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Unmanned

2017-2018

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Executive overview

Welcome to Jane's All the World's Aircraft - Unmanned

Jane's All the World's Aircraft - Unmanned (*JAWA-U*) seeks to provide accurate information concerning the world's unmanned aerial vehicles (UAV), unmanned aircraft systems (UAS), aerial targets, and associated control and communications and launch systems. It is compiled without 'fear or favour' from open sources, and in its current edition covers UAV/UASs from 41 countries around the world plus aerial targets from 25 countries. *JAWA-U* is published in both hardcopy and electronic formats, with the former being effectively a 'snapshot' of activity at the time of publication and the latter, a rolling platform that allows for updating and/or correction in near or real-time. In terms of the coverage offered, physical and performance data are given for each UAV/UAS/target type together with information on the type's control and payload systems, variants (where appropriate), contractor/s, status, and end users, and every effort is made to ensure the veracity of the material.

Aurora Flight Science's 20% subscale LightningStrike prototype made its maiden flight during the spring of 2016 *(Aurora Flight Sciences)* 1678499

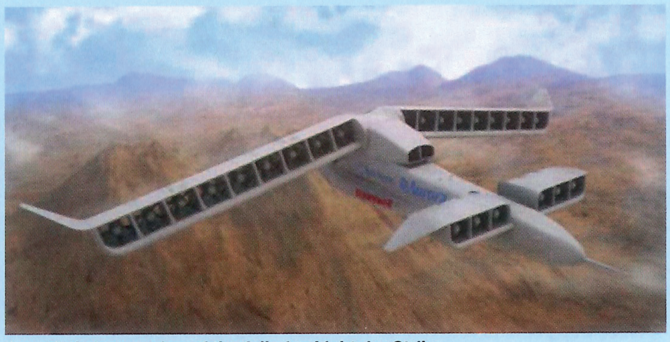
Three of the best ...

JAWA-U's 'Executive Overview' allows the Editor to expand on several topics that have caught his attention during the compilation of the current edition.

Here, the American Defense Advanced Research Projects Agency's (DARPA) vertical take-off and landing (VTOL) X-Plane (VTX) programme, defence against non-conventional use of drones, and the concept of 'swarming' capabilities are discussed. DARPA's VTX effort is of interest due to one of its key objectives being an increase in the sustainable maximum speed for a VTOL air vehicle (AV) from around 170 kt (315 km/h) to 400 kt (741 km/h). Other programme targets include a hover efficiency of at least 75%, a cruise lift-to-drag ratio of at least 10, and an ability to lift a useful load that represents at least 40% of the VTX AV's gross projected weight.

VTX was launched during 2013 and resulted in DARPA awarding Phase 1 development contracts to Aurora Flight Sciences (AFS), Boeing, Karem Aircraft, and Sikorsky during March 2014. Of these, AFS proposed its hybrid electric distributed propulsion LightningStrike vehicle, while Boeing's PhantomSwift concept featured shaft-driven, fuselage-mounted, ducted lift fans together with an additional pair of tilting ducted fans that were mounted on the AVs wingtips and were designed to provide both lift and forward thrust. For its part Karem Aircraft offered its TR36XP tiltrotor, while Sikorsky (now a Lockheed Martin subsidiary) bid a tail sitting design that utilised semi-articulated rotors for vertical lift, forward flight, and to increase airflow across its wing surfaces. Again (and while not specified by DARPA), all four VTX submissions were unmanned.

After evaluating the four described solutions, in March 2016 DARPA announced that it had down selected AFS's LightningStrike concept for development and prototype fabrication under Phase 2 of the VTX programme. As such, LightningStrike is as interesting as the VTX programme itself by virtue of its novel approach to meeting the required goals. Here, the vehicle takes the form of a fuselage module that supports rear-mounted main wing surfaces and forward-mounted canards. In turn, each main wing surface takes the form of a close-coupled biplane structure (as do the canards) that house between them 18 ducted fans and can be directed to provide vertical lift (vertical alignment) and directed thrust (horizontal alignment). For their part, the canards house three fans apiece and are also configured to offer vertical lift and directed thrust. Power is provided by a Rolls-Royce AE1107 turboshaft (the power plant used in the manned V-22 tiltrotor) that drives three one-megawatt, Honeywell-sourced generators that (in turn) provide electrical power for the motors that drive the AVs 24 ducted fans.The main wing fans are said to utilise 100 kW ThinGap brushless electric motors (70 kW units for the canards), with thrust control being by means of blade pitch and upper and lower elevons in the fan housings. Elsewhere, unconfirmed (but frequently reliable) US media sources suggest that the full-size (see following) LightningStrike demonstrator will weigh in at around 5,443 kg (12,000 lb), and will be capable of carrying fuel and payloads of 1,361 kg (3,000 lb) and 680 kg (1,500 lb) respectively.



An artist's impression of the full-size LightningStrike demonstrator *(Aurora Flight Sciences)* 1647130

As understood by *JAWA-U*, the LightningStrike programme (aside from the fabrication of the demonstrator itself) involves wind tunnel testing at the University of Maryland; construction and flight testing of a 20% subscale prototype; construction of a ground-based power system test rig at AFS's Manassas, Virginia, facility; and construction of a power train (engine, a single generator, and an array of ducted fans) rig at Rolls-Royce's Indianapolis, Indiana, facility.

Within this overall construct, AFS announced on 18 April 2016 that its 147.5 kg (325 lb) subscale LightningStrike AV had been successfully test flown as part of a risk reduction exercise that was designed to validate the type's flight control system and the configuration of the then planned full-scale demonstrator. *Jane's* sources suggested that the full-size demonstrator would be completed sometime during 2018. *JAWA-U* awaits with interest to see if the full-scale LightningStrike AV is a success and whether it will lead to an operational application.

Manning the ramparts ...

The ready availability of a wide range of 'hobby' drones and their potential as tools for insurgent warfare has resulted in increasing interest in anti-drone defences. Looking at the potential threat in more detail, *Jane's* analysis suggests that the 'detection and defeat' of small UAVs (and 'especially quadcopters') has emerged as a 'high priority task for many militaries and governments' following the use of 'commercially-available and relatively cheap platforms' as intelligence, surveillance, and reconnaissance and/or offensive tools (armed with a range of weapons that have included 'small grenades') by several non-state groups (analysis by Huw Williams, Editor of *Jane's International Defence Review*). In terms of potential threat size (as of 2016), it has been estimated (Rohde & Schwarz analysis) that the worldwide marketplace was seeing more than 300,000 drones being sold per month (with approximately one million being sold in the United States in the run-up to Christmas 2015 alone), and that by 2025 the commercial drone market could reach a value of more than USD8.8 billion.

Detecting and intercepting such small targets is problematic using traditional anti-aircraft systems, particularly in areas where the environment impacts adversely on sensor performance and/or there is the possibility of civilian casualties resulting from kinetic action. Against such a background, proposed counter-drone solutions range from the French Air Force's somewhat bizarre concept of training large birds-of-prey to attack and bring down suspect drones, through counter-counter drones that can net and disable a threat AV, laser-targeted sniper rifles, to architectures that incorporate detection sensors and radio frequency (RF) jammers that can disrupt the radio control link between an operator and an AV.

Here, three such link types have been identified (Rohde & Schwarz analysis) as being the most common, namely frequency hopping spread spectrum (FHSS), wireless local area network (WLAN), and Bluetooth. Of these, FHSS is estimated to represent more than 80% of all such control systems and is likely to offer a range of somewhere between 1 and 3 km. For their part, WLAN systems are deemed to be effective at ranges of between 100 m and 2 km and, in some cases, offer first person view (FPV) and/or GPS navigation capabilities. Finally, Bluetooth provision appears to be the low-cost option offering ranges of up to 60 m.

JAWA-U believes that sensor/RF effector suites are the most likely solution to enter widespread service, with such a belief being predicated on their ability to cut the AV-operator radio link and force the drone to land in a non-destructive manner. Within the space available, two exemplars of this approach are offered in the forms of German contractor Rohde & Schwarz's ARDRONIS architecture and the Blighter Anti-UAV Defence System (AUDS).

