Notification of a Proposal to issue a Certification Memorandum

Safe recovery from human errors and HMI appropriate for the mission

(SORA OSO#19/#20 low robustness airworthiness requirements)

EASA CM No.: Proposed CM–HF-001 Issue 01 issued 22 July 2024

Regulatory requirement(s): AMC 1 to Art. 11 of Regulation (EU) 2019/947

EASA Certification Memoranda clarify the European Union Aviation Safety Agency's general position on specific initial airworthiness, validation, continuing airworthiness or organisational items. They are intended to provide guidance on a particular subject and may provide complementary information for compliance demonstration, similar to AMC/GM even if not formally adopted through an ED Decision. Certification Memoranda are not intended to introduce new certification requirements or to modify existing certification requirements.

Log of issues

Issue	Issue date	Change description
1.0	22.07.2024	First issue.

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1. Identification of Issue

1.1. Background

This MoC has been developed by the airworthiness task force (AW TF) established under the UAS Technical Body (TeB) and provides prescriptions to UAS designers to show compliance with OSO#19 and OSO#20 for UAS to be utilized in SAIL III operations. The establishment of compliance and the declaration of compliance to this MoC are under the responsibility of the UAS designers / manufacturers, who are the target audience of this MoC.

Applicants who wish to propose the application of alternative standards to those referenced by this SAIL III MoCs/CMs should contact their Competent Authority. The proposal may need to be assessed by the AW TF and, if found appropriate, may be reflected in further revisions of the CM.

Members of the UAS TeB Airworthiness TF

- EASA
- AESA
- Austro Control
- DAC Luxembourg
- DGAC
- ENAC
- FOCA
- HCAA
- Irish Aviation Authority
- LBA
- CAA Latvia
- CAA Norway
- CAA Romania
- CAA Netherlands

2. Applicability

This CM, applicable to UAS operated in the specific category SAIL III, proposes means of compliane (MoC) against the airworthiness requirements of OSO#19 and OSO#20.

OSO #19 addresses the risk of human errors that may affect the safety of the operation if they are not prevented or are not detected and recovered from in a timely fashion. Related to the design of UAS OSO #19 covers i.e. systems detecting and/or recovering from human errors (e.g., functional tests, safety pins, use of acknowledgment features, fuel or energy consumption monitoring functions).

OSO #20 requires that a Human Factors evaluation has been performed and the HMI found appropriate for the mission.

The design criteria associated to OSO#19 and #20 for SAIL III are characterized by low integrity, and are expressed by the EASA AMC to article 11 as follows:

- OSO#19: Systems detecting and/or recovering from human errors are developed according to industry best practices.
- OSO#20: The UAS information and control interfaces are clearly and succinctly presented and do not confuse, cause unreasonable fatigue, or contribute to remote crew errors that could adversely affect the safety of the operation.

The criteria for a low level of assurance for OSO #19 is satisfied when the manufacturer declares that the required level of integrity is achieved.

The criteria for a low level of assurance for OSO #20 is satisfied when the manufacturer conducts a human factors evaluation of the UAS to determine if the HMI is appropriate for the mission. The HMI evaluation is based on inspection or analyses. The adequacy of the result of the HMI evaluation is declared.

3. List of abbreviations

ASTM	American Society for Testing and Materials
ATC	Air Traffic Control
CAP	Civil Aviation Procedure
C2	Command and Control
CS	Certification Specification
CMU	Command and Monitoring Unit
DAA	Detect and Avoid
EASA	European Aviation Safety Agency
FAA	Federal Aviation Administration
FTS	Flight Termination System
GAMA	General Aviation Manufacturers Association
HF	Human Factor
HMI	Human Machine Interface
MoC	Means of Compliance
NAA	National Aviation Authority
NATO	North Atlantic Treaty Organization
OSO	Operational Safety Objective
SAIL	Specific Assurance and Integrity Level
SORA	Specific Operations Risk Assessment
UA	Unmanned Aircraft
UAS	Unmanned Aircraft System

