

ABO Workshop

Summary of UAV Workshop & UAV Developments

ECMWF, Reading UK

12-13th February 2020

Stewart Taylor

Technical Co-ordinator

EUMETNET-Aircraft Based Observations (E-ABO)



EUMETNET
EUROPEAN METEOROLOGICAL
SERVICES NETWORK

Presentation content

1. Summary of WMO UAV Workshop
2. Current developments
3. Regulatory issues to consider
4. Recent developments...

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WMO UAV Workshop 1

ToR	No.	Task	Sub-tasks, Description	Responsible	Start	Due / Comp.	Prior.	Status (%)	Deliverables/ Activities	Progress	2019 Budget Estimate	2020 Budget Estimate
3	3.3	Activities related to development of UAV technology for operations.	<ol style="list-style-type: none"> 1. Study and report on potential meteorological applications of UAVs for WIGOS applications. 2. Study and report on Aviation. developments (FAA/EASA) regarding UAV and shared airspace. 3. Organise and hold a workshop on use of UAVs for operational meteorological observations. (30K) 	S. Taylor	Oct 2018	Dec 2020	1	0	<ol style="list-style-type: none"> 1. Update CIMO Guide 2. Update CIMO Guide 3. Report to IPET and TC. 		30	
3	3.4	Coordination of ABO in CIMO Upper-air Inter-comparison.	<ol style="list-style-type: none"> 1. Collaborate with relevant CIMO teams and experts regarding inclusion of ABO systems in the upcoming CIMO upper-air inter-comparison. 	S. Taylor	Oct 2018	Dec 2020	2	0				

https://library.wmo.int/index.php?lvl=notice_display&id=21533#.XbmHfHd2tPZ

WMO UAV Workshop 2

Can UAV systems meet requirements to be considered operational?

Practical requirements:

- Affordability
- Data quality
- Provision of data in real-time

Regulatory requirements:

- Use of airspace & security issues
- Meeting WMO regulatory requirements (data format, sharing data with members, etc)

Agency/ Country	UAV Application	User Application	Requirements/ Issues	Payload type / Duration /
	Boundary layer profiling (3kms)	NWP (high res.), convective initiation,	Regulations, automation of operation, battery	
	Full tropospheric sounding	NWP (high res.), convective initiation,		
	High-Alt Glider with dropsonde			

WMO UAV Workshop 3

Workshop Aims & WMO Role

- Gaps in WIGOS with potential for UAVs to fill boundary and low levels.
- Technical capabilities & current use of UAVs
- Requirements to enable use of UAVs in operational meteorology.
- Understanding of existing issues relating to use of airspace and regulations and their impact on use for meteorological operations.
- Future WMO activities to advance capabilities.
- Requirements of WMO to enable – regulations, data management, etc.

WMO UAV Workshop 4

Key Outcomes, Recommendations and Future Activities 1

- IPET-ABO to assess requirements for development of a data model for international exchange of UAV meteorological data.
- IPET-ABO to advise and coordinate any involvement of UAVs in the next WMO upper-air inter-comparison.
- WMO to investigate the possibility to collaborate with ICAO and national civil aviation authorities regarding the possibility to request approvals and appropriate regulations for use of dedicated airspace for operational vertical atmospheric profiling for meteorological applications.
- IPET-ABO to assess the possibility to coordinate the establishment of dedicated test bed sites for UAV capability and testing for operational meteorology, including an organised demonstration program.
- WMO and the IPET-ABO to consider how to promote wider implementation and use of UAVs in meteorological observations, including the publication of articles in relevant forums.
- IPET-ABO to develop Specific Operations Risk Assessment (SORA) standard scenarios for use of UAVs for meteorological purposes to facilitate their approval in accordance with national and international regulations.