ADRONIS is a modular solution that is billed as being effective against drone command links operating within the 400 MHz to 5.8 GHz frequency range. Currently, four options (designated as ARDRONIS-D, -I, -P and -R) are available, with the ARDRONIS-D variant providing simultaneous threat identification and direction-finding and comprising a DDF550 direction-finder (DF), an ADD078 DF antenna, and dedicated ARDRONIS software. ARDRONIS-I is billed as providing 'fast and reliable' link detection and identification and make's use of the contractor's EB500 receiver, a 20 MHz to 8 GHz HE600 antenna, and the ADRONIS software package. ADRONIS-I and -D offer the same detection, identification, and alarm capabilities, with the -D model adding the described DF capability.

The ARDRONIS-P configuration is described as being a 'comprehensive all-in-one solution' that incorporates the DDF550 DF unit, Rohde & Schwarz's WSE follower jammer, the ADRONIS software package, 2.4 GHz and 5.8 GHz omni-directional antennas, and the ADD078 DF antenna. Finally, the ADRONIS-R mates the WSE jammer with the HE600 detection antenna, the 2.4 GHz and 5.8 GHz omni arrays, and the ADRONIS software package.

Elsewhere, the AUDS architecture (which has been developed by a consortium made-up of UK contractors Blighter Surveillance Systems, Chess Dynamics, and Enterprise Control Systems, supported by US contractor Liteye Systems) has been procured by the US military and provides a remote detection, tracking, and drone control link disruption capability. Digging down, AUDS can be deployed as a fixed, semi-permanent, or temporary capability and comprises a command and control station, Blighter's Ku-band (12.5 to 18 GHz) A400 frequency modulated continuous wave (FMCW) Doppler surveillance radar, Chess Dynamics' Hawkeye EO imaging package, and Enterprise Control Systems' directional 'RF inhibitor'.

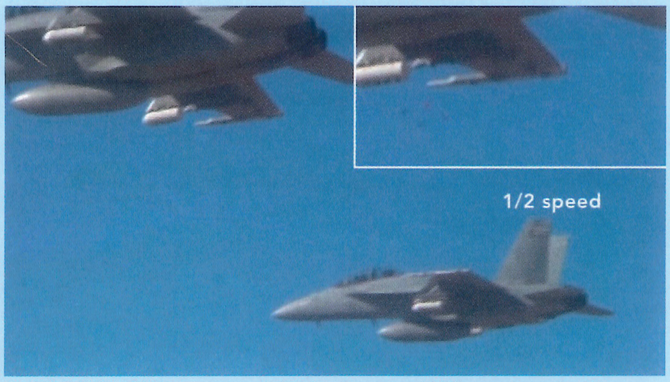
The A400 radar is used to detect UAV's with radar cross sections of down to $0.01\ m^2$ at ranges of up to 5.4 n miles (10 km; 6.2 miles), while the Hawkeye package incorporates a 2.3-megapixel Piranha 46 HR colour camera, a 3 to 5 µm band Gen 3 thermal camera and an EO video tracker, with an optical disrupter (with a 1.4° high intensity beam output) as an option. Finally, Enterprise Control Systems' RF inhibitor is billed as utilising a high-gain quad-band (including Global Navigation Satellite System (GNSS) frequencies and with a penta-band 5.8 GHz option) antenna array; custom, threat specific inhibition waveforms; 'optimised' disruption profiles; and 'software defined intelligent RF inhibition'.

In terms of overall capability, *Jane's* sources characterise AUDS as having achieved Technology Readiness Level 9 (TRL 9 - an actual system that has been proven in an operational environment); as having participated in 12 'overseas trials'; and as having been subjected to 1,500 test approaches by 60 types of UAV. While *JAWA-U* has no doubt about systems such as AUDS and ARDRONIS 'working as advertised', they are obviously expensive solutions to a problem in which the scale and potential for harm (particularly if associated with pathogens and/or radioactive material) is extremely worrying and in urgent need of a simple, low-cost solution that can be deployed on the widest of scales.

Meanwhile, back at the hive ...

First mooted in the early 2000s, the 'swarming UAV' concept is perhaps the most interesting innovation within *JAWA-U's* current domain. As of this edition, three such programmes

The AUDS counter-drone system has been procured by the US military *(Blighter Surveillance Systems)* 1695094



On 26 October 2016, a swarm of 103 Perdix micro-UAVs was launched from a trio of F/A-18 fighters over the China Lake range in California *(DVIDS)* 1527529

An artist's concept of a Gremlin swarm *(DARPA)* 1565673

(DARPA's Gremlins effort, the US Navy's Office of Naval Research's (ONR) Low-Cost UAV Swarming Technology (LOCUST) programme, and the US Department of Defense's Strategic Capabilities Office's (SCO) Perdix effort) are described by way of illustration.

DARPA's Gremlins programme aims to demonstrate the viability of 'volleys' of low-cost, reusable UASs that can be 'safely and reliably' recovered in mid-air. The Gremlin AVs would be deployed with a mixture of payloads that would be capable of generating a variety of effects in a distributed and co-ordinated manner and providing forces with 'improved operational flexibility at a lower cost than is possible with conventional, monolithic platforms'. Once recovered, each Gremlin would have a lifetime of some 20 uses and as of March 2016 DARPA had awarded Phase 1 Gremlin design contracts to four contractor teams led by Composite Engineering, Dynetics, General Atomics Aeronautical Systems, and Lockheed Martin. Technology areas being covered at this stage of the programme included launch and recovery techniques, aircraft integration concepts, airframe design (leveraging existing technology and requiring 'only modest modifications to current aircraft'), high-fidelity analysis, and precision digital control, relative navigation, and station keeping techniques. The Phase 1 Gremlins effort was intended to pave the way for proof-of-concept flight demonstration that would include validation of multiple-AV mid-air recovery.

The need for affordable capability is also a driver in the ONR's LOCUST programme that currently centres on Raytheon's Coyote AV, which (per unconfirmed (but frequently reliable) US media sources) has been modified with software that manages the swarm (via, it is thought, RF links), assigns roles to specific AVs within the swarm, and can dynamically re-assign individuals if the mission changes in some way. LOCUST's prime aim would appear to be intelligence, surveillance, and reconnaissance, and for an operational application to emerge, the AVs used would have to be inexpensive enough to be 'throw away'. As *JAWA-U* understands the effort, 2016 was when the modified Coyote demonstrated its ability to both swarm and operate collaboratively, with a potential Phase 2 programme aiming to demonstrate that a 'throw away' variant is both possible and operationally effective.

For its part, the Massachusetts Institute of Technology's (MIT) Lincoln Laboratory's Beaver Works Perdix utilises a 'distributed brain' for decision making within the swarm, with each AV adapting to its neighbour and its environment. Each AV within the swarm communicates and collaborates with every other AV around it, with individual swarms having no requirement for a leader and the ability to adapt to the number of AVs within them. Functionally, the device's operator plans and calls a sports-like 'play' that the Perdix 'brain' decides how best to implement. Because Perdix cannot change a requested 'play', an operator can predict a swarm's behaviour without having to micromanage it.

In programmatic terms, MIT began Perdix development during 2013, with the first example being air-dropped during September 2014. Thereafter, September 2015 saw 90 Perdix missions being flown during that year's 'Northern Edge' exercise in Alaska, with a swarm of 103 Perdix AVs being trialled at China Lake in California during October 2016. By January 2017, the SCO was reporting more than 670 Perdix AVs as having been flown; that it was transitioning the programme to the 'Services'; and that it had partnered with the Defense Industrial Unit - Experimental (DIUx) to find manufacturers who would be capable of 'rapidly' building a run of 1,000 such UAVs.

In *JAWA-U*'s view, the jury remains out on whether swarming will end up as an interesting technological blind alley or as a viable operational tool. That said, the advent of techniques such as 3-D printing and the ever-growing potential for crossover between the smart device manufacturing base and military grade requirements seems to make the low-cost/high-capability vehicles required for swarming an increasingly practical proposition.

Timelines ...

JAWA-U rounds off this Executive Overview with a selection of significant and/or interesting UAV-related events that have taken place during the period March 2016 to February 2017.

April 2016 The French Army ordered two Sagem Patroller UASs (each comprising five AVs and two ground control stations [GCS]) together with a further four AVs and two more GCS for training purposes. The acquisition was to fulfil the service's Systéme de Drones Tactiques (SDT - Tactical Drone System) requirement.

May 2016 The United Kingdom became the launch customer for General Atomics Aeronautical Systems Inc's (GA-ASI) Certified Predator B (CPB) multirole UAV. In British service, the CPB has been assigned the 'Protector' nomenclature.

