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| WEATHER CLIMATE WATER | **World Meteorological Organization**  **COMMISSION FOR OBSERVATION, INFRASTRUCTURE AND INFORMATION SYSTEMS**  **Second Session** 24 to 28 October 2022, Geneva | **INFCOM-2/INF. 2(3)** |
| Submitted by: Chair of UAS-DC Scoping Planning & Organizing Committee  4.X.2022 |

## UAS Demonstration Campaign Plan

Annex: [Plan for the WMO Uncrewed Aircraft Systems, Demonstration Campaign](#_Annex_–_Plan)

**Background**

The first session of the Commission for Observation, Infrastructure and Information Systems (INFCOM-1), Part III adopted [Decision 18 (INFCOM-1)](https://library.wmo.int/doc_num.php?explnum_id=11197#page=247) – Plan for a global demonstration project on the use of Uncrewed Aircraft Systems in operational meteorology, with the following elements:

INFCOM:

Decides to endorse the further development and scoping of a WMO-coordinated global demonstration project on the utilization of Uncrewed Aircraft Systems (UAS) in support of the provision of observations for operational meteorological and hydrological applications:

Requests the Standing Committee on Earth Observing Systems and Monitoring Networks (SC-ON) and Standing Committee on Measurements, Instrumentation and Traceability (SC-MINT) to consult with the relevant WMO bodies, international organizations, research institutions, private entities and others to formulate a proposal and plan for this activity, based on the concept provided in the annex to the present decision, to be presented to the Commission for approval at its next session.

Development of the Scope and Plan for the UAS Demonstration Campaign (UAS-DC)

Since the INFCOM-1 session, much progress has been made on developing the scope and plans for the UAS Demonstration Campaign (UAS-DC) including, but not limited to, those activities and items given below. For more details on the status of the UAS-DC, see the WMO Community Platform site here: <https://community.wmo.int/uas-demonstration>.

Progress on the UAS-DC

* A subgroup on UAS has been formed under the JET-ABO and been given the responsibility to oversee the formation and activities of the Scoping, Planning and Organizing Committee and the development of the UAS Demonstration Campaign Plan.
* The [Scoping, Planning and Organizing Committee](https://contacts.wmo.int/Details_of_group/?id=87cc2843-bae3-eb11-bacb-000d3a4afc4a) has also been established under the JET-ABO, initially formed from a group of 16 secretariat and INFCOM experts, and has met eight times to work on developing the UAS-DC Plan.
* A [UAS-DC website](https://community.wmo.int/uas-demonstration) has been established.
* [An initial version of the UAS-DC Plan](https://wmoomm.sharepoint.com/:w:/s/wmocpdb/Ealt99XWgv5Bjjk6WOiYfhQBYAAzHa2ZK_qVz7dfAN4h_g?e=CbXQBC&wdLOR=cED55ECB8-2B7F-4E52-A434-D2EC9B69A1D0) has been developed under the coordination of the Scoping, Planning and Organizing Committee (SPOC).
* An informal joint SC-ON, SC-IMT task team has been formed to develop a UAS data representation format with an initial data model and CF-NetCDF format nearing completion.
* Two surveys have been conducted over September and October 2021 to canvas the potential interest in participation in the campaign of 1) WMO Member NMHSs, and 2) Research and private agency operators and data users. This resulted in an indication of interest in participation from:
  + 14 WMO Member NMHSs
  + 48 international research or private operator agencies
* Communication email groups have been formed based on contacts submitted from the surveys and initial communication to prospective participants made.
* An initial [Kick-off online meeting](https://community.wmo.int/meetings/wmo-uas-demonstration-campaign-kick-meeting) with potential UAS participants was held on 19 January 2022, with more than 80 attendees and follow up participant meetings have been held in May and September 2022.
* Progress reports have been made to SC-ON and SC-MINT, most recently during November and December 2021, and March 2022, with strong support given for the proposed development plan.
* Following the endorsement of the UAS-DC Plan by the management group in March 2022, Members have, in September 2022, received a letter from the Secretariat informing them of the INFCOM Management Group decision and requesting their response to a second survey on their proposed contribution to the campaign.

**Plan for the UAS Demonstration Campaign**

The current version 1.2 of the UAS Demonstration Campaign is provided in the [annex](#_Annex_–_Plan) to this document.

## Annex – Plan for the WMO Uncrewed Aircraft Systems, Demonstration Campaign

Plan for the   
WMO Uncrewed Aircraft Systems, Demonstration Campaign

Version 1.2, September 2022

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### Background

The WMO Uncrewed Aircraft Systems (UAS) Demonstration Campaign (UAS-DC) is aimed at demonstrating the potential capability of UAS to play a role as an operational component of the WMO Integrated Global Observing System (WIGOS) under the Global Basic Observing Network (GBON).

This document contains and describes the proposed plan to organize and conduct the WMO UAS Demonstration Campaign and identifies the roles of various organizing entities and stakeholders, the tasks and activities to be undertaken and the resources required to implement the campaign.

UAS-DC Aims

In particular, the UAS-DC will focus on the following aims:

1. To demonstrate current capabilities of a range of UAS and to assess their capacity to contribute to meeting operational requirements for upper-air observations and the filling of observational gaps of the WIGOS GBON;
2. To demonstrate the capacity of UAS and their data processing systems to collect and provide data in an interoperable format ready for use by relevant applications and modelling centres for real-time and off-line use by regional and global forecast systems;
3. To measure, analyse and report on the impacts and benefits of UAS observations on relevant WMO Application Areas and forecast system performance;
4. To determine and report on areas of development and improvement needed for UAS to adequately meet requirements to efficiently, economically and environmentally responsibly contribute operationally to WIGOS; and
5. To determine and make recommendations relating to regulatory requirements imposed on UAS that impact on their ability to contribute to WIGOS.

