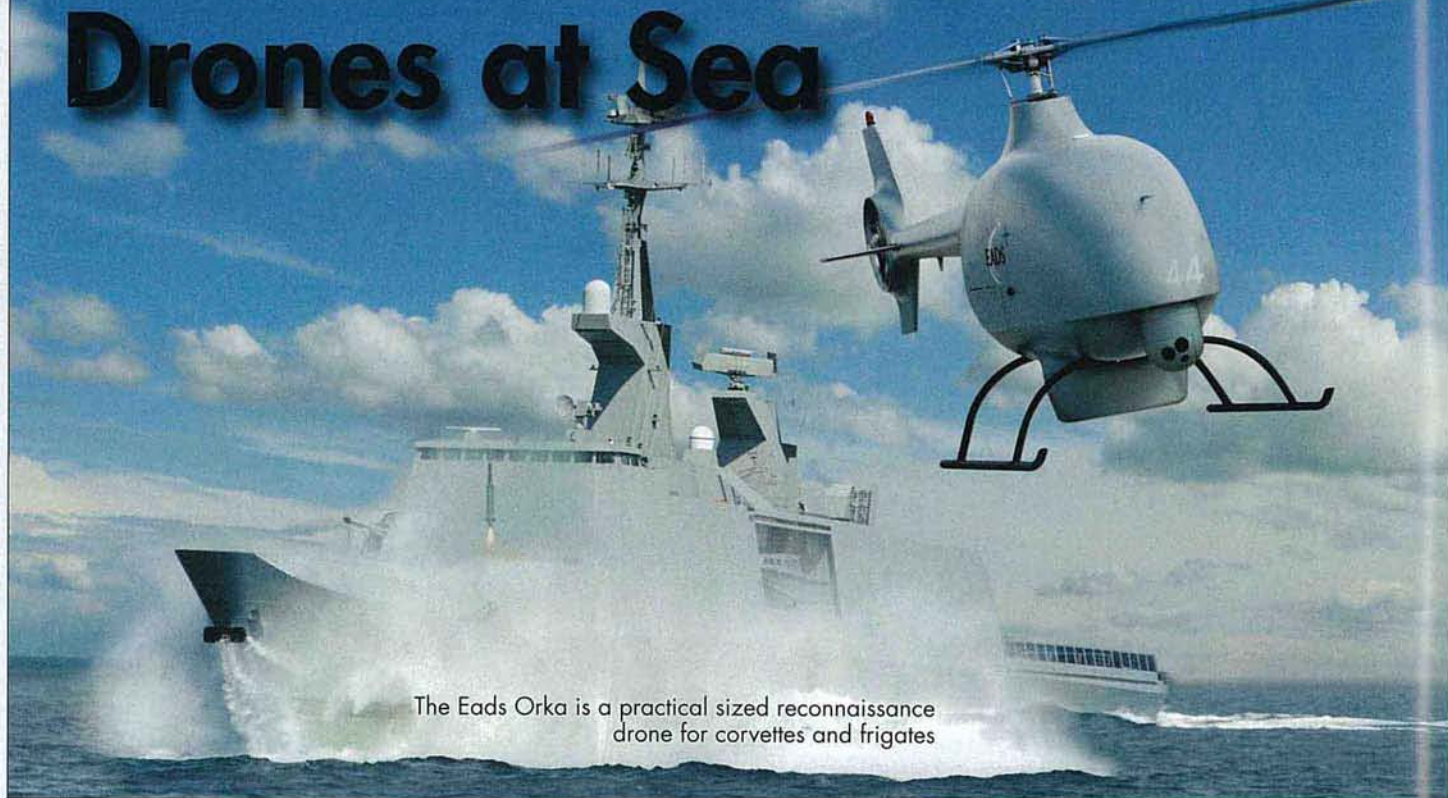


Drones at Sea



The Eads Orka is a practical sized reconnaissance drone for corvettes and frigates

Unmanned aircraft can provide small vessels with imagery from beyond the horizon, increasing their potential strike range while reducing vulnerability to surprise attacks. The naval community is warming up to the rotary-wing concept.

Roy Braybrook

Ship-based drones have for decades acted as targets. In principle, they can also provide sea/land surveillance and targeting at short-to-medium ranges, complementing the wider but less detailed situational awareness provided by ground- and space-based assets. They may be used for communications relay, battle damage assessment and to direct fire support for amphibious forces. In the longer term, ship-based Ucavs (unmanned combat air vehicles) will perform anti-shipping strikes and first-day-of-war attacks against ground-based air defence systems.