June 2016 Chinese contractor the Guizhou Aviation Industry Group publicly unveiled a novel propeller-driven surveillance UAV that employs a box-wing design. During the same month, the Indian Ministry of Defence issued a letter of request covering a potential procurement of 22 General Atomics Aeronautical Systems Inc (GA-ASI) Guardian maritime surveillance UAVs. Elsewhere in the world, June 2016 saw the prototype Piaggio Aerospace P.1HH HammerHead UAV crash off the coast of Sicily during a test flight.

July 2016 The Armada de México (Mexican Navy) deployed its Arcturus T-20 JUMP VTOL UAVs to undertake maritime surveillance along the coast of Mexico's state of Sonora. During the same month, the Israel Aerospace Industries/Avionics Services Cacador (Hunter) surveillance UAV made its maiden flight in Brazil.

August 2016 *Jane's* sources reported control of the UK's Watchkeeper surveillance UAV fleet being passed from the British Army to the country's Joint Helicopter Command.

During June 2016 the Indian Ministry of Defence issued a letter of request covering a potential procurement of 22 Guardiuan maritime surveillance UAVs *(GA-ASI)* 1455354

The prototype P.1HH HammerHead UAV crashed during the course of a June 2016 test flight *(Piaggio Aerospace)* 1631192

Elsewhere in the world, August 2016 saw Canada announce that it was procuring the Insitu RQ-21A UAV for use by its army, while Spain joined France, Germany, and Italy in the consortium that was developing a pan-European MALE UAV system.

September 2016 Low-rate initial production of the US Navy's MQ-4C Triton surveillance UAV was approved. During the same month, South Korea's Aerospace Research Institute unveiled its 'production ready' TR60 tiltrotor UAV.

October 2016 Iranian media published pictures of what appeared to be an Islamic Revolutionary Guard-run production line of UAVs derived from the Lockheed Martin RQ-170 AV that Iran acquired during 2011. During the same month, French media sources reported the Islamic State as having made a drone attack against French Special Forces operating in the Irbil region of northern Iraq.

November 2016 India's Rustom-II medium-altitude long-endurance (MALE) UAV made its maiden flight. During the same month, a German-operated Heron 1 surveillance UAV made its first operational sortie over Mali.

December 2016 The Israeli Air Force announced that it was procuring 900 additional Elbit Hermes multirole UAVs.

January 2017 France's Defence Procurement Agency (DGA) announced that the French Army was to receive 35 Thales France Spy'Ranger AVs to fulfil its Systéme de Mini-Drone de Reconnaissance (SMDR - Mini Reconnaissance Drone System) requirement. During the same month, Airbus Helicopters announced its expectation that its VSR700 VTOL UAV would make its maiden flight during 2017, while Vanilla Aircraft's diesel-powered VA001 UAV established an approximately 56-hour endurance record for a combustion engined, 50 to 500 kg (110 to 1,102 lb) class UAV.

February 2017 The Royal Australian Navy selected Schiebel's S-100 CAMCOPTER to fulfil its interim VTOL UAS requirement.

Martin Streetly
February 2017

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Martin Streetly and Beatrice Bernardi
February 2017

Editor Biographies

Martin Streetly

Described by one leading electronic defence contractor as being "a writer who during his career has probably done more than anyone to widen the understanding of [electronic warfare] to the otherwise uninformed", Martin Streetly is a full-time author who specialises in the history, technology and application of defence electronics (with a particular emphasis on electronic warfare - EW) and all aspects of airborne intelligence, surveillance and reconnaissance (ISR). He is the Editor of the *Jane's All the World's Aircraft: Unmanned* and a contributing editor/subject matter expert (airborne ISR and signals intelligence/EW equipment) on the *Jane's C4ISR & Mission Systems: Air* yearbook. Over time, he has also acted as the compiler/editor of both the *Jane's Radar & Electronic Warfare Systems* yearbook and the *Jane's Electronic Mission Aircraft* bi-annual reference publication.

Over the past 34 years, Martin has been a regular contributor to various *Jane's* publications such as *Jane's Defence Weekly* and *Jane's International Defence Review* as well as a variety of other international defence and technology publications. Here, the list includes the *Journal of Electronic Defense* (acting as the magazine's European Editor for 12 years up to March 2001), *The Knowles Report, Defence Helicopter, Asian Military Review, Digital Battlespace, Microwave Journal* (as the publication's European Correspondent), *Flight International, Defence, Naval Forces, Military Simulation & Training*, the *NAVINT* naval intelligence newsletter, *Combat Aircraft* and the *UAS Global Perspective* annual. Over time, he has appeared on the UK's Channel 4 News programme, the BBC and the Discovery Channel. During the 1991 Gulf War, he worked with the UK's Independent Television News Ltd and a range of international newspapers (including the *New York Times* and the *Jerusalem Post*) and has been invited to lecture on EW technology by industry, NATO, the Government of the United Arab Emirates and the Association of Old Crows.

Over and above the described body of work, Martin has published four books on the history and technology of airborne EW, the details of which are as follows:

Confound and Destroy: 100 Group and The Bomber Support Campaign Macdonald & Jane's Publishers Ltd, London, 1978 and Jane's Publishing Ltd, London 1985.

World Electronic Warfare Aircraft Jane's Publishing Ltd, London 1983 and 1984.

Martin Streetly *(IHS Markit/Michael J Gething)* 1484382

The Aircraft of 100 Group Robert Hale Ltd, London, 1984.

Airborne Electronic Warfare: History, Techniques and Tactics Jane's Publishing Ltd, London, 1988.

Of these, *Confound and Destroy* is considered by many as being the definitive study of the birth of airborne EW in the UK, while over 5,000 copies of the two editions of *World Electronic Warfare Aircraft* have been sold worldwide. As of 2017, Martin is working on both a second, fully revised edition of *Confound and Destroy* and a history of airborne signals intelligence that has the working title of *On Watch*.

Beatrice Bernardi

Beatrice is a full-time senior analyst for the aviation desk at *Jane's*, and has recently become a co-editor of *Jane's All the World's Aircraft: Unmanned*. In this role, her contribution now involves having overall responsibility for aerial targets, control and communications, and launch and recovery systems chapters of the yearbook.

Beatrice joined *Jane's* in 2014 as an intern for the air team. Now, as a senior analyst, she continues to develop her knowledge and skills in the air domain, with a particular focus on airborne unmanned systems. Her proficiency in Italian, English, Spanish, Russian and French allows her to research and directly engage with primary sources.

She has a masters degree in intelligence and international security from King's College London (2013-2014), with a focus on Russia and Central Asia. Her thesis discussed the effectiveness of the United States' covert Unmanned Aerial Vehicle (UAV) programme in Pakistan and future trends in UAV technology. Beatrice also has a masters degree in international relations from Ca' Foscari University of Venice (Italy), obtained in 2013; and a bachelors degree in Russian and Spanish from University of Padua (Italy), obtained in 2010.

Beatrice Bernardi *(IHS Markit/Beatrice Bernardi)* 1699233

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Glossary of aerospace terms

The following 'across the board' abbreviations and acronyms are used in this publication; others with more individual meanings are explained in the text as they occur.