The demonstration project will include the following aspects relating to UAS operations, data delivery and data use:

* Continuous and routine operation of UAS over the project observations period(s);
* Near-real-time delivery of data to a central repository in prescribed inter-operational common formats;
* Use of UAS data by stakeholder data users and applications and implementation and operation of data assessment practices during the observations period(s); and
* Ongoing data quality assessment throughout and following the observation period(s).

**The original conceptual plan as approved by INFCOM for elaboration is provided in the document: [Conceptual Plan for a Global Demonstration Project on Uncrewed Aircraft Systems (UAS) Use in Operational Meteorology.](https://wmoomm.sharepoint.com/:w:/s/wmocpdb/ETyGIf06oFtOjnp5hLRLijMBeVzvO4cYAAfsnZsaFLghEg?e=1Vy7pW)**

### UAS Demonstration Campaign Description

The WMO Uncrewed Aircraft Systems Demonstration Campaign (UAS-DC) will comprise a twelve-month period of meteorological and hydrological observations made voluntarily by UAS operated by participant operators at their own cost. The demonstration will involve contributors from the public, governmental and private sectors and will collaborate with researchers and developers in the field of UAS deployment and operation for meteorological and hydrological research and operational forecasting applications.

Coordination and Planning

The UAS-DC will be planned, coordinated and undertaken under the auspices of the WMO Commission for Observation, Infrastructure and Information Systems (Infrastructure Commission – INFCOM)[[1]](#footnote-2). INFCOM, Joint Expert Team on Aircraft-based Observing Systems (JET-ABO) will have primary delegated responsibility for coordinating related planning and coordinating activities within the INFCOM.

The JET-ABO will coordinate the formation of a Scoping, Planning and Organizing Committee (SPOC[[2]](#footnote-3)) that will consist of Members and other experts from among the participant operators and WMO Application Areas, as well as from other key stakeholder groups and sectors. The SPOC will play a primary role before, during and after the UAS-DC including:

* Overseeing the development and approval of the plan for the UAS-DC, including its scope and requirements of participants;
* Developing a communications plan;
* Coordinating required external approvals, e.g., with regulators, for the UAS-DC;
* Overseeing and coordinating the UAS-DC before and during the campaign.

Scope and Participation

The UAS-DC is expected to commence at the beginning of March 2024 and continue through to the end of August 2024 so that the campaign will coincide with the 2024 Paris Olympics[[3]](#footnote-4), which will take place from 26 July to 11 August 2024.

The campaign will also have two Special Observing Periods (SOP) during which participants will be strongly encouraged to contribute a higher frequency and greater coverage of UAS observations. One of these SOPs will be expected to be timed to coincide with the 2024 Olympics.

The campaign will have the two primary participatory groups: (1) Participant UAS Operators and (2) Participant Data Users. In addition, the campaign will require the input of a range of stakeholders and collaborators including representatives of regulatory authorities.

The UAS operated during the campaign will include autonomous and remote-piloted fixed-wing and copter aircraft, operating from the surface to the upper troposphere. Airspace regulations may limit access above the planetary boundary layer through the atmospheric airspace used by piloted aircraft, however it is expected that the SPOC will work with regulators to obtain special permissions for airspace use in certain domains and locations. For this reason, it will be critical to collaborate with airspace regulators and operators at both national and international levels.

As the campaign is aimed at demonstrating UAS capability to meet [requirements](https://community.wmo.int/rolling-review-requirements-process) for operational collection and provision of observations in support of the GBON, the campaign will focus on the near-real-time provision of measurements of atmospheric variables required for assimilation in Numerical Weather Prediction systems (NWP) and the enhancement of short-term weather predictions. Along with required observational and systems metadata, this will include, but not necessarily be limited, to:

* air temperature
* air pressure
* relative humidity
* wind speed
* wind direction
* snow cover
* snow depth
* soil moisture
* albedo
* roughness length
* aerosols or particulates
* volcanic ash
* turbulence

The campaign will have defined requirements for the quality and uncertainty of measured atmospheric variables and for the timely provision of those data. Standardized data representation formats will therefore be specifically developed and defined for use during the campaign for participant operators to relay data to a central data repository from which data users will be able to access the data in near-real time.

Participant UAS Operators will be invited to contribute observations from a relatively unlimited range of geographical domains with a key requirement to submit them on a routine, ongoing basis throughout the campaign. Operators will be required to contribute at least one month of observations to the campaign but will be encouraged to commit to providing observations throughout the entire campaign and especially during the SOP.

Participant Data Users will be engaged to make use of the data, both during and after the campaign, within operational and test applications so as to be able to assess the impact of UAS data and assist in analysing and improving the operational aspects of the UAS systems and the quality of the data produced.

Of critical importance to the campaign and its desired outputs and outcomes, will be the compilation and provision by the campaign participants of reports both during and after the campaign observing period. Such participant reports will be used to:

* Adjust and improve the campaign parameters and requirements during the campaign as necessary and in the interests of improving observational outputs and data use;
* Measure, assess and report on the impact of UAS observations by data users;
* Contribute to the final reports to be produced by the WMO INFCOM after the campaign is complete;
* Analyse the capabilities of UAS to contribute observations to WIGOS and the GBON and make related recommendations for future actions.

### Expected Outcomes

The UAS Demonstration Campaign will be expected to deliver or contribute to the following outcomes:

1. Assessment of the capabilities of UAS to contribute to WIGOS and GBON as a component operational observing system;
2. Understanding of the technical and operational developmental improvements required of UAS to meet standards for transition to operations under WIGOS;
3. Improved understanding of the impact that operational UAS have on NWP and other forecast systems and products;
4. Improved understanding of the impact of the limitations imposed by airspace regulations on UAS operations in support of meteorology, hydrology and climate.