4. Definitions

For this MoC the following definitions are established:

a) *alert: an indication that is meant to attract the attention of the crew, and identify to them an operational or UAS system condition. Warnings, cautions, and advisories are considered alerts.*
b) *automation: the technique of controlling an apparatus, a process or a system by means of electronic and/or mechanical devices, which replaces the human organism in the sensing, decision-making and deliberate output.*
c) *clutter: an excessive number and/or variety of symbols, colours, or other information that may reduce the access to the relevant information, increase interpretation time and the likelihood of interpretation error.*
d) *CMU: for the purpose of this MoC the CMU is considered as the area where the primary flight controls displays are located.*
e) *controls: the interaction with a control means that the crew manipulates in order to operate, configure, and manage the UAS or its flight control surfaces, systems, and other equipment. This may include equipment in the CMU such as: control devices, buttons, switches, knobs, flight controls, and levers.*
f) *control device: a control device is a piece of equipment that allows the crew to interact with the virtual controls, typically used with the graphical user interface; control devices may include the following: keyboards, touchscreens, cursor-control devices (keypads, trackballs, pointing devices), knobs, and voice-activated controls.*
g) *crew member: a person that is involved in the operation of the UAS and its systems;*
h) *cursor-control device: a control device for interacting with the virtual controls, typically used with a graphical user interface on an electro-optical display.*
i) *design item: a design item is a system, an equipment, a function, a component or a design feature.*
j) *display: a device that presents data or information from the UAS to the crew.*
k) *human error: a deviation from what is considered correct in some context, especially in the hindsight of the analysis of accidents, incidents, or other events of interest. Some types of human error may be the following: an inappropriate action, a difference from what is expected in a procedure, an incorrect decision, an incorrect keystroke, or an omission. In the context of this MoC, human error is sometimes referred to as 'crew error' or 'pilot error'.*
l) *abnormal/malfunction or emergency conditions: for the purposes of this MoC, abnormal/malfunction or emergency operating conditions refer to conditions that do require the crew to apply procedures different from the normal procedures included in the flight manual.*

5. Reference documents and available standards

The following references are used to build this MoC or may be used as a source for additional guidance:

1. CAP 722 | Ninth Edition Amendment 1 Unmanned Aircraft System Operations in UK Airspace – Policy and Guidance

CAP 722: Unmanned Aircraft System Operations in UK Airspace - Guidance (caa.co.uk)
2. NATO STANDARD AEP-83 LIGHT UNMANNED AIRCRAFT SYSTEMS AIRWORTHINESS REQUIREMENTS *NSO NSDD (nato.int))*
3. 'General Aviation Manufacturers Association (GAMA) Publication #12, "Recommended Practices and Guidelines for an Integrated Flightdeck/Cockpit in a 14 CFR (or equivalent) Certificated Airplane, *https://gama.aero/documents/gama-publication-12-recommended-practices-and-guidelines-for-an-integrated-cockpitflightdeck-in-a-part-23-airplane-version-2-0/*
4. The future of remote Pilot Competency in the Specific Category'.
5. General Aviation Manufacturers Association (GAMA) Publication #10, "Recommended Practices and Guidelines Part 23 Cockpit/Flight deck design *https://gama.aero/documents/gama-publication-10-recommended-practices-and-guidelines-for-part-23-cockpitflight-deck-design-version-1-0/*
6. FAA AC 23-23 Standardization guide for integrated cockpits in Part 23 Airplanes https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/22314
7. FAA Human Factors for maintenance handbook https://www.faasafety.gov/files/gslac/courses/content/258/1097/AMT_Handbook_Addendum_Human_Factors.pdf
8. CS 27.1302 and related AMC
9. ASTM F3298-19 "Standard Specification for Design, Construction, and Verification of Lightweight Unmanned Aircraft Systems"
10. ASTM F3478-20 "Standard Practice for Development of a Durability and Reliability Flight Demonstration Program for Low-Risk Unmanned Aircraft Systems (UAS) under FAA Oversight"

6. Documentation and record-keeping

Designers / manufacturers need to declare that they achieve the integrity criteria and base the declaration on evidence, which is the documentation of appropriate testing, analysis, simulation, inspection, design review or operational experience or a combination thereof.

Delivery of such evidence to the authority may not be required in the frame of a declaration of compliance to OSOs #19 and #20, however, declaring compliance, designers / manufacturers are responsible to determine, collect, record such evidence, and make it available in case the authority should so require.