WMO UAV Workshop 5

Key Outcomes, Recommendations and Future Activities 2

- 3-4 workshop participants to become IPET-ABO associate members to provide expertise on UAV systems to WMO and the team to:
 1. Work with IPET-ABO leadership to develop WMO UAV guidance materials.
 2. Provide input to the WMO Integrated Global Observing System (WIGOS) vision for observing systems evolution to 2040 and the subsequent implementation plan for the evolution of WIGOS.
 3. **Develop a white paper on UAV systems** which should include:
 - i) Assessment of current status of UAVs.
 - ii) Benefits and impacts.
 - iii) Roadmap for UAV integration in operational meteorology.
 - iv) Recommendations to manufacturers and regulators.

Kick off meeting 29th Jan 2020

– next meeting 21st Feb 2020

WMO UAV Workshop 6 – Pilot Project

Stakeholders

- WMO/NMHS,
 - **NMHS:**
 - Data reception, data processing (?), quality control and dissemination to data users.
 - **Manufacturer:**
 - UAV to meet requirements,
 - Willingness to collaborate – without impact business model,
 - Sensors meeting WMO quality criteria
- Manufacturer (for sensor array/implementation),
 - **Operator:**
 - Ability to meet the MET requirements,
 - Spatial and/or temporal coverage – areas of relevance to network gaps,
 - Sensor array
 - **Regulatory Body:**
 - Airspace issues,
 - Ability to fly routine synoptic times,
 - Defined areas for operations,
- Operator – agree terms to fly MET payload.
- Regulatory constraints?

WMO GRUAN TT-UA1 - discussed but not seen as “within scope” of intercomparison – but if any co-located UAV trials occurring in the region, at the same time, data would be used...

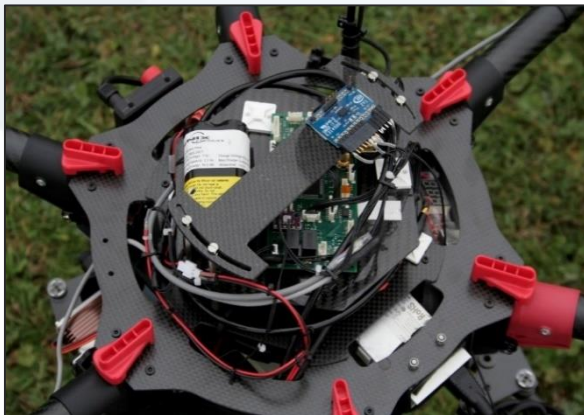
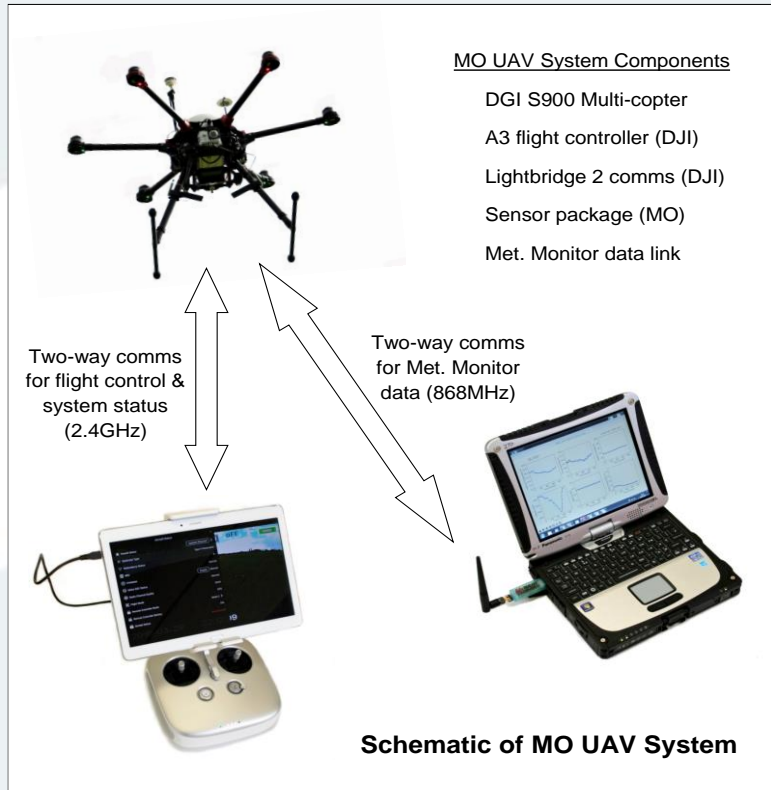
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Current (known) Developments and Research Activities 1