### Stakeholders, Participants and Roles

The demonstration will involve contributors from both the public, Government and private sectors and seeks to collaborate with researchers and developers in the field of UAS deployment and operation for meteorological and hydrological research and operational forecasting applications.

| Stakeholder/Participant | Role | Entry | Communications |
| --- | --- | --- | --- |
| Scoping, Planning and Organizing Committee | Organization and coordination of the UAS-DC | Appointed by the INFCOM/SCs under the management of the JET-ABO and its Subgroup on UAS | See [Annex 1](#Annex_I) |
| WMO INFCOM, Executive, Standing Committees and work groups and teams  See the [WMO Community Platform](https://community.wmo.int/governance/commission-membership/commission-observation-infrastructure-and-information-systems-infcom) | Provision of expert input to plan formulation and implementation;  Coordination with participant communities;  Approvals and Recommendations to CBs; | UAS-DC sponsoring body. | The SPOC, SG-UAS and JET-ABO will facilitate interactions and coordination with the INFCOM and its various bodies as required. |
| Member UAS operator | Participant UAS Operator | Written agreement to participate provided to WMO (SPOC) | Members to be invited to participate through letter to Permanent Representatives with WMO;  Possible formalized response through a survey form |
| Research UAS operator | Participant UAS Operator. | Written agreement to participate provided to WMO (SPOC), possibly formalized with an MoU. | Members to be requested to communicate with their national research agencies;  WMO WRP to be consulted regarding communications processes from WMO;  Possible formalized initial response through a survey form. |
| Private UAS operator | Participant UAS Operator. | Written agreement to participate provided to WMO (SPOC), possibly formalized with an MoU. | Initial advice of the DC to be made with HMEI.  Obtain an initial indication of intention to participate via an online survey form. |
| Member NWP Data User (World Meteorological Centres of GDPFS) | Participant Data User | Invited to participate and make use of UAS data within NWP applications.  Written agreement to participate provided to WMO (SPOC) | Initial less formal communications by email to WMC contacts;  To be formally invited to participate through letter to PRs with WMO |
| Member Data User | Participant Data User. | Invited to participate and make use of UAS data generated for forecast applications. | To be formally invited to participate through letter to PRs with WMO based on feedback from a survey. |
| Research Data User | Participant Data User. | Invited to participate and make use of UAS data generated for forecast applications.  Agreement to participate with WMO (SPOC), possibly formalized with an MoU. | Obtain an initial indication of intention to participate via an online survey form. |
| ICAO | Regulations Adviser and Facilitator | Invited to collaborate as member of or adviser to the SPOC.  Initially through Mr Jun Ryuzaki, ICAO rep. to JET-ABO; | Processes and strategies to be developed in the Pre-Campaign Phase |
| National Civil Aviation Authority | Regulations Adviser and Facilitator. | Invited to participate as members of or collaborators with the SPOC. | WMO and WMO experts to initiate contacts and participation as required. |
| WMO Legal Counsel | Establishment of legal framework for the UAS-DC, including development of legal requirements of participants and the content of agreements. | Internal Secretariat. | Internal Secretariat and to the SPOC. |

### Demonstration Campaign Scope and Requirements

The table below sets out the scope of the UAS-DC, along with the decisions required to finalize the campaign scope and requirements. The remainder of the plan will be adapted and adjusted according to the development of this scope and the related requirements of the various campaign elements.

The UAS-DC plan and the campaign elements will only have confirmed status when the decision of INFCOM (or SC-ON if delegated) has provided approval.

Status will be one of:

1. Proposed by SG-UAS;
2. Proposed by SPOC;
3. Proposed by SC-ON, SC-MINT;
4. Confirmed by INFCOM (or SC-ON)

| Element | Current Proposed | Status | To do |
| --- | --- | --- | --- |
| Campaign Observing Periods | 1. 6-month period, commencing at the start of March 2024 and including two 1-month SOP. 2. Two UAS-DC SOP will be held during the 6-month full campaign period. SOPs will aim at promoting a greater coverage of UAS observations both temporally and spatially in certain regions over a 1-month period so as to provide data users with a larger data set to more comprehensively measure impact and quality. | Proposed by SG-UAS | * To be reviewed by SPOC, SC-ON and SC-MINT * SPOC to determine SOPs requirements * To be confirmed by INFCOM * To be approved by WMO CB |
| UAS Types | 1. Autonomous copter or fixed-wing small UAS 2. Remote-piloted copter or fixed-wing small UAS 3. Automated high altitude fixed-wing UAS 4. Remote-piloted high altitude fixed-wing UAS. | Proposed by SPOC | * To be reviewed by SC-ON and SC-MINT * To be confirmed by INFCOM * To be approved by WMO CB |
| Requirements of Participating UAS | 1. Provide one or more required atmospheric variables along with the supporting observational metadata under a Continuous, Routine Data Provision programme throughout at least one month of the campaign and preferably during at least one of the SOP, at least one of the Modes of Operation and in one or more of the Observing Locations. 2. Physical variables provided must meet the prescribed quality requirements. 3. Provide data to the Central Data Repository in the Standard Data Representation Format. 4. Where and when possible, conduct comparison of measurements with Intercomparison Systems. | Proposed by SPOC | * To be reviewed by SC-ON and SC-MINT * To be confirmed by INFCOM * To be approved by WMO CB |
| Requirements of UAS Participant Operators | 1. Adhere to the UAS-DC Data Policy ([Annex II](#Annex_II)). 2. Commit to participation at least 6 months prior to the observing period commencement. 3. Endeavour to provide continuous, routine provision of data for at least 1 month during the demonstration observing period. 4. Endeavour to commit to participating in at least one of the two SOP. 5. Obtain and demonstrate to WMO any documents that demonstrate required permissions and approvals of the relevant national regulator to participate. 6. Obtain and demonstrate to WMO obtainment of required insurance and indemnify WMO against any third-party claims. 7. Provision of data in the standard data representation format to the central data repository in Near-real Time. 8. Submitted reports by UAS-DC participants to be the property of WMO. 9. Observations to be made available to Participant Data Users via the Central Data Repository. 10. Provision of a Standard Participant Operator Report and input into demonstration results and outcome reports. | Proposed by SPOC | * To be reviewed by SC-ON and SC-MINT * To be confirmed by INFCOM * To be approved by WMO CB |
| Requirements of Participant Data Users | 1. Adhere to the UAS-DC Data Policy ([Annex II](#Annex_II)). 2. Provision of a Data User Impact Report on the impact of UAS and benefits of data used, to be provided within 1-year of the completion of the UAS-DC observing period. 3. Provision of 3-monthly reports during the UAS-DC observing period, aimed at providing preliminary impact and quality information and improving campaign outputs and results. | Proposed by SPOC | * To be reviewed by SC-ON and SC-MINT * To be confirmed by INFCOM * To be approved by WMO CB |
| Observing Locations and Modes | 1. Oceanic Atmospheric Boundary Layer (ABL) - Vertical profiles of the atmospheric boundary layer with UAS from stationary or moving platform location. 2. Remote land, mountain, coastal and cryosphere observations and vertical profiles with UAS. 3. Upper troposphere and lower stratosphere observations of UAS. 4. Testbed observations and vertical profiles UAS. | Proposed by SPOC | * To be reviewed by SC-ON and SC-MINT * To be confirmed by INFCOM * To be approved by WMO CB |
| Intercomparison Systems | 1. Radiosonde 2. Surface-based observing systems 3. Other aircraft-based observing systems (e.g. AMDAR) 4. Other UAS, including those participating in the UAS-DC 5. Weather radar 6. Doppler or water vapour LIDAR 7. Microwave radiometer 8. Sodar 9. Tower 10. Tethered Balloon | Proposed by SPOC | * To be reviewed by SC-ON and SC-MINT * To be confirmed by INFCOM * To be approved by WMO CB |
| Definition of “Continuous, Routine Data Provision” | Continuous Routine Data Provision shall mean: The making and provision of observations of the Required Physical Variables and associated Supporting Observational Metadata in accordance with the Modes of Operation at a frequency of at least once per day, on at least 4 days per week. | Proposed by SPOC | * To be reviewed by SC-ON and SC-MINT * To be confirmed by INFCOM * To be approved by WMO CB |
| Definition of “Near-real Time” | Near-real Time, in the context of the operation and delivery of UAS data shall mean: preferably within 30 minutes of the observation time if possible, and no later than within 3 hours as a maximum. | Proposed by SPOC | * To be reviewed by SC-ON and SC-MINT * To be confirmed by INFCOM * To be approved by WMO CB |
| Definition of “Modes of Operation” | Modes of operation of UAS will included, but not necessarily be limited to:   * Boundary layer vertical profiles * Profiling to above the boundary layer * Straight and level runs (SLRs) in the boundary layer * SLRs above the boundary layer * High level (troposphere) profiling and SLRs * Very high level (upper troposphere/ lower stratosphere) profiling and SLRs | Proposed by SPOC | * To be reviewed by SC-ON and SC-MINT * To be confirmed by INFCOM * To be approved by WMO CB |
| Definition of “Required physical variables” (RPV) | 1. Air temperature 2. Air pressure 3. Relative humidity | Proposed by SPOC | * SG-UAS to specify units and quality criteria * To be reviewed by SC-ON and SC-MINT * To be confirmed by INFCOM * To be approved by WMO CBUAS |
| Definition of “Additional physical variables (APV)” | 1. wind speed 2. wind direction 3. snow cover 4. snow depth 5. soil moisture 6. albedo 7. roughness length 8. aerosols or particulates 9. volcanic ash 10. turbulence | Proposed by SPOC | * SG-UAS to specify units and quality criteria * To be reviewed by SPOC * To be reviewed by SC-ON and SC-MINT * To be confirmed by INFCOM * To be approved by WMO CB |
| Definition of “Supporting observational metadata” (SOM) | 1. 2D-positional coordinates 2. Vertical coordinates 3. Time of observation 4. Platform identifier and type 5. Launch location and elevation | Proposed by SPOC | * SG-UAS to specify additional metadata requirements, units and quality criteria * To be reviewed by SPOC * To be reviewed by SC-ON and SC-MINT * To be confirmed by INFCOM * To be approved by WMO CB |
| Definition of “Standard Data Representation Format” (SDRF) | 1. Data shall be submitted in a pre-defined [NetCDF](https://www.unidata.ucar.edu/software/netcdf/?_ga=2.66026477.25100267.1626098551-944796668.1626098551) or WMO BUFR format tailored for UAS data representation. | Proposed by SPOC | * SG-UAS to test and finalize SDRF by end-2021 * To be reviewed by SPOC * To be reviewed by SC-ON and SC-MINT * To be confirmed by INFCOM * To be approved by WMO CB |
| Definition of “Central Data Repository” | To be determined and to be defined:  Host organization/entity  Period over which UAS data will be stored.  Data provision conditions, validation and security.  Data access conditions, validation and security. | To be defined | * SG-UAS to work with WMO/WIS and Data Users to determine requirements and solution for CDR * To be reviewed by SPOC * To be reviewed by SC-ON and SC-MINT * To be confirmed by INFCOM * To be approved by WMO CB |
| Definition of “Standard Participant Operator Report” | Standard Participant Operator Report shall consist of:   * 1. Technical description of UAS operated.   2. Description of Observing Locations and Modes of deployment.   3. Statistical summary of observations contributed.   4. An assessment of all environmental impacts of UAS during the campaign period.   5. Estimation of manufacture/purchase costs of equipment deployed.   6. Estimation of deployment and operational costs.   7. Analysis and results of intercomparisons made or obtained.   8. Assessment of UAS performance.   9. Assessment of UAS deficiencies or issues encountered.   10. Assessment of quality of observations provided.   11. Recommendations in relation to the campaign.   12. The report shall be submitted within 6 months of the final day of the final campaign observing period at the latest. | Proposed by SPOC | * To be reviewed by SC-ON and SC-MINT * To be confirmed by INFCOM * To be approved by WMO CB |
| Definition of “Data User Impact Report” | Data User Impact Report shall consist of:   1. Statistical summary of observations used. 2. Statistical/empirical report of observations impact and/or quality, including comparisons made with Intercomparison Systems. 3. Objective analysis and assessment of impact on data user application. 4. Recommendations in relation to the UAS observations used. 5. Recommendations in relation to the campaign. 6. The initial report shall be submitted within 3 months of the final day of the final campaign observing period and a final report within a further 6 months at the latest. | Proposed by SPOC | * To be reviewed by SC-ON and SC-MINT * To be confirmed by INFCOM * To be approved by WMO CB |