7. Link with other OSOs

The following OSOs require to establish procedures and information that are essential input to enable the manufacturer to perform a human factor evaluation. The manufacturer should develop and provide the procedures and information related to the operation of the UAS in the intended operations:

- OSO #08 Operational procedures are defined, validated and adhered to
  - Operational procedures appropriate for the proposed operation are defined.
  - If available, operational procedures provided by the UAS designer should be utilized.
- OSO #09 Remote Crew trained and current
  - The theoretical and practical training is adequate for the operation

- OSO #16 Multi Crew Coordination
  - Procedures to ensure coordination between the crew members and robust and effective communication channels are available.
- OSO #17 – Remote crew is fit to operate
- OSO #18 – Automatic protection of the flight envelope from human errors
  - While the assessment of flight envelope protection function is excluded from this OSOs since it is specifically covered by OSO #18, the related procedures for the interaction with the crew should be considered.

Relevant points are introduced in the checklist in Annex I on items related to OSOs #8/9/16/17/18 that are considered essential to perform a HF evaluation.

8. Human Factors for Human Machine Interface design and the HF Evaluation Process

8.1. UAS human factors design issues

Manufacturers developing UAS must ensure that their projects address potential Human Factors issues:

- Information needed for the safe conduct of the flight and information concerning unsafe conditions must be provided to the crew, or maintenance personnel, as appropriate, in a clear, consistent, and unambiguous manner.
- Systems, equipment, and controls, including signs and announcements must be designed and located to minimise errors which could contribute to the creation of hazards.

In addition to traditional manned aviation Human Factors issues, the physical separation of the remote pilot introduces several issues that must also be considered:

- Degradation of information due to remote operation and associated lack of multi-sensory feedback, which does not allow the remote pilot to correctly understand how the UAS is operating or provides misleading information;
- Temporal degradation resulting from data latency, pilot recognition, pilot response and pilot command latency over the data link requires consideration in the design of controls and displays;
- Potential changes to the remote pilot's risk perception and behaviour arising from the absence of sensory/perceptual cues and the sense of a "shared fate" with the vehicle;
- Bandwidth limitations and reliability of the data link compromising the amount and quality of information available to the remote pilot and thereby limiting his/her awareness of the UAS status and position;
- If the remote pilot swaps with another remote pilot during a flight, issues around effective hand-over procedures and communication must be mitigated.

Typical Human factors related issues to be addressed include but are not limited to:

- Non-optimal workspace layout which increases the likelihood of errors;
- Failure to provide on a timely manner relevant information for planning or corrective actions to the remote pilot;
- Insufficient notice of the need to perform a task (possibly related to data latency or poor planning);
- Incomplete situational awareness (missing/inadequate information and/or data latency);
- Information overload/underload;
- Incorrect prioritisation of alerts;
- Lack of clarity regarding where to find the relevant control instructions (Standard Operating Procedures, Flight Manuals, work instructions ambiguous maintenance procedures);

- Non-obvious system mode changes.

8.2. A system design approach

A systems approach is recommended for the analysis, design and development of the UAS. This approach deals with all the systems as a combined entity and addresses the interactions between those systems. Such an approach should involve a detailed analysis of the human requirements and encompass typical Human Factors domains:

- Manpower;
  - How many people are required to operate the UAS
- Personnel;
  - What their qualifications and skills should be
- Training;
  - How to develop and maintain the competence of operators
- Human Engineering;
  - What the system should look like and how it can be operated
- System Safety;
  - What operator actions could jeopardize the safety of operation and mission success
- Health Hazards
  - What elements of the system operation could be hazardous to the health of operators or maintainers.

8.3. A Human Centred Assessment Process

Human Factors assessments should follow an iterative process to demonstrate that a systems approach has been followed. Where an initial system has been changed, any design modifications or change of the operational procedures should be reassessed. Evaluations based only on one assessment, will only be sufficient at the very end of the process after modifications have been introduced as a validation exercise to demonstrate that design assumptions are valid.

8.4. Mission Requirement & System Function Description

UAS can be operated in different environments and types of missions by crews with different capabilities. The HF assessment needs to be representative of the intended operations and address the full operational scope/envelope intended by the UAS Operator following the operational procedures and the remote crew training. Therefore, the intended operations applicable to the UAS should be considered and documented. This will bound the scope of the intended deployment and therefore limit the assumptions made about human factors / human performance to the relevant cases.

The intended function of each system and the tasks expected to be performed by the crew members must be known and the flight manual should describe the indications, controls, and related crew member procedures. (OSO #8). This equipment list will form the basis of subsequent Human Factors Analyses.

- The manufacturer should review the checklist in Annex II for guidance on the selection of the HF design principles, appropriate to the design and the operation of the UAS and complement it as necessary to establish a comprehensive set of HF design principles.