The first ship-launched unmanned aircraft was the Fairey Queen radio-controlled gunnery trainer of the 1930s, followed by the de Havilland DH.82B Queen Bee target, of which over 380 were delivered in 1943-44. Both were used by Britain's Royal Navy.

The next significant use of naval drones occurred early in the 1960s, when the US Navy introduced the 1155-kg Gyrodyne QH-50 Dash (Drone Anti-Submarine Helicopter) torpedo platform. Reports indicate that in total 746 QH-50s were delivered, of which 411 were lost in accidents.

In 1968 and 1969 the US Navy used camera-equipped QH-50Ds for surveillance and gun-spotting over Vietnam. However, weapon delivery remained the

drone's primary mission, and in 1969 the Dash was withdrawn from US Navy service in favour of the Honeywell Asroc (Anti-Submarine ROcket) system, which could ballistically deliver torpedoes or a nuclear depth bomb. Darpa continued to operate QH-50Ds over Vietnam between 1969 and 1972, and the US Army used the QH-50 as a drone controller/trainer until 2006.

Gyrodyne technology passed via licence agreements to other drone developers, notably IAI (now Israel Aerospace Industries) for its Hellstar project, and Eads-Dornier for the Seamos (See-Aufklärungsmittel und Ortungssystem) radar platform.

Designed to provide reconnaissance and target acquisition for the forthcoming K-130 corvettes, the 1100-kg Seamos was originally to have entered service in 2005. Automatic take-offs and landings on a simulated moving deck were reportedly carried out successfully, but BWB funding was terminated in 2002. Planned developments included the introduction of the Rolls-Royce 250-C20 turboshaft engine.

Another now-defunct naval drone project using contra-rotating rotors was Canada's Bombardier CL-227 Sentinel, the shape of which inspired its nickname 'Flying Peanut'.

In the last 40 years control systems have made substantial advances, and accident rates in all aircraft categories have fallen dramatically. However, night-

time carrier landings remain the most dangerous aspect of aviation, hence there is strong case for drones replacing manned naval aircraft.

Not all navies recognise the need for drones. In 2005-2006 Britain's Royal Navy and a contractor team led by Thales UK carried out the Juep (Joint UAV Experimentation Programme) trials, operating a Boeing Scaneagle from the Type 23 frigate HMS *Sutherland* (F81). In early 2007 an Urgent Operational Requirement was drafted by the Ministry of Defence for a maritime drone to provide persistent situational awareness in support of British operations in the northern Persian Gulf. However, this failed to win funding and was subsequently shelved, although the House of Commons Defence Committee has recently called for an explanation of this decision.

Pioneers

Israel was responsible for a great deal of early drone development, driven by the threat of Arab-operated, Soviet-built, ground-based air-defence systems. When the US Navy attempted to project power over the Lebanon in late 1983, the service quickly lost three aircraft to Soviet Sams, and found it had no means to safely direct naval gunfire at Syrian positions. Looking for a quick solution, it was decided to navalise the ground-based Israeli drones that had been used successfully over Lebanon in 1982.

Following US Marine Corps trials with the Mazlat Mastiff III in 1984, in late 1986 the US Navy introduced an IAI design, built by AAI as the 205-kg RQ-2 Pioneer, on the battleship USS *Iowa*. The RQ-2 served on all three US Navy battleships



Most ship-based drones are rail-launched, as instanced by this 221-kg AAI Shadow 400 about to depart (left) from the rear deck of a Republic of Korea Navy vessel. Recovery is performed by remotely piloting the drone into a large vertical net, a technique developed for the same manufacturer's RQ-2 Pioneer. (AAI)

and was purchased by the US Marine Corps for use from the Tarawa class LHAs. For ship operations, the RQ-2 used rocket-assisted take-off and landed into a vertical net.

The US Navy ended RQ-2 operations only in 2002, transferring these assets to the Marine Corps. The latter's VMU-2 still operates some RQ-2Bs (alongside later designs) from Camp Al Taqaddum in Iraq.

A hydraulic catapult and net recovery are used by the Republic of Korea Navy to operate the 211-kg AAI Shadow 400, which has an endurance of five hours.