### Demonstration Components and Key Tasks and Activities

This document will encompass planning for the following components of the UAS Demonstration Campaign:

1. Formation of the SPOC
2. Pre-Campaign Period
3. Demonstration Campaign Period
4. Post-Campaign Period

Note that the timeline will be adjusted according to the final decision relating to Campaign Observing Periods.

| Component | Key Tasks, Activities. | Who | Outputs | Timeline |
| --- | --- | --- | --- | --- |
| Formation of SPOC | 1. Development of ToR. 2. Initial formation 3. Expansion to include required stakeholder area representatives | * SG-UAS * SC-ON | * Terms of Reference of SPOC * Formation of SPOC | May 2021– June 2021 |
| Pre-Campaign Period | 1. Regular meetings of SPOC and adaption of its membership as required. 2. Development & finalization of Plan for the UAS-DC 3. Finalization of demonstration scope and requirements 4. Approval from INFCOM & WMO EC to proceed 5. Onboard consultancy as required 6. Develop communications materials 7. Initiate & undertake communications 8. Communications with regulatory bodies to establish scope of the campaign 9. Establishment of regulatory requirements and approval processes for UAS Participant Operators 10. Determination of national regulations that will impact UAS constraints, including impact on sensors & measured variables. 11. Establishment of legal framework for the UAS-DC including agreements with participants 12. Determine data quality requirements for physical variables and requirements for operators to demonstrate capacity to comply. 13. Plan, develop and test the SDRF for UAS data provision 14. Discuss and develop requirements for downlink capabilities of UAS 15. Develop data repository for UAS and intercomparison data 16. Develop data repository visualization interface 17. Regular meetings of SPOC and adaption of its membership as required. | * SPOC * SG-UAS * SC-ON * INFCOM * Consultancy * Stakeholders * Participants | * UAS-DC Plan * Demonstration scope * Documentation to support SC-ON and INFCOM decision * Website * Flyers * Guidance for UAS participation including airspace usage * Guidance for data provision * Guidance for data users * Date repository * Organizational meetings held * Promotional events held * List of participants * List of data users * Data repository visualization interface | July 2021–September 2023 |
|  | 1. Development & finalization of Plan for the UAS-DC 2. Finalization of demonstration scope and requirements 3. Approval from INFCOM & WMO EC to proceed 4. Onboard consultancy as required 5. Develop communications materials 6. Initiate & undertake communications 7. Communications with regulatory bodies to establish scope of the campaign 8. Establishment of regulatory requirements and approval processes for UAS Participant Operators 9. Determination of national regulations that will impact UAS constraints, including impact on sensors & measured variables. 10. Establishment of legal framework for the UAS-DC including agreements with participants 11. Determine data quality requirements for physical variables and requirements for operators to demonstrate capacity to comply. 12. Plan, develop and test the SDRF for UAS data provision 13. Discuss and develop requirements for downlink capabilities of UAS 14. Develop data repository for UAS and intercomparison data 15. Develop data repository visualization interface 16. Plan develop and test the data provision API for provision of UAS data. 17. Coordinate organizational meetings, including meetings with Participants as required 18. Obtainment of approvals, agreements as required by airspace regulatory bodies 19. Coordinate promotional events as required 20. Establish list of participants including operators, data users |  |  |  |
| Demonstration Campaign Period | 1. Data repository management and maintenance activities 2. Monitoring of demonstration processes and activities 3. Monitoring of UAS data quantity and quality 4. Routine meetings with participants 5. Routine communications with participants 6. Communications with airspace regulators 7. Provision of support for data users 8. Provision and review of reports by participants | * SG-UAS * SPOC * Consultancy * Participants | * Routine reports on data repository status * Routine reports by participants * Data quantity and quality reports * Meetings with participants * Adjustments to processes as required | August 2023–August 2024 |
| Post-Campaign Period | Data user analysis of data impacts and compilation of assessment reports.  Operator analysis and compilation of performance assessment reports.  Provision of assessment reports by contributing data users, UAS Operators, and stakeholder airspace regulatory bodies.  Full UAS-DC analysis of impacts and outcomes based on Participants report. | 1. Participant Data Users 2. Participant Operators 3. JET-ABO/SG-UAS, SPOC, SC-ON | 1. Data user reports 2. Operator reports including system performance, environmental impact, regulations impacts, etc. 3. UAS-DC report, including outcomes, impacts, recommendations, etc. | September 2024 – September 2025 |

Critical and Strategic Considerations

Communications

Communications both before and throughout will be critical to the success of the campaign. Therefore, a separate communications and meetings plan is developed below. In relation to this plan, the following considerations will be important:

* Ensuring that the campaign is of interest to the data user community will be dependent upon ensuring that there is sufficient UAS operator participation to derive sufficient coverage and impact from the output UAS observations. This will be especially important during the SOP. Therefore, the initial communications efforts should focus on generating and gauging the interest of potential operator participation.
* The use initially of surveying of the various participant and data user communities will be a first step, which will not only allow the gauging of interest but also the establishment of email lists for subsequent communications.