A Ampère
AA Anti-aircraft
AAA Anti-aircraft artillery
AAM Air-to-air missile
AC Alternating current
ACAS Airborne collision avoidance system
ACTD Advanced concept technology demonstration
ADC Air data computer
ADF Automatic direction finder/finding
ADS Air data sensor
ADT Air data terminal
AFB Air Force Base (US)
AFCS Automatic flight control system
AFRL Air Force Research Laboratory (US)
AFRP Aramid fibre-reinforced plastics
AFV Armoured fighting vehicle
AGARD Advisory Group for Aerospace Research and Development (NATO)
Ah Ampère hour
AHRS Attitude and heading reference system
Al-Li Aluminium-lithium
AoA Angle of attack
APU Auxiliary power unit
ARINC Aeronautical Radio Inc (US company)
ARPA Former temporary title of DARPA (which see)
ASROC Anti-submarine rocket
ASW Anti-submarine warfare
ATC Air traffic control
ATM Air traffic management
AUVSI Association for Unmanned Vehicle Systems International (US)
AUW All-up weight
AV Air vehicle
Avgas Aviation gasoline
AVO Air vehicle operator

BDA Battle damage assessment
BER Bit error rate
BITE Built-in test equipment
BLOS Beyond line of sight
BPSK Bi-phase shift keying
BVR Beyond visual range
BW Bandwidth
BWB Bundesamt für Wehrtechnik und Beschaffung (Germany)

C2 Command and control
C3I Command, control, communications and intelligence
C4 Command, control, communications and computers
C of A Certificate of Airworthiness
CAD Computer-aided design
CAS Calibrated airspeed
CASA Civil Aviation Safety Authority (Australia)
CCD Charge coupled device
CCI Command and control interface
CCIR Comité Consultatif International des Radiocommunications (France)
CD (1) Circular dispersion; (2) chrominance difference
CDL Common datalink
CDMQ Commercially developed, military qualified
CDR Critical design review
CEP Circular error probability
CFAR Constant false alarm rate
CFRP Carbon fibre-reinforced plastics
CG Centre of gravity
CIA Central Intelligence Agency (US)
CKD Component knocked down
CMOS Complementary metal oxide semiconductor
CMT Cadmium mercury telluride (CdHgTe)
COA Certificate of Authorisation (US)
comint Communications intelligence
CONOPS Concept of operations
CONUS Continental United States
COTS Commercial off-the-shelf
CR Close range
CRT Cathode ray tube
CTOL Conventional take-off and landing
CW Continuous wave

DARO Defense Airborne Reconnaissance Office (US)
DARPA Defense Advanced Research Projects Agency (US)
dB Decibel
DEAD Destruction of enemy air defences
DERA Defence Evaluation and Research Agency (UK)
DF Direction-finding
DGA Direction Générale de l'Armement (France)
DGAC Direction Générale de l'Aviation Civile (France)
DGPS Differential GPS
DLI Datalink interface
DND Department of National Defence (Canada)
DoD Department of Defense (US)
DoF Degrees of freedom
DPCM Digital pulse code modulation

EAS Equivalent airspeed
ECA Experimental Certificate of Airworthiness (US)
ECCM Electronic counter-countermeasures
ECM Electronic countermeasures
ECR Electronic combat reconnaissance
EEPROM Electronically erasable programmable read-only memory
EHF Extra high frequency
EISA Extended industry standard architecture
ELF Extremely low frequency
elint Electronic intelligence
ELT Emergency locator transmitter
EMD Engineering and manufacturing development
EMI Electromagnetic interference
EMP Electromagnetic pulse
EO Electro-optical
EOD Explosive ordnance disposal
EPLRS Enhanced position location and reporting system
ERP Effective radiated power
ESM Electronic support (or surveillance) measures
EW Electronic warfare

FAA Federal Aviation Administration (US)
FADEC Full authority digital engine control
FBW Fly-by-wire
FCS Future Combat System (US Army)
FLIR Forward-looking infra-red
FLOT Forward line of own troops
FM Frequency modulation
FoV Field of view
FPA Focal plane array
FRP Full rate production
FSAT Full-scale aerial target
FSED Full-scale engineering development
FSK Frequency shift keying
FSRWT Full-scale rotary-wing target
FY Financial year

GCI Ground controlled intercept
GCS Ground control station (or system)
GDT Ground data terminal
GEN Generation
GFE Government-furnished equipment
GFRP Glass fibre-reinforced plastics
GLCM Ground-launched cruise missile
GMTI Ground moving target indicator
GOTS Government off-the-shelf
GPS Global positioning system
GPWS Ground proximity warning system
GSE Ground support equipment

HAE High-altitude endurance
HALE High-altitude, long endurance
HF High frequency
HFE Heavy-fuel engine
HMMWV High-mobility multipurpose wheeled vehicle (US)
HUD Head-up display
Hz Hertz (cycles per second)

IAS Indicated airspeed
ICAO International Civil Aviation Organization
IDF Israel Defense Forces
IED Improvised explosive device
IEEE Institute of Electrical and Electronic Engineers
IEWS Intelligence, electronic warfare and sensors
IF Intermediate frequency
IFF Identification, friend or foe
IFOR Implementation Force (NATO)
IFR (1) Instrument flight rules; (2) in-flight refuelling
IGE In ground effect
IIRS Imagery interpretability rating scale
imint Imagery intelligence
IMU Inertial measurement unit
INS Inertial navigation system
InSb Indium antimonide
I/O Input/output
IOC Initial operating (or operational) capability
IOT&E Initial operational test and evaluation
IR Infrared
IR&D Internal research and development
IRLS Infra-red linescan
IRST Infra-red search and tracking
ISA International standard atmosphere
ISAF International Security Assistance Force (UN)
ISR Intelligence, surveillance and reconnaissance
ISTAR Intelligence, surveillance, targeting, acquisition and reconnaissance

JAA Joint Aviation Authorities (Europe)
JATO Jet-assisted take-off
JPO Joint Project Office (US)
JSIPS Joint Services Imagery Processing System
JSOW Joint Stand-Off Weapon
JTIDS Joint Tactical Information Distribution System

lb st Pounds static thrust
LCD Liquid crystal display
LCS Littoral Combat Ship
LiSO2 Lithium disulphide
LLTV Low-light television
LO Low observables
LOS Line of sight
LPC (1) Linear predictive coding; (2) low-pressure compressor
LR Long range
LRF Laser range-finder
LRIP Low-rate initial production
LRU Line-replaceable unit
LTA Lighter than air

MAE Medium-altitude endurance
MALE Medium-altitude, long endurance
MANPADS Man-portable air defence system

masint Measurements and signatures intelligence
MAV Micro air vehicle
MDI Miss-distance indicator
MEMS Micro-electromechanical system
MER Multiple ejector rack
MFD Multifunction display
MIL-STD Military standard(s) (US)
MLRS Multiple Launch Rocket System
MMI Man-machine interface
MMW Millimetre wave
MoD Ministry of Defence
Mogas Motor (automobile) gasoline
MoU Memorandum of Understanding
MOUT Military operations in urban terrain
MPCS Mission planning and control station (or system)
MPO Mission payload operator
MPS Mission planning system
MR Medium range
MRE Medium-range endurance
MTBF Mean time between failures
MTCR Missile Technology Control Regime
MTI Moving target indicator
MTOW Maximum take-off weight
MTTR (1) Multitarget tracking radar; (2) mean time to repair

NACA National Advisory Committee for Aeronautics (US)
NAS (1) Naval Air Station (US); (2) national airspace (US)
NASA National Aeronautics and Space Administration (US)
NATMC NATO Air Traffic Management Committee
NATO North Atlantic Treaty Organisation
NBC Nuclear, biological and chemical (warfare)
NCW Network-centric warfare
NEC Network-enabled capability
Ni/Cd Nickel/cadmium
NIIRS National imagery interpretability rating scale (US)
NLOS Non-line of sight
NOLO No onboard live operator (US Navy)
NTSC National Television Standards Committee (US)
NULLO Not utilising live local operator (US Air Force)

OAV Organic air vehicle
OEF Operation 'Enduring Freedom'
OEI One engine inoperative
OEM Original equipment manufacturer
OGE Out of ground effect
OIF Operation 'Iraqi Freedom'
OLOS Out of line of sight
OPA Optionally piloted aircraft
OPAV Optionally piloted air vehicle
OPV (1) Optionally piloted vehicle; (2) offshore patrol vessel
OTH Over the horizon

PAL (1) Phase alternation line; (2) programmable array logic
PCI Personal computer interface
PCM Pulse code modulation
PDR Preliminary design review
PIM (1) Position of intended movement; (2) previously intended movement
PIP Product improvement programme
PLRS Position location and reporting system
POC Proof of concept
PPC Pulse position coded
PPI Planned position indicator
PRF Pulse repetition frequency
PRI Pulse repetition interval
PtSi Platinum silicide
PWM Pulsewidth modulation

QPSK Quadrature phase shift keyed

R&D Research and development
RAAF Royal Australian Air Force
RAM Random access memory
RAN Royal Australian Navy
RAST (1) Recovery, assist, secure and traverse (helicopter); (2) radar-augmented subtarget
RATO Rocket-assisted take-off
RCO Remote-control operator
RCS Radar cross-section
RDT&E Research, development, test and evaluation
RF Radio frequency
RFA Rectangular format array
RFI Request for information
RFP Request for proposals
RISC Reduced instruction set computer
RMS (1) Reconnaissance management system; (2) root mean squared
ROA Remotely operated aircraft
RON Research octane number
RPA (1) Remotely piloted aircraft; (2) rotorcraft pilot's associate
RPH Remotely piloted helicopter
rpm Revolutions per minute
RPV Remotely piloted vehicle
RSTA Reconnaissance, surveillance and target acquisition
R/T Receiver/transmitter
RTS (1) Remote tracking station; (2) request to send
RVT Remote video terminal
RWR Radar warning receiver