An advanced net-based recovery system is being developed for the 12.2-kg Advanced Ceramics Research Silver Fox, which was funded by the Office of Naval Research for possible use in ship security and harbour patrol duties. The existing Silver Fox Block 4, as used by the US Navy's Special Clearance Team One, can also be catapulted from an eleven-metre rigid inflatable boat. At the end of the sortie it then ditches in the sea.

Another drone designed to be recovered by ditching (launched by being catapulted from its container) is the 36-kg DRS Technologies Neptune, which first flew in January 2002. A number of Neptune systems were purchased by the US Navy in 2002 and 2003.

Taking water-compatibility one stage further, some drones have been designed to take off from the sea. Examples include the 70-kg Warrior (Aero-Marine) Gull 36 UXV, which is an amphibian, and the 135-kg Oregon Iron Works Sea Scout, which is a flying boat designed for use by special forces. In recovery, the Sea Scout uses auto-landing avionics by Geneva Aerospace and a laser-radar to measure wave height.

The latter company's auto-landing system has also been used in runway trials of its own 109-kg Dakota drone, the development of which was funded by the US Naval Research Laboratory. There are indications that the same system is to be used in shipboard landing tests with a larger air vehicle.

A novel launch and recovery system was developed by Insitu (now a Boeing company) for the Scaneagle, which is employed by the US Navy in a contractor-furnished service to provide persistent intelligence, surveillance and reconnaissance (ISR) for expeditionary operations.

Following launch from a Superwedge pneumatic catapult, the long-endurance, GPS-guided, 20-kg Scaneagle is recovered by means of a patented skyhook system. Remotely piloted in the terminal phase, using the camera (EO or IR) in the drone turret, the Scaneagle is flown to engage either of the spring-loaded claws on its wingtips with a 15-metre rope suspended from a boom on the ship.

In September 2007 it was stated that the Scaneagles had made over 700 skyhook recoveries to US Navy vessels. Largely in support of the US Marine Corps, Scaneagles have now flown over 7000 sorties, totalling over 100,000 combat flight hours.

The current gasoline-engined Scaneagle Block D is claimed to be the smallest drone equipped with an inertially stabilised EO/IR turret. Compared to earlier models, it also has an increased resolution infrared camera, a Mode-C transponder for air traffic control, a new

video transmitter and Rover III compatibility to allow control by forward operators. It has a ceiling of 16,000 ft and cruises at 90 km/h, with a dash capability of 140 km/h.

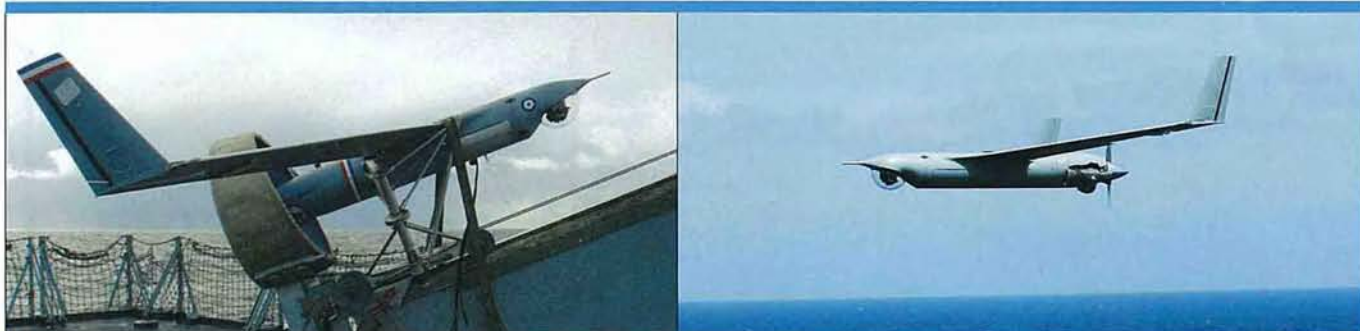
The Block D made a flight of over 22 hours in late 2006, and in early 2007 a Scaneagle with a heavy fuel engine exceeded 28 hours. Boeing is studying a range of sensor options, including a synthetic aperture radar, a magnetic anomaly detector and a sensor to detect chemical and biological traces in the atmosphere.

The Scaneagle is already required to be capable of transmitting imagery and data to the US Navy's Boeing P-8A Poseidon maritime patrol aircraft and Australia's Boeing 737 AEW&C Wedgetail. At a later stage such aircraft may also be required to control the drone. Boeing is studying a compressed-carriage version for the US Special Operations Command, and the possibility of underwater launch.