Data Representation and Provision

Given that provision of data in near-real time to a central repository is a key aspect of the campaign, the plan must give a priority to early collaborative work on the development of standardized, widely accepted and easily useable UAS data representation. Ideally, such a data representation should be developed quickly enough to be able to be made available at least 6 months prior to the campaign (i.e. by early 2023) commencement for testing and validation.

It is expected that a CF-NetCDF format specification will be developed initially, with a BUFR translation adapted soon after. While their full approval under the relevant WMO/INFCOM process is not considered a necessary outcome of the UAS-DC, this ideally would be undertaken and achieved before the commencement if possible.

UAS Participant Operators

While it is expected that a number of WMO Member NMHSs will participate as UAS Operators during the campaign, the majority of interest in participation is expected to come from the research and private sectors. In nearly all cases, it would be best if the research and private participant operators could consult, and possibly partner with their country’s WMO Member NMHS. The nature of this partnership might vary but might be expected to encompass aspects such as:

* Facilitating knowledge and expertise regarding operational data provision under the WMO Information System
* Providing support for communications infrastructure
* Providing support for access to testbeds and/or other locations from which UAS operations might be conducted
* Assisting with obtaining approvals for airspace regulatory bodies

Participant Data Users

[Aims](#_UAS-DC_Aims) 1 and 2 of the campaign are very much associated with the data user communities and are therefore associated with the defined requirements (see the [WMO Rolling Review of Requirements](https://community.wmo.int/rolling-review-requirements-process), [requirements database](https://space.oscar.wmo.int/observingrequirements)) for observations under the GBON, which supports the NWP Application Areas of WMO. Within the many wider Application Areas, many make direct use of both NWP outputs, as well as the observations that are assimilated by them, as part of forecast product processes and systems. For this reason, this data user community will be critical to the campaign, both during and after, to assist in measuring, analysing and reporting on the impact of the observations produced by the campaign. As a potential beneficiary of the future provision of operational UAS observations, the engagement of these communities in the campaign should be readily engaged, but will depend upon:

* Early, ongoing, clear and concise communication of the relevant campaign information
* The provision of observational data in a readily understood and useable format from a central and accessible repository that includes required metadata
* Participation by UAS Operators that will ensure an observational output that is significant and likely to have an impact on NWP and other relevant forecast applications and systems
* Provision of observations of sufficient and sufficiently documented quality

Airspace Regulations

Another important aspect of the campaign will be that of airspace regulations relating to UAS. This will have implications for the following elements of the UAS-DC planning and coordination:

* Participant operators will need to be legally responsible for compliance with and adherence to national and international regulations relating to UAS-DC operation where they will operate
* WMO will likely require some form of agreement with participants to ensure that they do all they can to be compliant and that they indemnify WMO
* WMO may be able to work with airspace regulators to obtain special permissions on behalf of operators to enhance observational capabilities and coverage during the campaign
* Working with Participant UAS Operators to identify any operational constraints and waiver procedures
* Determination of any vehicle constraints and how those might impact data collection

Communications Plan

| Communication With | Communication By | Concerning | Communication mode | Component | Commence | Complete |
| --- | --- | --- | --- | --- | --- | --- |
| General | WMO | 1. UAS-DC generally. | [WMO Community Platform Website](https://community.wmo.int/uas-demonstration/infcom-1-decision-uas-demonstration-project) | All | August 2021 | Established August 2021.  Update on ongoing basis. |
| Flyer | Pre-campaign | October 2021 | November 2021 |
| WMO ABO, WIGOS newsletter articles when appropriate | All | August 2021 | December 2025 |
| WMO Members | SPOC | 1. Initial interest in participation. 2. Provision of website availability and address. 3. Survey form location. | Circular letter by WMO and request completion of survey form available via website.  Survey form records will be used to construct an email list of Member Participant UAS Operators and Member Participant Data Users. | Pre-campaign | June 2021 | Survey released August 2021  Will be left open until December 2022 |
| HMEI and HMEI Members | SPOC | 1. Initial interest in participation. 2. Provision of website availability and address. 3. Survey form location. | Email request to HMEI to communicate with members.  Survey form records will be used to construct an email list of Private Participant UAS Operators. | Pre-campaign | June 2021 | Survey released August 2021  Will be left open until at least December 2022 |
| Participant Operators | SG-UAS, SPOC | Participation and all campaign matters. | 1. [WMO Community Platform Website](https://community.wmo.int/uas-demonstration/infcom-1-decision-uas-demonstration-project) 2. Email group will be formed based on survey feedback – will be [uas-demo-operators@groups.wmo.int](mailto:uas-demo-operators@groups.wmo.int) 3. A series of meetings will be held to advise Participants on requirements and UAS-DC details 4. A Participant agreement with WMO will be established to communicate requirements for participation. | Throughout UAS-DC | August 2021 | December 2025 |
| Participant Data User | SG-UAS, SPOC | Participation and all campaign matters. | 1. [WMO Community Platform Website](https://community.wmo.int/uas-demonstration/infcom-1-decision-uas-demonstration-project)Email group will be formed based on survey feedback – will be [uas-demo-datausers@groups.wmo.int](mailto:uas-demo-datausers@groups.wmo.int) 2. A series of meetings will be held to advise Participants on requirements and UAS-DC details. 3. A Participant agreement with WMO will be established to communicate requirements for participation. | Throughout UAS-DC | December 2021 | December 2025 |
| Regulatory Authorities | SPOC | 1. Regulatory requirements for Participants at both the global and national level. 2. Development of a policy for use of airspace by Participants during the UAS-DC. | 1. ICAO to be represented in the SPOC. 2. Key national regulators to be represented in the SPOC. 3. Participant UAS Operators to communicate directly with national regulators – this should be communicated and agreed in the Participant agreement with WMO. | Pre-campaign | October 2021 | July 2023 |