SAM Surface-to-air missile
SAR (1) Synthetic aperture radar; (2) search and rescue
satcom Satellite communications
SBIR Small business innovative research (US contract type)
SCSI (1) Small computer system interface; (2) single card serial Interface
SEAD Suppression of enemy air defences
sfc Specific fuel consumption
SFDR Spurious free dynamic range
SFOR Stabilisation Force (NATO)
SHORAD Short-range air defence
shp Shaft horsepower
Sigint Signals intelligence
SINCGARS Single channel ground and airborne radio system
S/L Sea level
SPIRIT (Trojan) Special Purpose Integrated Remote Intelligence Terminal
SPRITE Signal processing in the element
SR Short range
SSB Single sideband
STANAG Standardisation NATO Agreement
STOL Short take-off and landing

Tacan Tactical air navigation
TAS True airspeed
TBD To be determined
TBO Time between overhauls
TCAS Traffic collision and avoidance system
TCDL Tactical common datalink
TCS Tactical control station (or system)
TED Transferred electron device
TER Triple ejector rack
T/FDOA Time/frequency difference of arrival
TFT Thin film transistor
TICM Thermal imaging common modules
TMD Theatre missile defence
TMT Telemetry
T-O Take-off
TTL Transistor/transistor logic
TUAV Tactical unmanned aerial vehicle
TV Television
TWT Travelling wave tube

UAS Unmanned (or uninhabited) aircraft system
UAV Unmanned (or uninhabited) aerial vehicle
UCAR Unmanned (or uninhabited) combat armed rotorcraft
UCARS UAV common automated recovery system (US)
UCAV Unmanned (or uninhabited) combat air vehicle
UCS Universal control station (NATO)
UHF Ultra-high frequency
UN United Nations
UNSA Uninhabited naval strike aircraft
UOR Urgent operational requirement
USAF United States Air Force
USD Unmanned (or uninhabited) surveillance drone (NATO)
USMC United States Marine Corps
USN United States Navy
UTCS Universal target control station
UTM Universal Transverse Mercator
UTV Unmanned (or uninhabited) target vehicle
UV Ultra-violet

VCR Video cassette recorder
VDU Video (or visual) display unit
VFR Visual flight rules
V/H Velocity/height (ratio)
VHF Very high frequency
VHS Very high speed
VLA (1) Very light aircraft; (2) very large array
VLAR Vertical launch and recovery
VLF Very low frequency
VLSI Very large scale integration
VME Virtual memory environment
VOR VHF omnidirectional radio range
VTOL Vertical take-off and landing
VTR Video tape recorder

WAAS Wide area augmentation system
WAS Wide area search

Conversion Factors

Conversion factors used in *Jane's All the World's Aircraft: Unmanned* are as follows:

From	To	Multiply by
acres	ha	0.404686
cc	cu in	0.06102
cu ft	m^3	0.0283168
cu ft	litres/dm^3	28.3392
cu in	litres/dm^3	0.0164
cu in	cc	16.387
cv	hp	0.98632
cv	kW	0.7355
ft	m	0.3048
ft/min	mph	0.011364
ft/min	m/s	0.00508
g	oz	0.03527
g/h/kW	lb/h/hp	0.001644
ha	acres	2.471053
hp	cv	1.01387
hp	kW	0.7457
Imp gallons	litres/dm^3	4.54596
Imp gallons	US gallons	1.20095
in	mm	25.4
kg	lb	2.20462
kg/h/kW	lb/h/hp	2.95644
kg/kN	lb/lb st	0.009807
kg/kW	lb/hp	1.643
kg/m^2	lb/sq ft	0.204816
km, km/h	miles, mph	0.621371
km, km/h	n miles, kt	0.5399568
km^2	sq miles	0.3861
km^2	sq n miles	0.2915533
kN	lb st	224.80455
kN-s	lb-s	224.77
kW	hp	1.341
lb	kg	0.453592
lb/hp	kg/kW	0.60864
lb/h/hp	g/h/kW	608.29
lb/h/hp	µg/J	169.0
lb/h/lb st	mg/Ns	28.325
lb/lb st	kg/kN	101.972
lb-s	kN-s	0.0044489
lb/sq ft	kg/m^2	4.88243
lb st	kN	0.0044483
litres/dm^3	cu ft	0.035287
litres/dm^3	cu in	60.9756
litres/dm^3	Imp gallons	0.219975
litres/dm^3	US gallons	0.264177
m	ft	3.28084
m^2	sq ft	10.7639
m^3	cu ft	35.3147
m/s	ft/min	196.8504
mg/Ns	lb/h/lb st	0.0353
µg/J	lb/h/hp	0.00592
miles, mph	km, km/h	1.609344
miles, mph	n miles, kt	0.86898
mm	in	0.03937
n miles, kt	km, km/h	1.852
n miles, kt	miles, mph	1.15078
oz	g	28.3495
sq ft	m^2	0.092903
sq miles	sq n miles	0.7553062
sq miles	km^2	2.58999
sq n miles	km^2	3.4299045
sq n miles	sq miles	1.3239663
US gallons	Imp gallons	0.83267
US gallons	litres/dm^3	3.785411

Radio and radar bands and frequencies. Radio and radar performance can be referred to either by wavelength (measured in mm, cm, m or km) or by frequency (measured in MHz or GHz). *Jane's* house style, as used in this publication, is to use the frequency band, with the frequency range, where known, in parentheses: for example, G-band (5.25 to 5.85 GHz). However, some originators' diagrams used herein may show use of wavelength bands. These can be understood using the accompanying table.

Band designation	Abbreviation	Frequency	Wavelength
General			
Extremely Low Frequency	ELF	30 Hz - 3 kHz	10,000 - 100 km
Very Low Frequency	VLF	3 - 30 kHz	100 - 10 km
Low Frequency	LF	30 - 300 kHz	10 - 1 km
Medium Frequency	MF	300 kHz - 3 MHz	1 km - 100 m
High Frequency	HF	3 - 30 MHz	100 - 10 m
Very High Frequency	VHF	30 - 300 MHz	10 - 1 m
Ultra High Frequency	UHF	300 MHz - 3 GHz	1 m - 10 cm
Super High Frequency	SHF	3 - 30 GHz	10 - 1 cm
Extremely High Frequency	EHF	30 - 300 GHz	1 cm - 1 mm
NATO Radar and Electronic Warfare			
A-band		0 - 250 MHz	100 m - 120 cm [1]
B-band		250 - 500 MHz	120 - 60 cm
C-band		500 MHz - 1 GHz	60 - 30 cm
D-band		1 - 2 GHz	30 - 15 cm
E-band		2 - 3 GHz	15 - 10 cm
F-band		3 - 4 GHz	10 - 7.5 cm
G-band		4 - 6 GHz	7.5 - 5 cm
H-band		6 - 8 GHz	5 - 3.75 cm
I-band		8 - 10 GHz	3.75 - 3 cm
J-band		10 - 20 GHz	3 - 1.5 cm
K-band		20 - 40 GHz	1.5 - 0.75 cm
L-band		40 - 60 GHz	0.75 - 0.5 cm
M-band		60 - 100 GHz	0.5 - 0.3 cm

Band designation	Abbreviation	Frequency	Wavelength
Radar and Satellite Communications			
P-band		230 MHz – 1 GHz	120 – 30 cm [1]
L-band		1 – 2 GHz	30 – 15 cm
S-band		2 – 4 GHz	15 – 7.5 cm
C-band		4 – 8 GHz	7.5 – 3.75 cm
X-band		8 – 12.5 GHz	3.75 – 2.5 cm [1]
Ku-band		12.5 – 18 GHz	2.5 – 1.6 cm [1]
K-band		18 – 26.5 GHz	1.6 – 1.1 cm [1]
Ka-band		26.5 – 40 GHz	1.1 – 0.75 cm [1]
mm-band		40 – 100 GHz	0.75 – 0.3 cm

[1] *Approximate value*

Professional Organisations

International

AUVSI
Association for Unmanned Vehicle Systems International
2700 South Quincy Street, Suite 400, Arlington, Virginia 22206, United States
Tel: (+1 703) 845 96 71
Fax: (+1 703) 845 96 79
e-mail: info@auvsi.org
Web: www.auvsi.org
Formed: 1972 (as National Association for Remotely Piloted Vehicles).
Membership: 250 corporate and academic and more than 6,000 individual members from government, military, industry and academia internationally. Represents 1,500 organisations in 50 countries.