- Meteorology Community (NHMS);
 - CMA, DHMZ, FMI, Météo France, DWD, Hong Kong Observatory, Met Eireann, KNMI, UKMO,
- Government research;
 - NOAA (UAS Programme), NCAR, Oklahoma State University
- Regulatory bodies;
 - IATA, some NMHSs provided information on UAV Traffic Management (UTM) status.
- UAV Companies;
 - Singular, Black Swift, Flyht, DroneX, Meteomatics, ZipLine

Current (known) Developments and Research Activities 2



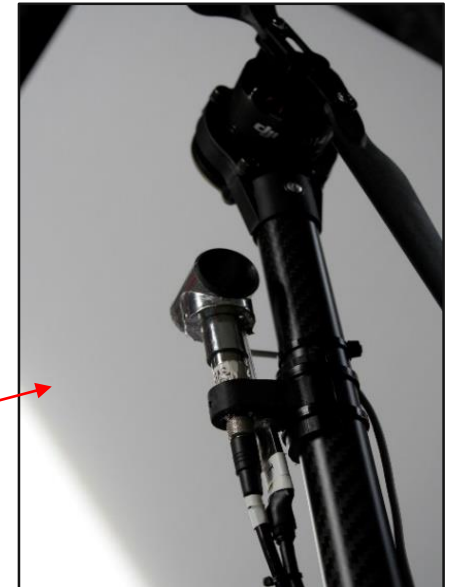
Met Office Sensor Package and Comms Link

Sensors:

- FP07 fast tip thermistor
- Vaisala HMP 110 humidity/temperature probe
- HYT-271 humidity/temperature sensor
- BMP 280 pressure sensor
- BMP055 9-axis sensor to calculate pitch, roll and direction

Sensor housing (FP07 / HMP110):

- Optimum sampling position found to be under prop (see photo)
- Air pressure drop measured with a BMP 280



Acquired data is logged locally to flash memory and transmitted over the 868MHz comms link to a ground station for display in real time.

Current (known) Developments and Research Activities 3

Multi-copter and Fixed-Wing UAV Progress 2018 – 2019

DJI S900 multi-copter:

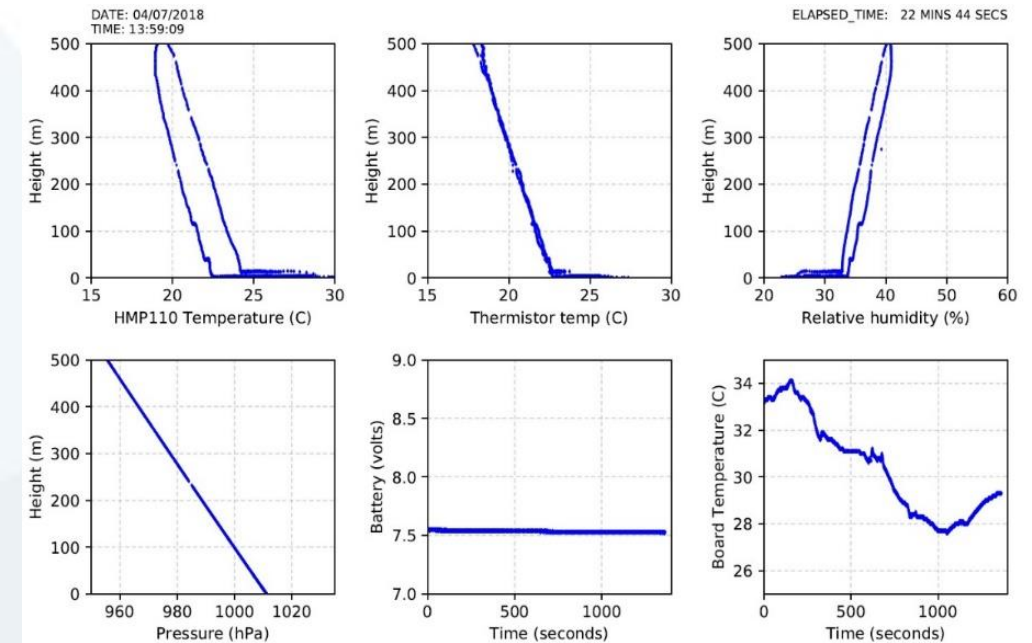
- Continued development of MO sensor package and comms link.
- Boundary Layer meteorological data acquired from:
 - vertical profiles to 500m (sample plots shown)
 - vertical profiles through fog (photo shows aerial view of Cardington hangars through fog)
 - manoeuvres adjacent to 25m and 50m mast instrumentation, for data comparison/verification
- Looking at determination of winds from UAV tilt angle.