Meetings Plan

Most, if not all meetings with participants and stakeholders will be conducted by teleconference. There may be a need for one or two face to face meetings, but these are not as yet envisaged or planned.

| Meeting name | Participants | Content | When | Where / Format |
| --- | --- | --- | --- | --- |
| SPOC Meeting | Members of the SPOC. | Scoping, planning and organization of the UAS-DC. | Routinely and when necessary.  During the Pre-campaign Phase, this should be at least monthly. | Videoconference meetings |
| UAS Data Representation team | Team formed from members of the JET-ABO, UAS-DC SPOC and the SC-IMT data representation groups. | Development of the UAS data representation standard and the UAS-DC data repository. | Routinely and when necessary.  Meetings will commence during the Pre-campaign Phase and continue until the DR standard and data repository are in place. | Videoconference meetings |
| UAS-DC Kick-off Meeting | SPOC, All Participants, All Stakeholders. | Introduction to all aspects of the campaign.  Meeting should perhaps aim to form other teams or subgroups as necessary. E.g.:   * Data user group * UAS operator group. | **Mid-January 2022** | Videoconference.  May need to run in two session and/or else record the meeting |
| UAS Data Representation Testing | UAS Data Representation Team, SC-IMT experts, Participant Representatives, Data User representatives. | Team to develop a test plan and processes for testing the UAS Data Representation format and the functions of the UAS Data Repository. | Routine meetings to commence Feb/March 2022 and continue through the Pre-Campaign Phase. | Videoconference meetings. |
| UAS-DC Participant Planning Conferences | SPOC, All Participants. | Conferences to provide an update to all participants on the status of the UAS-DC and provide key details and advice. | June 2022  December 2022  June 2023 | Videoconference meeting(s) |
| UAS-DC Participant Data User Meetings | SPOC, Participants Data Users. | Meetings to provide information on the UAS-DC to Data Users and for the SPOC to obtain data requirements. | Commence in February 2022 and continue as necessary. | Videoconference meeting(s) |

Resourcing

The following are the key aspects relating to resourcing of the demonstration campaign:

* Participant Operators and Participant Data Users will be self-funded and resourced;
* Partnerships between national meteorological services and third-party operators may involve resourcing agreements or arrangements but these will not be facilitated by or involve WMO;
* WMO will not pay participants for the provision of or generation of data by participants;
* WMO may seek and/or allocate funding to the resourcing of some aspects of the campaign but these will be limited to:
  + Consultancy to support key organizational or developmental aspects of the programme; and
  + Limited funding to support travel of Secretariat personnel or experts to attend meetings or events related to the campaign.

### Annex I – Scoping, Planning and Organizing Committee Members and Terms of Reference

SPOC Membership

| Representing | Application Area | Country | Organization | Name | Role | Contact |
| --- | --- | --- | --- | --- | --- | --- |
| JET-ABO | UAS observing systems/ data assimilation | USA | NCAR | James Pinto | SC-ON Project Lead | James Pinto (pinto@ucar.edu)  Deputy Director Aviation Applications Program  NCAR/Research Applications Laboratory  Boulder, CO |
| JET-ABO | UAS observing systems | UK | Met Office | Debbie O’Sullivan | SPOC Chair, SC-ON Project Lead | Debbie O’Sullivan (debbie.osullivan@metoffice.gov.uk) |
| JET-ABO | Regulatory Authority | Canada | ICAO | Jun Ryuzaki | JET-ABO representative | jryuzaki@icao.int |
| WMO/I | ABO | N/A |  | Dean Lockett | WMO Coordinator | dlockett@wmo.int |
| WMO/S&I | WWR | N/A | WMO | Estelle de Coning | Secretariat advice |  |
| WMO/S&I | AER | N/A | WMO | Oksana Tarasova | Secretariat advice |  |
| WMO/I | Hydrology | N/A | WMO | Dominique Berod | Secretariat advice |  |
| WMO/I | WIS | N/A | WMO | Enrico Fucile | Secretariat advice |  |
| WMO/I | GDPFS | N/A | WMO | Yuki Honda | Secretariat advice |  |
| WMO/I | Ocean Observations | N/A | WMO | Champika Gallage | Secretariat advice |  |
| WMO/I | GCW | N/A | WMO | Rodica Nitu | Secretariat advice |  |
| WMO Member Expert | Aircraft-based Observations | Argentina | SMN Argentina | Nicolas Rivaben | Representing SC-MINT & JET-ABO | <https://contacts.wmo.int/contact_details_public/?id=0460af51-836a-e811-a95c-000d3a38c0ab>  nrivaben@smn.gov.ar |
| WMO Member Expert | SC-MINT | Hong-Kong China | Hong-Kong Observatory | Pak-Wai Chan | Representing SC-MINT | <https://contacts.wmo.int/contact_details_public/?id=1d15bd71-836a-e811-a95c-000d3a38c0ab>  pwchan@hko.gov.hk |
| WMO Member Expert | UAS Observing Systems | USA | NOAA | Temple Lee | SPOC Member | Temple R. Lee, Ph.D.  Research Physical Scientist  Atmospheric Turbulence and Diffusion Division  NOAA Air Resources Laboratory  Oak Ridge, TN 37830  Email: temple.lee@noaa.gov |
| Germany | UAS Research | Germany | Geophysics and Meteorology Institute | Ulrich Löhnert | SPOC Member | Prof. Dr Ulrich Löhnert  Institut für Geophysik und Meteorologie  Universität zu Köln Phone: +49 (0)221 470 1779  Pohligstraße 3 Fax: +49(0)221 470 5161  50969 Köln ulrich.loehnert@uni-koeln.de |
| WMO Member Expert | UAS Observing Systems | Finland | FMI | Anne Hirsikko | SPOC Member | anne.hirsikko@fmi.fi |
| FAA | National Regulatory Authority | USA | FAA | Kevin Johnston | SPOC Member | kevin.l.johnston@faa.gov |
| WMO Member Expert | UAS Observing Systems | Swizterland | MeteoSwiss | Maxime Hervo | SPOC Member | Maxime.Hervo@meteoswiss.ch |
| WMO Member Expert | Data User, NWP Applications | Germany | DWD | Alexander Cress | SPOC Member | alexander.cress@dwd.de |
| Proposed Participant Representatives | | | | | | |
| Participant | Research Operator | USA | University of Nebraska–Lincoln  Earth and Atmospheric Sciences | Professor Adam Houston | SPOC Member | [ahouston2@unl.edu](mailto:ahouston2@unl.edu)  402-413-9476 |
| Participant | Research Operator | Canada | Ontario Tech Uni, Oshawa, Toronto, ONT, Canada | Prof. Ismail Gultepe | SPOC Member | ismail.gultepe@gmail.com |
| Participant | Research Operator | USA | University of Colorado | Gijs Deboer | SPOC Member | gijs.deboer@colorado.edu |
| Participant | Private Participant | USA | Collins Aerospace | Jeannine Collins | SPOC Member | jeannine.hendricks@collins.com |