UCARE
UAVs: Concerted Actions for Regulations
Contact details as for UVS International except:
Web: www.ucare-network.org

UVS International
86 rue Michel Ange, F-75016 Paris, France
Tel: (+33 1) 46 51 88 65
Fax: (+33 1) 46 51 05 22
e-mail: info@uvs-international.org
Web (1): www.uvs-international.org
Web (2): www.uvs-info.com
Formed: 16 May 1997 (as Euro UVS; present name adopted February 2004).
Membership: 252 corporate, military and institutional members from 37 countries and ten international organisations worldwide; 108 honorary members from 23 countries and eight international organisations.

National

AESiNT
Asociación Española de Sistemas No Tripulados
c/o Logstar Aviación, C/Fray Francisco 27, E-01007 Vitoria-Gasteiz, Spain
Tel/Fax: (+34 917) 47 82 71
e-mail: jmliquete@logstar.es
Formed: Early 2004.
Membership: No information received.

JUAV
Japan Unmanned Aerial Vehicles Association
c/o Fuji Heavy Industries Ltd, 1-1-11 Yonan, Utsunomiya, Tochigi 320-8564, Japan
Tel: (+81 28) 684 70 60
Fax: (+81 28) 684 70 71
e-mail: kitagaway@uae.subaru-fhi.co.jp
Web: www.juav.org (in Japanese only)
Formed: September 2004.
Membership: Fuji, Hirobo, Hitachi, Kawada, Kawasaki, Mitsubishi Heavy Industries, Mitsubishi Electric, Sky Remote, Yamaha and Yanmar.

Korea UVS Association
Korea Unmanned Vehicle Systems Association
c/o Korea Aerospace Research Institute, PO Box 113, No. 45 Eoeung-dong, Yu-Sung, 305600 Taejon, South Korea
Tel: (+82 42) 860 23 52
Fax: (+82 42) 860 20 06
Web: www.korea-uvs.org (in Korean only)
Formed: 29 August 2003.
Membership: Over 30 South Korean corporate, military and institutional members.

UAV DACH
UAV DACH
c/o Von Bothmer, Am Kölnkreuz 17, D-53340 Meckenheim, Germany
Tel/Fax: (+49 2225) 83 95 29
e-mail: info@uavdach.org
Web: www.uavdach.org (in German only)
Formed: 2000.
Membership: German-speaking working group; name derived from names of original member countries: Germany (D), Austria (A) and Switzerland (CH); now also from Netherlands. The current 12 members comprise Autoflug, Diehl BGT Defence, DLR, EADS Deutschland, EMT, ESG, IABG, Rheinmetall Defence Electronics and Stemme UMS from Germany; Schiebel Elektronische from Austria; RUAG Aerospace from Switzerland; and ADSE from Netherlands (September 2006).

UAVS
Unmanned Aerial Vehicle Systems Association
The Granary, 1 Waverly Lane, Farnham, Surrey GU9 8BB, United Kingdom
Tel: (+44 1252) 73 25 77
Fax: (+44 1252) 73 25 01
e-mail (1): secretary@uavsuk.org
e-mail (2): secretary@uavsuk.co.uk
e-mail (3): secretary@uavsuk.com
Web (1): www.uavs.org
Web (2): www.uavsuk.co.uk
Web (3): www.uavsuk.com
Formed: November 1998.
Membership: More than 30 corporate and other members from the UAV systems industry and academia in the UK (March 2007).

UNITE
UAV National Industry Team
c/o Am Tech, 499 Seaport Court, Suite 100, Redwood City, California 94063, United States
Tel: (+1 650) 569 38 38
Fax: (+1 650) 569 38 39
e-mail: scarmona@amtech-usa.org
Formed: 2002.
Membership: AeroVironment, Aurora Flight Sciences, Boeing, General Atomics — Aeronautical Systems, Lockheed Martin and Northrop Grumman. (According to a 7 February 2007 announcement, UNITE was intending to disband later that year).

UVS Canada
Unmanned Vehicle Systems Canada
PO Box 81005, Ottawa, Ontario K1P 1B10, Canada
Tel: (+1 613) 845 01 45
Fax: (+1 613) 248 49 32
e-mail: admin@uvscanada.org
Web: www.uvscanada.org
Formed: November 2003.
Membership: Includes some 300 individual and corporate members from industry, government and academia in Canada, the US and Asia.

UVS New Zealand Australia
Unmanned Vehicle Systems New Zealand and Australia Association Inc,
17 Arwen Place, PO Box 58642, East Tamaki, Greenmount, Auckland 1730, New Zealand
Tel: (+64 9) 273 63 07
Fax: (+64 9) 273 63 08
e-mail: info@uvs-nza.com
Web: www.uvs-nza.com
Formed: Date unknown.
Membership: No information received.

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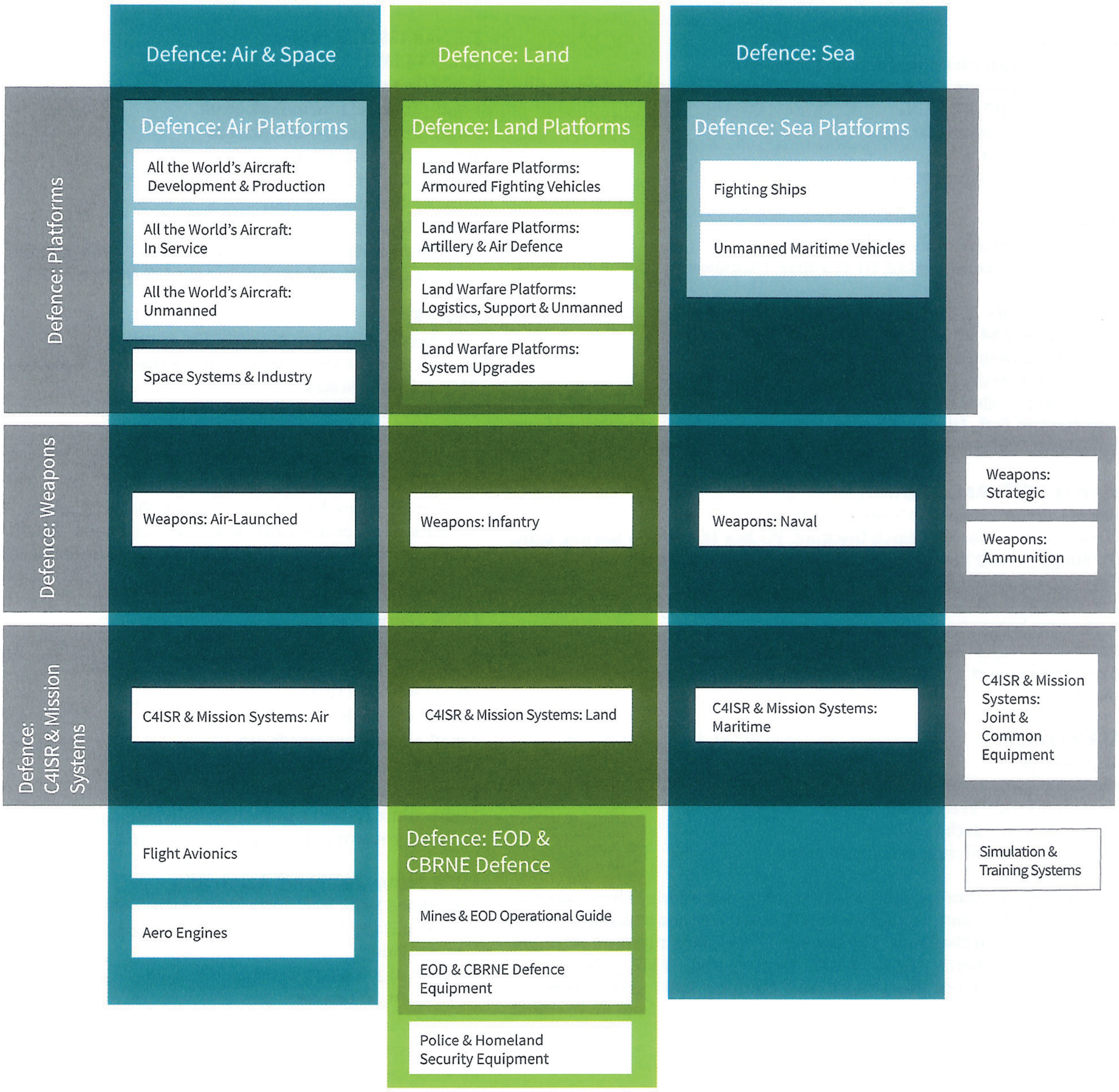

