VTOL UAV is able to operate in extreme temperatures (-30C to +50C) with sustained winds up to 50km/h or gusts up to 80km/h. (Photo: Courtesy of Aeryon Labs Inc.)
Another hybrid design, the V-BAT from California-based MLB Company, has a rear-mounted ducted fan for lift, propulsion, and stabilisation (see figure 12). Similar to FLEXROTOR, after vertical take-off, V-BAT transitions to conventional flight. Weighing 25kg, the UAS can remain airborne for 10 hours. Marketed for shipboard operations, V-BAT requires a 6mx6m vertical take-off and landing area. According to MLB literature, each system comprises a flight vehicle, TASE 300 gimbal, and GCS. The V-BAT is delivered flight ready at a cost of US$320,000. An electric-powered version was tested in 2012.

Fig. 14: At least three ALADIN miniature UAS configured with different sensor payloads for day and night reconnaissance missions can be stored together with the swivel-mounted launching catapult in the two-stage pressure-proof container, with an inner diameter of 800mm and a height of 3m.
(Photograph courtesy of Gabler Maschinenbau GmbH)

In November 2012, Challis Heliplane UAV Inc., a Canadian UAS design firm, launched the newly developed E950 electric hybrid helicopter drone. Blending the stable hovering characteristics of a conventional helicopter and the high cruise speed capabilities of an airplane, the UAS resembles a helicopter with the forward facing propeller. At high speed, the single wing on the retracting blade side of the craft counters lift asymmetry. The E950 has 8.1m range and one-hour flight time. With 25kg maximum gross weight, the helicopter drone hybrid has a 10kg payload capability. EO and IR cameras are housed in a three-axis stabilised system. Take-off and landing are autonomous, navigational waypoints can pre-progamme using ground control software. Almost twice as fast as a conventional helicopter, the UAS is able respond quickly and keep pace with high-speed watercraft in an EEZ border security capacity. According to Doug Challis, President of Challis Heliplane UAV, “the E950 could maintain view on a speedboat from a sighting height of 1,500m and be capable of very high-speed shallow dive toward the target at 200km/hr.” The cost for the E950 autopilot system, including UAS, GCS, and a two week training course is approximately CAD$85,000.

THE FUTURE IS MICRO

Tested aboard a ship in the harsh Bering Sea environment, Canadian-based Aeryon Labs’ Aeryon SCOUT micro-VTOL UAV was successfully launched and retrieved in 3-4m sea swells. Electric-powered with rear silent operation, the 1.3kg UAS has a 25-minute flight time (see figure 13). Autonomous capabilities and point-and-click navigation and camera controls use an all-digital encrypted network. Operable from areas with limited deck space, SCOUT requires no special launch or recovery equipment. Immediately deployable from a 150mm diameter protective launch container or by hand, Florida-based Prioria Robotics’ MAVERIC is a compact, highly automated UAS. Extending upon launch, MAVERIC’s wings bend around the carbon fibre fuselage for storage. With a length at 79cm wingspan and 1.16kg weight, the vehicle has 45-70-minute flight endurance. The UAS is capable of fully autonomous operation from launch to landing based on programmable waypoints. Normally landed by deep stall, the MAVERIC has also been recovered aboard ships using a net trap system. According to Christopher Norris, Prioria Robotics’ Business Development Executive, a complete MAVERIC UAS system starts at approximately US$150,000, including three air vehicles and a control station. A single system with an analogue camera is available for approximately $73,000.

[Ed.: Submarine-launched mini-UAS can provide a coherent C4ISR capability. EMT’s ALADIN miniature UAS was successfully evaluated with the VOLANS launching equipment developed by Gabler Maschinenbau GmbH during flight testing in 2007 (see figure 14). With its take-off weight of 3kg, the fully autonomous unarmed system can be operated over distances of over 75nm (flown over sea and over land) at a typical altitude of 30 to 300m. Carrying an integral EO payload, the UAS could be employed to eliminate the submarine’s limitations – while operating near the shoreline – in observing objects or areas of interest which are masked by terrain. The detection range of a submarine using traditional optrons (0.5m above the water surface) could be increased from the approximately 3-5nm to over 38nm, when a submarine-launched UAS is watching at targets at an altitude of 300m.]