The US Navy plans to employ the Scaneagle on Aegis class cruisers and possibly FFG-7 class frigates for fleet protection. Both Navy and Marine Corps Scaneagles are to be superseded by the Small Tactical Unmanned Aircraft System (Stuas, or Tier II in Marine Corps



In 2007 BAE Systems released preliminary details of its proposed 8000-tonne UXV Combatant ship, designed to operate large numbers of fixed- and rotary-wing drones for extended periods. (BAE Systems)



The 20-kg Boeing/Insitu Scaneagle drone is launched from a pneumatic Superwedge catapult, pictured here during British trials from the Royal Navy's Type 23 frigate HMS Sutherland. The drone is to be deployed aboard US Navy Aegis class cruisers and possibly FFG-7 class frigates for fleet protection. (Boeing)

parlance), a 70-kg class drone with a heavy-fuel engine. The leading contenders are thought to be the 59-kg Boeing/Insitu Integrator, the 62-kg Raytheon/Swift Engineering Killerbee and a derivative of the AAI Aerosonde. All three would be rail-launched, the Integrator being recovered by skyhook and the others by net. Initial contract award is expected in mid-2009.

Rotary Wings

The need for catapult and arrestor devices can be avoided by designing the drone for vtol. This is normally achieved by use of rotary wings, as in the cases of the QH-50, Seamos and CL-227 projects mentioned earlier.

One fundamental disadvantage of a helicopter is that the combined weight of powerplant, transmission system and rotors penalises the amount of fuel that can be carried, thus limiting range and endurance. In addition, rotors generally restrict forward speed, due to the forma-



Seen in this artist's impression with the HSV-2 Swift wave-piercing catamaran demonstrator, the Northrop Grumman MQ-8B Fire Scout will equip the US Navy's Littoral Combat Ships. (Northrop Grumman)

tion of shock waves on the advancing tip and stalling of the inboard section of the retreating blade.

A breakthrough in helicopter performance is promised via the 'optimal speed rotor system' of the 2950-kg Boeing A160T Hummingbird, which has been funded by Darpa and the US Naval Air Warfare Center. The A160T was designed to achieve an unrefuelled range of 4600 km, an endurance of 24 hours with a 135-kg payload and a speed of 260 km/h at 30,000 ft. It first flew in June 2007, and has already demonstrated a flight of 18.7 hours and hovered out of ground effect at 20,000 ft.

High speeds can be achieved by a compound helicopter, which uses a small fixed wing to reduce the lift that the rotor has to generate in forward flight. (A stub wing is to be tested on the A160T, mainly to provide weapon mountings). In addition, both Sikorsky and Mil are developing helicopters with pusher propellers at the rear, to reduce the forward thrust component that the main rotor has to generate. It may also be noted that the Mil design bureau has recently patented an invention to reduce retreating blade stall.

A tilt-rotor drone, a category led by the Bell Eagle Eye, can achieve a maximum cruise speed of over 400 km/h. However, in October 2007 the US Coast Guard stopped funding Eagle Eye development, which was to have led to the purchase of up to 69 as part of its Deepwater re-equipment. In October 2008 the US Coast Guard issued a request for information on vtol drones that could operate from its new security cutters, complementing land-based fixed-wing drones such as the General Atomics MQ-9.

In many circumstances the performance limitations of a conventional helicopter are acceptable. One drone helicopter with excellent prospects is the 1430-kg Northrop Grumman MQ-8B Fire Scout, based on the (manned) Schweizer 333, and powered by a 313-kW Rolls-Royce 250 engine. The MQ-8B is aimed at the US Navy's VTUAV requirement to equip the Littoral Combat Ship, but it has also been selected by the US Army as its Class IV drone for the Future Combat System.

The US Navy has so far ordered two low-rate initial production (Lrip) batches of MQ-8Bs. Technical evaluation is due to

start on an FFG-7 class frigate in early 2009, followed by operational evaluation and initial operational capability before the end of 2009.

The baseline US Navy MQ-8B has a Flir Systems Brite Star II EO/IR sensor and a Tactical Common Data Link, but the service plans to start development of a multi-mode maritime radar for the drone in FY09. Northrop Grumman has already demonstrated a Telephonics RDR-1700B radar on its company-owned Fire Scout demonstrator (P6).