Yuneec H520 multi-copter:

- Recent acquisition will provide altitude capability to 6000ft.

Bormatec Maja:

- Provision of fixed-wing capability with Pixhawk autopilot.



Sample plots from vertical profile to 500m altitude on 4th July 2018



Current (known) Developments and Research Activities 3

FMI - Finland

Professor Timo Vihma and his group does BL research based on drone-borne observations. One example of on-going activities with drones: <https://www.mdpi.com/2073-4433/9/7/268>.

Some of other activity includes use of autonomous drone for frequent vertical profiling of standard MET information. Measurements up to 0,5 km have been carried out. So far we have analysed reliability of observations and setup. One of our aviation forecastors have looked at data as sounding observations while in duty. We did not yet do any implementation in NWP, but would very much like to do so.

These have been in-house development activities and will be introduced in next ISARRA conference. The community could be interesting contact to you: http://www.isarra.org/?page_id=227.

International Society for Atmospheric Research using Remotely piloted Aircraft

Innovative Strategies for Observations in the Arctic
Atmospheric Boundary Layer (ISOBAR)—The Hailuoto
2017 Campaign

The Small Unmanned Meteorological Observer SUMO:
Recent Developments and Applications of a Micro-
UAS for Atmospheric Boundary Layer Research

Current (known) Developments and Research Activities 4

MeteoFrance

Utilisation d'un drone pour améliorer la prévision des cyclones

Une campagne de mesure par drone permettant d'échantillonner l'atmosphère au-dessus de l'océan Indien dans les zones de formation des cyclones vient de prendre fin à La Réunion. Retour sur cette mission dont l'objectif est d'améliorer les prévisions des cyclones.



De gauche à droite : Fabrice Julien (CNRM), Sergio Pizziol (Boréal), Sébastien Barrau (CNRM), Radiance Calmer (CNRM), Christophe Mazel (Boréal), Greg Roberts (CNRM), Pierre Serres (Boréal), Michel Gavart (DG Boréal) et Sophian Arix (CNRM). © MF par drone

Par Sophie Rousset — Date de publication : 13/03/2019 08:55
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Contributeurs : Sébastien Barrau

Projet MIRIAD : des drones pour améliorer les modèles



L'objectif du projet MIRIAD est de pouvoir effectuer des vols rasants à une dizaine de mètres au-dessus de la mer, sur de longue distance (1000 km) afin de mieux caractériser les échanges océan/atmosphère et améliorer les paramétrisations des modèles numériques de prévision du temps et de climat.

Current (known) Developments and Research Activities 5

DHMZ – Croatia.

Road traffic air pollution measurement in Zagreb city using UAV

Assessment of air quality has been traditionally conducted by ground based monitoring. In Zagreb there are three ground based stations for air quality.