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6. If for any reason IHS is unable to deliver the Products on time due to Client's failure to provide appropriate instructions, documents or authorisations etc; (i) any risk in the Products will pass to the Client; (ii) the Products will be deemed to have been delivered; and (iii) IHS may store the Products until delivery, whereupon the Client will be liable for all related costs and expenses.
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8. The possession and usage rights of the Products in accordance with clause 3 above will not pass to Client until IHS has received in full all sums due to it in respect of: (i) Fees; and (ii) all other sums which are or which become due to IHS from Client on any account. Until such rights have passed to Client, the Client will: (i) hold the Products in a fiduciary capacity; (ii) store the Products (at no cost to IHS) in such a way that they remain readily identifiable as IHS property; (iii) not destroy, deface or obscure any identifying mark or packaging on or relating to the Products; and (iv) maintain the Products in satisfactory condition and keep them insured on IHS' behalf for their full price against all risks to the reasonable satisfaction of IHS.
9. The quantity of any consignment of Products as recorded by IHS on despatch from IHS' place of business shall be conclusive evidence of the quantity received by the Client on delivery unless Client can provide conclusive evidence proving otherwise. IHS shall not be liable for any non-delivery of the Products (even if caused by IHS' negligence) unless Client provides conformed claims to IHS of the non-delivery. Any such conformed claim for non-receipt of the Products must be made in writing, quoting the account and Order Confirmation number to the IHS' Customer Service Department, within thirty (30) days of the estimated date of delivery as stated in the Order Confirmation.
10. The Products supplied herein are provided "AS IS" and "AS AVAILABLE". IHS does not warrant the completeness or accuracy of the data, material, third party advertisements or information as contained in the Product or that it will satisfy Client's requirements. IHS disclaims all other express or implied warranties, conditions and other terms, whether statutory, arising from course of dealing, or otherwise, including without limitation terms as to quality, merchantability, fitness for a particular purpose and noninfringement. To the extent permitted by law, IHS shall not be liable for any errors or omissions or any loss, damage or expense incurred by reliance on information, third party advertisements or any statement contained in the Products. Client assumes all risk in using the results of the Product(s).
11. If the Products supplied hereunder are subscription based, except as otherwise provided herein the period of supply will run for one calendar year from the start date as specified in the Order Confirmation and the Fees will cover the costs of supply of all issues of the Product published in that year. If Client attempts to cancel the Product subscription anytime during such period; (i) the Fees payable for that year will be invoiced by IHS in full; or (ii) where Client has already paid the Fees in advance, any Fees relating to the remaining period shall be forfeited. In addition to other rights and subject to the provisions of this clause, IHS in its sole discretion may discontinue the supply the Products in the event Client commits breach of any of the provision of these terms and conditions.
12. In the event of breach of any of the provision of these terms and conditions by IHS, IHS' total aggregate liability for any damages/losses incurred by the Client arising out of such breach shall not exceed at any time the Fees paid for the Product which is the subject matter of the claim. In no event shall IHS be liable for any indirect, special or consequential damages of any kind or nature whatsoever suffered by the Client including, without limitation, lost profits or any other economic loss arising out of or related to the subject matter of these terms and conditions. However, nothing in these terms and conditions shall limit or exclude IHS' liability for (i) death or personal injury caused by its negligence; (ii) fraud or fraudulent misrepresentation; or (iii) any breach of compelling consumer protection or other laws.
13. Client represents and warrants that it will not directly or indirectly engage in any acts that would constitute a violation of United States laws or regulations governing the export of United States products and technology.
14. The parties will comply with all applicable country laws relating to anti-corruption and anti-bribery, including the US Foreign Corrupt Practices Act and the UK Bribery Act. The parties represent and affirm that no bribes or corrupt actions have or will be offered, given, received or performed in relation to the procurement or performance of these terms and conditions. For the purposes of this clause, "bribes or corrupt actions" means any payment, gift, or gratuity, whether in cash or kind, intended to obtain or retain an advantage, or any other action deemed to be corrupt under the applicable country laws.
15. All Products supplied herein are subject to these terms and conditions only, to the exclusion of any other terms which would otherwise be implied by trade, custom, practice or course of dealing. Nothing contained in any Client-issued purchase order, Clients' acknowledgement, Clients' terms and conditions or invoice will in any way modify or add any additional terms to these terms and conditions. IHS reserves the right to amend these terms and conditions from time to time.
16. These terms and conditions and any dispute or claim arising out of or in connection with them or their subject matter shall be governed by and construed in accordance with the laws of England and Wales and shall be subject to the exclusive jurisdiction of the English Courts.

How to use

This title is designed to describe both the airborne and the ground-based elements of the principal Unmanned Aerial Vehicle (UAV) and aerial target systems known to be currently under development, in production and/or in service worldwide. It does so within a common entry structure (see below), to enable informed comparison between systems of a comparable nature.

Structure

The title is divided into four product sections, the first two of which are devoted to the air vehicles of each system. The next two deal with major subsystems. All product entries are listed in alphabetical order of country of origin, and within each country in alphabetical order of manufacturer or other prime contractor. The title is completed by an alphabetical listing of manufacturers' addresses and contact details, and separate indexes, by manufacturer and equipment name, for the product entries.

Unmanned Aerial Vehicles: the major section, this covers UAVs of every size and type, both fixed-wing and rotary-wing. Lighter than air systems are also included.

Aerial targets: this section covers all kinds of aerial target, including ballistic and towed targets. Where a manufacturer may offer a UAV variant of a standard target, this is also noted.

Control and communications: coverage in this section ranges from dedicated, customised complete ground control stations to individual elements thereof such as remote video terminals and datalinks.

Launch and recovery systems: covers systems known to be in general use. However, it should be noted that many UAV and target manufacturers also produce such systems tailored to their own products but not adaptable for other use.

Record Structure

Air vehicle (UAV and target) entries are described under the following main headings:

Type: gives a quick-reference summary of each aircraft's primary purpose.

Development: gives the history of development up to the time of publication, or entry into service if earlier.

Description: this is subdivided under the following subheadings:

Airframe: gives a brief description of the air vehicle's general configuration and construction.

Mission payloads: describes the main sensor or weapon payloads installed in, or capable of carriage by, each air vehicle.

Guidance and control: details the method(s) by which the air vehicle is commanded and controlled throughout its mission. (*Editor's note:* Readers should be wary of the term 'autonomous', which tends to be over-used in manufacturers' product literature as though it were synonymous with 'automatic'. Strictly, 'autonomous' should imply that the air vehicle is capable of making its own decisions without human input. Where the word appears in this volume, it has been taken in editorial good faith, but the editor is not always in a position to determine its strict accuracy).

Transportation:is intended primarily to give an idea of the portability of the system.

System composition: gives, wherever possible, an overall picture of the number of air and ground vehicles, personnel and support equipment making up a standard or typical fielded system.

Launch: details the method, with alternatives where applicable, by which the air vehicle is despatched for a mission.

Recovery: the means, also with alternatives if applicable, by which the air vehicle is retrieved at the end of a mission.

Power plant: aircraft power plant (including fuel capacity where known).

Variants: where more than one major version of a particular type exists, the principal differences — and any alternative names or designations — are detailed under this heading.

Specifications: are given in standardised form under the five main headings of Dimensions, External; Dimensions, Internal; Areas; Weights and Loadings and Performance to the fullest extent of the information available.

Readers should note that weights given by manufacturers are, unfortunately, not to a consistent standard. Thus, aircraft empty weight may or may not include such items as onboard (non-payload) avionics; some payload figures may include fuel; maximum take-off or launching weight may include the weight of a launch booster; and so on. These factors will be clarified wherever such details have been provided.

Status: gives the current known operational status of each system or programme and includes any other known information considered to be of interest.