The Volans concept, being developed by EMT and Gabler, would house an Aladin drone and rail in a mast-mounted container, allowing a submarine to launch from periscope depth. (Gabler/EMT)

The success of the MQ-8 demonstrates that the cost and risks involved in developing a drone helicopter in the one-tonne class can be minimised by basing the design on a well-proven manned aircraft. On similar lines, IAI's Malat division is developing a naval rotary unmanned air vehicle (Nruav) for the Indian Navy based on the Hindustan Aeronautics (Hal) Chetak (Alouette III). Planned payloads include an IAI/Elta radar and a Tamam Mosp optronic sensor. The production conversions would be carried out by Hal.

The first successful shipboard drone helicopter designed for the surveillance role was probably Austria's Schiebel Camcopter 5.1, four of which were sold to the Egyptian Navy in 2002. The 200-kg Camcopter S-100 is a much-improved derivative; now in production for, inter alia, the United Arab Emirates armed forces. It has a payload of 50 kg, an



The MQ-8B Fire Scout is illustrated in its primary role of sensor platform, transmitting imagery to US Marine Corps units on the ground and to US Navy ships providing fire support. (Northrop Grumman)

endurance of six hours and an operating radius of up to 180 km.

Schiebel is teamed with Thales UK in offering the S-100 against an eventual Royal Navy requirement, and with Diehl BGT Defence in promoting the S-100 for use from the German Navy's 1840-tonne Braunschweig class K-130 corvettes. The K-130 was designed from the outset with a helicopter pad and a small hangar to accommodate two drones.

Following studies in 2006 and 2007 of various drone helicopters proposed for the K-130s, Germany selected the S-100 as the basis for further investigation. In summer 2008 three one-week trials took place with an S-100 operating from a K-130 in the Baltic. This test series included over 130 sorties from the ship's helicopter pad, and over 20 hours of flying. In October 2008 France's DCNS successfully tested its Sada automatic deck landing and take-off system, using a Camcopter S-100 and the French Navy frigate *Montcalm*. The S-100 has also been tested from Indian, Pakistani and Spanish naval vessels.

Further European efforts to develop drone helicopters are illustrated by the Eads Defence & Security range (see the company's montage used as our title picture), notably the 1200-kg Orka, which is aimed at a forthcoming joint French Army/Navy requirement. In November 2006 France's DGA awarded a project definition study contract to Eads, which is working with Vertivision to develop the Orka on the basis of the two-seat Hélicoptères Guimbal Cabri. The system will include an automatic deck landing system. The Orka is designed for a payload of 150 kg and an endurance of eight hours.

The 190-kg Eads Shark is intended for smaller ships and non-military applications, and uses a scaled-down version of the coaxial rotor system developed for the Seamos (from the QH-50). The Shark is to have a 60-kg payload and an endurance of four hours. A prototype flew in June 2007. Eads is also working on the even smaller Scorpio family, which (like the Orka) uses a single main rotor. The principal models are the 13-kg Scorpio-6 and 40-kg Scorpio-30.

Sub-to-Air

Winged autonomous underwater vehicles (Auvs) are being developed to 'glide' like a fixed-wing aircraft, exploiting temperature variations in the ocean much as a sailplane uses atmospheric thermals for long-endurance unpowered flight. However, Auvs are outside the scope of the present discussion.



Israel Aerospace Industries' Malat division is developing a naval rotary unmanned air vehicle (Nruav) for the Indian Navy, based on the Hindustan Aeronautics-built Chetak (Alouette III). (Israel Aerospace Industries)



In 2008 a Schiebel S-100 carried out trials in the Baltic from a German Navy K-130 corvette, the 'BS' code on the helicopter pad indicating this was the first-of-class F260 Braunschweig. (Schiebel)

Lockheed Martin's Skunk Works led a team (including General Dynamics' Electric Boat division) that in 2005-2006 performed Darpa-funded risk-reduction work on its Cormorant drone, designed to be launched from the 211-cm Trident missile tubes of Ohio class submarines. The Cormorant is envisaged as a 4100-kg vehicle with a folding wing and a 13.3-kN turbofan engine. Designed primarily as a sensor platform, it would provide pre-strike reconnaissance and target damage assessment, and support special operations teams deployed from the submarine. The Cormorant would float to the surface, and then be launched into flight by boost motors. On completing its mission, it would descend by parachute, and be recovered to the submarine by a remotely-operated vehicle.

One alternative and less expensive approach would be to develop a submarine-launched capsule that can deploy an off-the-shelf folding-wing drone which is either not recovered or (in littoral warfare) would recover to a preplanned ground site.