However, performing fast, comprehensive data collection near pollution sources is not always feasible due to the complexity of sites, moving sources or physical barriers. Unmanned Aerial Vehicles (UAVs) equipped with different sensors have been introduced for *in-situ* air quality monitoring, as they can offer new approaches and research opportunities in air pollution and emission monitoring, as well as for studying atmospheric trends, such as climate change, while ensuring urban traffic and industrial air safety.

Equipment solution for research:

- UAV solution DJI Matrice 100



Current (known) Developments and Research Activities 6

ECMWF

HAPS (High Altitude Pseudo-Satellite) data.

This is an ESA funded pilot project together with Airbus on use of the stratospheric Airbus Zypher plane to provide in situ and other measurements to complement and provide synergies for Earth Observation satellites. It is still in its very early phase. See the HAPS4ESA workshops for details about ESA's interest in this <https://atpi.eventsair.com/QuickEventWebsitePortal/haps4esa/website>

We have also performed impact studies at ECMWF with LMD's/CNES's stratospheric constant pressure balloons.

ECMWF also in contact with Google Loon about getting access to their data.

Also working with the LMD team in Paris on the Strateole-2 stratospheric CNES balloon campaign for Aeolus. Six balloons are expected for the first campaign late 2019, with more to follow in 2021 and 2024. They will have additional high-accuracy temperature data from a 2-4 km fibre hanging down from the balloons.

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Regulatory Bodies 1

➤ FAA:

- Extensive Webpage for UAV/RPAS – operators and recreational users,
- Collaboration with industry, government and academia on UAVs operating in same airspace as manned aircraft.

➤ SESAR:

- Less than 20 years ago, UAVs were not part of Definition Phase, SESAR JU for research projects
- Several new research projects to look at UAVs in shared airspace (H2020)

➤ ICAO:

- 39th Assembly (2016), world governments requested a practical regulatory framework for national UAS activities,
- Working on framework for UAS Traffic Management (UTM).

Regulatory Bodies 2



Key documents

European ATM Master Plan:
Roadmap for the safe integration of drones
into all classes of airspace



U-space



SESAR
European Drones
Outlook Study
Unlocking the value for Europe



Regulatory Bodies 3

U-space projects under Horizon 2020

**CONCEPT OF OPERATIONS FOR
EUROPEAN UTM SYSTEMS - CORUS**

[See the project](#)

**GROUND BASED TECHNOLOGIES FOR A
REAL-TIME UNMANNED AERIAL SYSTEM
TRAFFIC MANAGEMENT SYSTEM (UTMS)
- CLASS**

[See the project](#)

**SENSE AND AVOID TECHNOLOGY FOR
SMALL DRONES - PERCEVITE**

[See the project](#)

**TECHNOLOGICAL EUROPEAN RESEARCH
FOR RPAS IN ATM - TERRA**

[See the project](#)

**AN INTEGRATED SECURITY CONCEPT
FOR DRONE OPERATIONS - SECOPS**

[See the project](#)

**DRONE EUROPEAN AIM STUDY -
DREAMS**

[See the project](#)

**INFORMATION MANAGEMENT PORTAL
TO ENABLE THE INTEGRATION OF
UNMANNED SYSTEMS - IMPETUS**

[See the project](#)

**DRONE CRITICAL COMMUNICATIONS -
DROC2OM**

[See the project](#)

**PROVING OPERATIONS OF DRONES
WITH INITIAL UTM - PODIUM**

[See the project](#)

**ADVANCED INTEGRATED RPAS
AVIONICS SAFETY SUITE (AIRPASS)**

[See the project](#)

**D-FLIGHT INTERNET OF DRONES
ENVIRONMENT - DIODE**

[See the project](#)

**DEMONSTRATION OF MULTIPLE U-
SPACE SUPPLIERS - DOMUS**

[See the project](#)

**A EUROPEAN UTM TESTBED FOR U-
SPACE - EURODRONE**

[See the project](#)