Customers: these are identified either by individual name, country or region, to the extent that this information is openly available. Specific force or unit allocations are also given, if known. However, it will be appreciated that, for reasons of defence security and/or customer confidentiality, this information cannot always be given.

Contractor: gives the name and basic location of each product's manufacturer; full addresses and contact numbers appear in the *Contractors* section.

Sub-system entries, UAV-related control and communications and launch and recovery systems are described under a more basic set of headings, as follows:

Type, Development and **Contractor** are as above.

Status contains customer details, where known.

Specifications groups the basic technical information under similar headings for size, weight and 'performance', although data listed under the last-named necessarily vary with the nature of the product.

Description All other information, including variants where applicable, is grouped under this catch-all heading.

Images

Where possible, photographs, line drawings and/or graphics are provided to illustrate equipments, with the images used being annotated with a seven-digit number that gives them a unique identity within the *Jane's* image database.

UNMANNED AERIAL VEHICLES

Argentina

Nostromo Caburé

Type: Tactical mini-UAV.

Development: Designed for RSTA, force and infrastructure protection, convoy security, BDA and law enforcement applications, *IHS Jane's* source's report Nostromo's Caburé (Owl) AV as having made its public debut at the Sinprode defence exhibition in Buenos Aires in September 2006. During the following July, Simrad Optronics of Norway is understood to have acquired a 30% holding in Nostromo Defensa and in 2011, the cited sources further note Nostromo and Israeli contractor Innocon as having signed an agreement with regard to making the Navigator GCS and flight control computer available for use in the Caburé UAS. Elsewhere in the programme, the same sources suggest over time Caburé procurements by the Argentinian government (a four month law enforcement/homeland security demonstration (including evaluation by the Argentina's Air Force and Marine Corps) that was contracted for in September 2007), an unidentified Argentinian company (one system for forest fire monitoring) and an unidentified US company (one system for a law enforcement demonstration programme). Again, late 2013 is said to have seen some 28 Caburé systems on order, with 'several' Caburé II AVs being said to have been acquired by the Argentinian Marine Corps together with R&D customers in France, Germany and Spain. Readers should also note that the following *Airframe*, *Mission payloads*, *Guidance and control*, *Power plant* and *Specifications* data refers to the Caburé III configuration.

Description: ***Airframe:*** The Caburé III AV utilises a fuselage module that supports a forward-mounted power plant, shoulder-mounted wings (with dihedral on their outer sections) and a tail boom that terminates in a tail assembly that is made-up of a fin and rudder and a pair of horizontal surfaces. Again, the Caburé III is not equipped with an undercarriage and *IHS Jane's* sources report the generic AV as being constructed from glass and carbon fibre and Kevlar.

Mission payloads: Nostromo lists baseline Caburé III payloads as comprising daylight CCD (768 × 494 pixels, ×10 zoom), low-light CCD (768 × 494 pixels, switches from colour to black and white in low-light conditions) and IR (324 × 256 pixels, uncooled focal plane array, 7.5 to 13.5 μm band) cameras. The AV is also equipped with an onboard video transmitter that can hand-off real-time imagery to its GCS.

Guidance and control: Caburé III guidance and control features include a 'military grade' autopilot (associated with an external GPS unit for navigation and providing a radio link with the AV's GCS and capable of generating autonomous flight commands and/or receiving 'dynamic' AV/payload commands from the GCS); an inertial measurement unit (3-axis rate gyros, accelerometers, magnetometers and wind estimation/auto trim capabilities); differential/absolute air pressure sensors and a GCS that is person portable or can be installed in a vehicle. Again, the GCS includes an autopilot interface unit, a video receiver, a laptop computer, mission planning and control software, a digital video recorder and an antenna array.

Transportation: *IHS Jane's* sources report the generic Caburé AV as being dismantled for transportation and carried in a backpack.

Launch: *IHS Jane's* sources report the generic Caburé AV as being either hand- or catapult launched.

Recovery: IHS Jane's sources report generic Caburé AV recovery as being by means of the deep stall to belly landing technique.

Powerplant: The Caburé III AV is powered by a 450 W brushless electric motor that draws power from a rechargeable lithium polymer (LiPo) battery pack and drives a two-bladed tractor propeller.

Variants: ***Caburé I:*** *IHS Jane's* sources report the Caburé I as having appeared during 2007 and to have been derived from a 'baseline' design.

Caburé II: *IHS Jane's* sources suggest that the Caburé II was the Caburé I configuration customised to meet an Argentine Marine Corps (AMC) requirement. The cited sources report the type as having made its maiden flight in October 2007 and as being equipped with a Mavionics MNC 2 autopilot, an Avlon digital video datalink and a multi-spectral camera payload.

Caburé III: *IHS Jane's* sources report the Caburé III as being the definitive AMC Caburé configuration that featured a re-designed airframe (including a tractor rather than pusher engine installation); was recoverable from water; offered increased range and endurance and had a 'minimised' acoustic signature. The cited sources further note the configuration as having made its maiden flight during December 2010.

Cabure

Dimensions, External	
Overall	
length	1.20 m (3 ft 11¼ in)
height	0.35 m (1 ft 1¾ in)
Wings, wing span	2.20 m (7 ft 2½ in)
Weights and Loadings	
Weight, Max launch weight	5.0 kg (11.00 lb)
Performance	
Climb, Rate of climb	354 m/min (1,161 ft/min)
Altitude	
Service ceiling, minimum	4,000 m (13,120 ft)
Speed	
Never-exceed speed	64 kt (120 km/h; 74 mph)
Max level speed	57 kt (105 km/h; 65 mph)
Stalling speed	21 kt (38 km/h; 24 mph)
Range, typical maxima, LOS	8 n miles (15 km; 9 miles)
Endurance	90 min
Power plant	1 × electric motor

Status: As of 2017, Nostromo Defensa was continuing to promote the Caburé III mini-UAV.

Contractor: Nostromo Defensa SA,
Córdoba.

Nostromo Yarará

Type: Small tactical UAV.

Development: Nostromo began researching and developing UAVs and aerial targets in 2000, with design of the Yarará (Rattlesnake) AV being thought to have begun in late 2005 or early 2006. First system delivery is said to have taken place by August 2006 (billed as being the first export of a production UAV from a South America manufacturer), with the type's public debut taking place at the Fuerza Aérea Argentina air show that took place on 10 August 2006. Applications comprise ISR, target acquisition, force/critical infrastructure protection, BDA, convoy security, border patrol and law enforcement and the Yarará made its first flight with a heavy fuel motor in August 2009. Elsewhere in the programme, early 2011 saw Nostromo Defensa announce an agreement with Israeli contractor Innocon under which, Naviator GCS and flight control systems would be made available for use aboard the Yarará and future AVs developed by the two companies. In terms of the type's over time customer base, *IHS Jane's* sources report Yarará procurements as including the Argentinian Air Force (three Yarará UAVs ordered during March 2011 for use by a then new UAV school at Cordoba Air Base), an unidentified Argentinian oil company (one system procured during 2007), the US Department of Defense (DoD) (one 'Yarará-C' system supplied during the second half of 2007) and an unidentified US customer (two systems delivered during 2006). Again, the same sources suggest that Nostromo had produced 12 Yarará AVs (against orders for 14) by the end of 2008.

Description: ***Airframe:*** The Yarará AV features a forward fuselage module that supports a fixed tricycle undercarriage, a ventral payload assembly, shoulder-mounted wings, a pylon-mounted power plant, a tailboom and a T-shaped tail assembly that incorporates a fin and rudder. *IHS Jane's* sources report the type as being constructed from composites.

Mission payloads: Nostromo characterises the Yarará AV's baseline payload as being a day/night EO sensor that takes the form of a single open architecture LRU that is 2-axis stabilised; carries either a daylight CCD colour camera (with a near IR capability and ×10 continuous zoom) or an uncooled thermal imager (320 × 240 pixels, 8 to 12 μm band) and provides ±170° coverage in azimuth and –90° to +20° in elevation.

Guidance and control: Yarará guidance and control features include a 'military grade' autopilot (which utilises an external GPS unit; provides 'intelligent, autonomous' flight control (with GPS waypoint navigation); autonomous take-off/flight/auto-landing/wind estimation/auto-trim capabilities and incorporates an IMU (3-axis rate gyros, accelerometers and magnetometers) and differential/absolute air pressure sensors); a

Three air vehicles make up a typical Yarara system *(Nostromo)*
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