Northrop Grumman's Stealthy Affordable Capsule System (Sacs) has received some funding from US Naval Sea Systems Command. Sacs is intended to launch 'non-marinised' drones and weapons from an SSGN submarine's 52-cm Tomahawk tube. In 2004 a Northrop Grumman Mald (Miniature Air-Launched Decoy) was successfully launched from the USS *Georgia* (SSGN-729) while submerged. The company is a member of the Team 2020 consortium, which aims to develop and demonstrate new technologies designed to enhance the effectiveness of future submarines.

Since late 2006 the US Navy's Space and Naval Warfare Systems Command (Sparwar) has been developing a 'canisterised' underwater launch system for drones of up to five kilograms, with tests initially using the Applied Research Associates Tacnav and Nighthawk. In this case the canister is taken to the sur-

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Reverting to a co-axial rotor system derived from that used on the Dornier Seamos radar platform, the 190-kg Eads Sharq is designed to operate from small vessels. (Eads)

face by an inflatable collar, which also stabilises its attitude on the surface.

EMT of Penzberg in Germany is working with Gabler Maschinenbau of Lübeck on a project named Volans (Verdeckte Optische Luftaufklärung Navalisiertes System), to allow a drone (a folding-wing 5.5-kg development of EMT's Aladin) to be launched from a submarine at periscope depth. A cylindrical container attached to a telescopic mast houses the drone, mounted on a short launch rail in a vertical attitude. Once the cylinder is above the surface, its lid opens and the drone/rail assembly is extended upward, which is then rotated to the horizontal for a fully autonomous launch.

Ucavs

Past attempts to develop a long-range, stealthy, carrier-based, manned strike aircraft have indicated that the result would be extremely expensive and undesirably heavy. However, a much lighter, less expensive drone might perform the same role, paving the way for follow-on attacks by less stealthy manned aircraft.

The feasibility of a 'Naval Ucas' is being investigated by the US Navy using two 20,200-kg Northrop Grumman

X-47Bs in the Ucas-D carrier demonstration programme. Following the award of a \$ 650 million contract in August 2007, the first aircraft is due to fly in November 2009, followed by the second one year later, and the first carrier operations in November 2011. The X-47B will be the first jet-powered tailless drone to land aboard an aircraft carrier.



An Eads Do-DT45 IR target with patented 'hot-nose' was used as a target for a South African Navy Denel Umkhonto missile during exercise 'Good Hope III' in March 2008. (Armada/RB)



Naval unmanned combat air systems are being pioneered by Northrop Grumman, funded to produce and test two X-47Bs under the US Navy's Ucas-D demonstration programme. The US Navy needs to establish with the X-47B that a Ucas is compatible with the cycle of manned aircraft operations, can be correctly manoeuvred on deck and can be landed safely. (Northrop Grumman)

If the Ucas-D programme continues (despite rumours to the contrary) and is completed successfully, it is expected to pave the way for an 'F/A-XX' competition, leading to operational deployment in 2025, allowing the last F/A-18E/F to be retired in 2030. The 'F/A-XX' is expected to perform stand-in jamming, electronic attack and strike missions, carrying a 2000-kg payload over a 2800-km radius at high subsonic speeds.

In a much smaller category, it may be noted that Canada's Advanced Subsonics and America's Spartan Electronics are collaborating on an electrically-powered, GPS-guided folding-wing Sonobouy Flight Kit (SFK) that will allow a ship to deploy the sensor up to 185 km. The US Navy is supporting this system for its Littoral Combat Ships. Although the SFK is not a drone, its development seems likely to inspire recoverable vehicles using the same launch equipment.

Targets

As explained earlier, the first naval drones were targets, and drones continue to be used in this role. Indeed, there is a growing demand for target drones to assist in air-defence training against increasingly effective anti-ship missiles.

The best-known ship-launched target is probably the 206-kg Northrop Grum-

man BQM-74, which has been exported as the Chukar to eleven countries. Over 7500 have been produced. The current BQM-74F/Chukar III is capable of over 970 km/h and operation as low as 15 ft. It seems possible that China's WF170 target (of which very little information is available) may also be ship-launched.

Eads Defence & Security Division has produced over 500 examples of its new Do-DT25/35/45/55 series drone, which has been designed to be either land- or ship-based. The most relevant example appears to be the 70-kg, twin-jet Do-DT45, which is capable of 756 km/h and can be used in sea-skimming mode down to 17 ft. □