**FINNISH-ESTONIAN "GULF OF FINLAND"
VERY LARGE U-SPACE DEMONSTRATION
- GOF USPACE**

[See the project](#)

**SAFE AND FLEXIBLE INTEGRATION OF
INITIAL U-SPACE SERVICES IN A REAL
ENVIRONMENT - SAFIR**

[See the project](#)

**VALIDATION OF U-SPACE BY TESTS IN
URBAN AND RURAL AREAS - VUTURA**

[See the project](#)

SAFEDRONE

[See the project](#)

Regulatory Bodies 4

The GOF U-Space project at a glance

Flight Information Management System (FIMS) safe, cross-border drone operations

- ⇒ Integration of UTM and ATM systems
- ⇒ Cross-agency / country drone (UAV) information management system
- ⇒ Accessibility of a Common operational picture
- ⇒ Enable Joint Operations / authority collaboration

Large scale demonstration



UAV use-case demonstrations

 Urban drone fleet ops in Helsinki with <u>Police intervention</u>	 Co-operation with Search and Rescue forces and general air traffic (GA)	 Maritime traffic surveillance combined with border guards over Gulf of Finland	 International parcel delivery between Helsinki and Tallinn	 Urban drone fleet ops in Tallinn in controlled airspace	 100km+ inspection flights in forestry and utility inspection	 Urban Air Mobility flight from Helsinki-Vantaa airport to downtown Helsinki
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Regulatory Bodies 5

Focus Area Pathfinder Program

In May 2015, the FAA announced the UAS Focus Area Pathfinder Program, an industry partnership program to develop and validate operational concepts for certification, operations, and safety beyond established or proposed policies and procedures. The three industry partners – CNN, PrecisionHawk, and BNSF Railways – focused their work on operational expansion of: visual line-of-sight operations over people; extended and beyond visual line-of-sight (BVLOS) in rural areas; and BVLOS over right-of-ways. The goal was to develop operational concepts in manageable segments while providing the safety and validation of risk mitigation actions.

By the end of 2017, the program's three focus areas had all met the planned objectives, namely to: define the parameters to allow safe operation of drones in the National Airspace System (NAS); obtain operational approval for the Pathfinder industry stakeholder to perform routine, limited operations; and to define under what conditions and constraints similar operations may be approved for future applicants.



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NCAS – UAV Working Group 1

- NCAS: research into air pollution, climate and high-impact weather, and long-term global changes in atmospheric composition and climate with 200+ members of staff embedded in UK universities and research institutes.
 - Meeting in Aug 2019 of academia, research institutes, industry players and WMO/EUMETNET representation,
 - Agreed to form UK group – now named “Research Association for the use of Drones in the Atmospheric Sciences” (RADAS),
 - Several research projects with UAVs are being funded or seeking grants,
 - Autonomous UAV from ocean floats (e.g. ARGO)
 - Network of UAV at ~10 UK ground sites
 - Met Office activities 2020, working with Cardington and 3 UK universities to compare a variety of UAV’s and sensors to radiosondes/lidar and standard operational MET measurements.
 - UK research councils are funding a lot of work linking up with Met Office – this can and should all be pulled through to help the wider international community.

Operational Development 1

University of Birmingham/Big Sky Science.

Working on BVLOS projects.

- Looking at a “long term” campaign ~3 years with some international partners.
- An opportunity to deploy MET sensors
- Regular flights (2-3 times per week) fixed wing drone flights in the Atlantic ocean
- Potentially up to 14,000ft and 50 nautical miles laterally
- Flights will incorporate a variety of environmental monitoring projects
- Flights could accommodate MET sensor and be timed to tie into required observation times

Airtask Group; possibility of adding MET sensors to their small aircraft.

- operate aircraft daily off the coast of mainland Scotland, the western isles and the Shetlands
- aircraft are invariably below 2000 ft. airborne every weekday (weather dependent, of course!)
- engineering department, in principle, do not see a problem fitting probes, aerals, power supplies etc
- it might even be possible to fit a low cost satcom system to allow real-time reporting of data.