SPOC Terms of Reference

The SPOC will:

1. Coordinate the development and oversee the holding of the WMO Uncrewed Aircraft Systems Demonstration Campaign (UAS-DC);
2. Conduct all activities related to the organization of the Campaign;
3. Develop and facilitate required WMO approvals of the Plan for the WMO Uncrewed Aircraft Systems, Demonstration Campaign;
4. Make recommendations to the managing Standing Committees on the extension of the membership of the SPOC as necessary to ensure the aims and scope of the UAS-DC are developed and met;
5. Develop a communications plan for the UAS-DC and facilitate required communications and meetings between the SPOC and/or the relevant WMO representatives, with participants, stakeholders, relevant entities and the public;
6. Coordinate the obtainment of the required approvals and/or partnerships to ensure the UAS-DC can be conducted according to the Plan;
7. Through the WMO Secretariat, facilitate the employment of consultancy as necessary and in accordance with the Plan to undertake required activities and tasks in support of the UAS-DC;
8. Evaluate the data, draft the final report and arrange for its approval by INFCOM; and
9. Report to the relevant Standing Committees of the Infrastructure Commission.

### Annex II – Data Policy for the WMO UAS Demonstration Campaign

[This policy is currently under development and subject to review.]

Following constitutes the data policy for the WMO UAS Demonstration Campaign (UAS-DC), which will take place over 2023 to 2024.

This policy shall apply to all Participants (as defined below) in the UAS-DC and will be applied through the establishment of an agreement between WMO and the Participant entity, prior to the commencement of the UAS-DC, expected to commence in March 2024.

Definitions

Participants

Participants are those persons or entities that belong to the following group:

* UAS Participant Operator – a company or individual that commits to the provision of UAS data to the WMO UAS-DC, in compliance with this Data Policy
* UAS Participant Data User – a company or individual that requests to, and is granted by WMO, access data from the UAS Data Repository for the purposes of using the data within meteorological or hydrological applications, in compliance with this Data Policy

UAS Data Repository

The UAS Data Repository is the digital platform established by WMO or its designated Member entities, to receive, store and make available to UAS Participant Data Users, data generated by UAS Participant Operators in the UAS-DC.

Data

In the context of the UAS-DC, the term, Data, shall include the following:

1. Data files and their contents submitted by Participants to the UAS-DC Data Repository;
2. Digital collections of the content of the UAS Data Repository that together form coherent information pertaining to the UAS-DC, including:
   1. Collections of observations of physical variables measured by a Participant-operated UAS; and
   2. Images, graphics, tabulations or other digital renderings of the Data.
3. Digital and printed reports about the UAS-DC that are authored by WMO and its Constituent Bodies and their work groups.

WMO

In the context of the UAS-DC Data Policy, “WMO” consists of, the Secretariat of the World Meteorological Organization, the WMO Member Constituent Bodies and their officially defined work groups and teams.

Data Policy Principles

WMO and Participants in the WMO UAS Demonstration Campaign, will comply with the following data policy principles:

1. Data can be used by UAS Participant Data Users within meteorological and hydrological applications in accordance with their agreement established with WMO;
2. Data can be used by WMO to compile, publish and disseminate reports pertaining to the UAS-DC;
3. Participants can use Data to compile digital, written reports that are submitted to WMO, and which then become Data;
4. Excluding reports associated with the UAS-DC and written or approved by WMO, WMO will not make Data available to any party outside the group of UAS-DC Participants.
5. In compliance with these Principles, WMO can retain a copy and make use of Data without any future time limitation.

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1. <https://community.wmo.int/governance/commission-membership/commission-observation-infrastructures-and-information-systems-infcom> [↑](#footnote-ref-2)
2. The [Terms of Reference and membership of the SPOC](https://community.wmo.int/governance/commission-membership/commission-observation-infrastructures-and-information-systems-infcom/commission-infrastructure-officers/infcom-management-group/standing-committee-earth-observing-systems-and-monitoring-networks-sc/joint-expert-team-4). [↑](#footnote-ref-3)
3. <https://www.paris2024.org/en/the-olympic-games-paris-2024/> [↑](#footnote-ref-4)