Operational Development 2

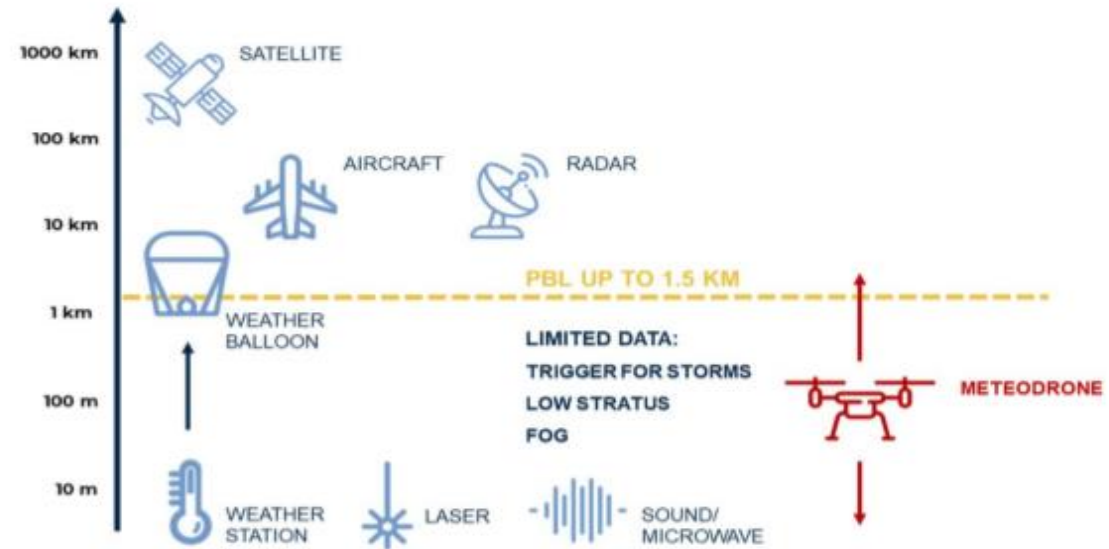
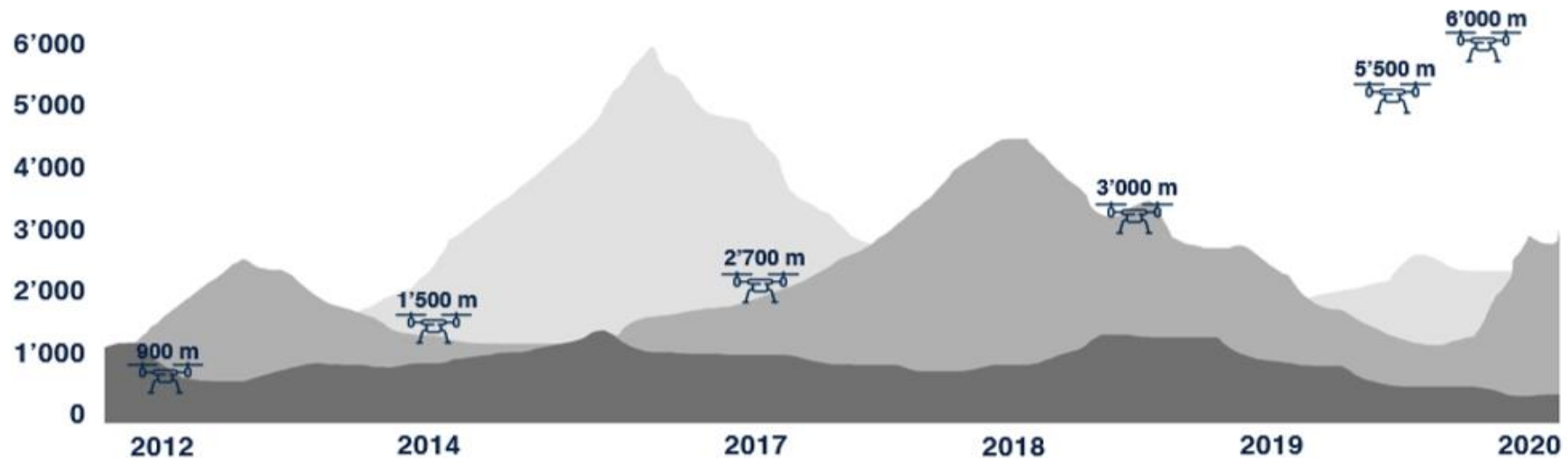


Illustration 1: Meteodrone closes the data gap.



Operational development 3

- Discussion with ZipLine – Africa medical/humanitarian relief organization.
 - NDA agreed
 - looking to test data – using E-AMDAR infrastructure
- New CAA Innovation Hub



CAA Safety & Airspace Regulation Group

including UAS, Airspace (Civil & MOD), Aerodromes, Spectrum, ATM, Strategy

The Innovation Hub is exploring a range of innovation themes that will contribute to shaping the future of air travel

- Urban Air Mobility
- Beyond Visual Line of Sight (BVLOS) UAS Operations
- Unified Traffic Management (UTM)

National BVLOS Experimental Corridor Development of infrastructure to support drone operations in non-segregated airspace



Operational Development 4

UNMANNED
AIRSPACE



Weekly news bulletin – 10 February 2020

Counter UAS systems tenders

USAF seeks US contractor to provide USD490 million C-UAS command and control management system

Counter-UAS systems and policies

Ascent Vision launches man-portable maritime counter UAS imaging system

Counter-UAS company CerbAir announces EUR5.5 million in new funding

Airways New Zealand and OSL partner to develop counter drone and UTM system

CONTROP launches new drone detection capabilities at Singapore Airshow

US Army extends C-UAS support contract with Syracuse Research

US DoD selects Fortem Technologies' counter UAS solutions

UAS traffic management system news

"Global remote ID of drones now viable via Iridium satellite services-" RelmaTech

South African regulator approves first BVLOS flight by United Drone Holdings and Iris Automation

African Drone Forum: "More autonomous than manned flights now in Rwanda"

UAV Navigation demonstrates unmanned operations with UHF datalink beyond 300 km

UK Maritime and Coastguard Agency plans unmanned demonstration search and rescue flights in civil airspace

FAA sets out next steps for UTM Pilot Program in Phase 1 summary report

AiRXOS joins with NUAIR to test UTM operations at Griffiss UAS Test Site, NY

Connected Skies event "will bridge the worlds of telecom and UTM" – GUTMA

UAS traffic management tenders

SESAR seeks proposals to demonstrate urban air mobility in open call backed by Horizon 2020 funding

Urban air mobility

Autonomous air taxi flight trials take off in New Zealand

Operational Development 5

South African regulator approves first BVLOS flight by United Drone Holdings and Iris Automation

📅 February 7, 2020 📁 UAS traffic management news

The South African Civil Aviation Authority (SACAA) has granted approval for United Drone Holdings (UDH) to conduct a beyond visual line of sight (BVLOS) long-range commercial flight with vertical take-off and landing (VTOL) aircraft. Permission was granted based on the utilization of the Iris Automation Casia onboard detect-and-avoid system, which was demonstrated during live flight operations that included the Casia system making automated manoeuvres to avoid collisions with manned aircraft. The approval from the SACAA requires no visual observers or ground-based radars, enabling BVLOS flights with only two crew members. The Casia technology triggers automated manoeuvres to avoid collisions and alerts the pilot on the ground in command of the mission.

African Drone Forum: “More autonomous than manned flights now in Rwanda”

📅 February 7, 2020 📁 UAS traffic management news

In 2019 Rwanda became the first country in the world where the number of autonomous UAS flights overtook the number of manned aviation flights.

CONTACT DETAILS

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