8.5. Level of scrutiny and depth of assessment

The depth and extent of HF Assessments or level of scrutiny is driven by four factors:

- The level of integration;
- The level of complexity;
- The level of novelty, and;
- The level of Criticality.

For the purpose of this MoC the level of novelty is the main driver and it should be understood as new functions or new design items that affect crew member tasks that are not previously evaluated by the same manufacturer.

Where the HMI introduces new functions, new design items and where the criticality of these system is considered high, all systems contributing potentially to a human error should be evaluated by means of a scenario based or system-level assessment. If any single human error can lead to a loss of control of the operation or immediate correct crew action is required to mitigate a foreseeable event the criticality shall be considered High.

Different methodologies exist to perform HFs assessments, from least to most onerous, the following are common approaches taken by manufacturers:

- Inspections and analysis involves:
  - Identifying the controls, information and system behaviour that involve crew member interaction,
  - Analysing the crew member tasks to be performed within the intended operation and types of missions, and
  - Evaluating whether the systems and their integration are appropriate for the intended function(s) and the associated crew member tasks.
- System Assessments require
  - System-level assessments focus on a specific design item,
  - an in-depth assessment of functional and operational aspects,
  - Shall include all the relevant operational procedures
- Scenario Based Approaches demand
  - A sample of various crews that are representative of the future users,
  - Exposure to real operational conditions in a test bench or a simulator, or in the operation
  - A set of detailed HF test objectives.
  - Scenarios that include triggering events or conditions (e.g. a system failure, an ATC request, weather conditions, etc.) likely to trigger crew member errors, difficulties or misunderstandings.
  - The scenario should be operationally representative with realistic task sharing and workflows.

The evaluation may use one or a combination of these methodologies depending on the assessed level of scrutiny for the affected equipment in relation to the deployed scenario based on the concept of operation for the UAS and the affected procedures.

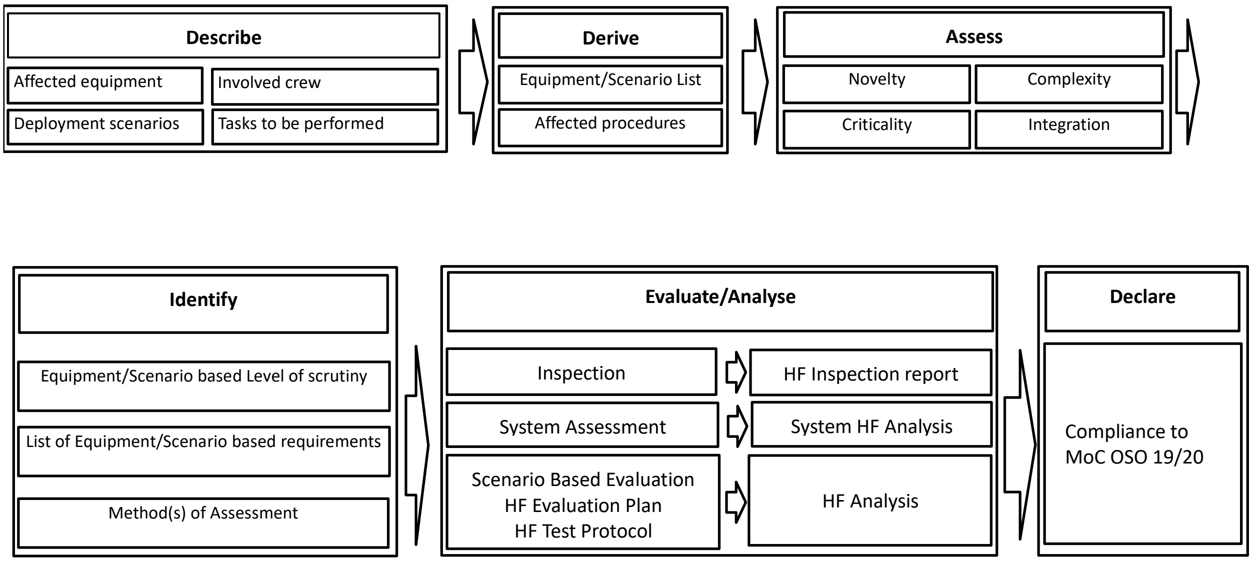

Figure 1: OSO#19/#20 Human Factors Assessment Process

Common for all methods is that the evaluation is performed by appropriately trained experts and that a representative UAS configuration is identified for the evaluation and deviations are justified. The HF assessment collects objective data through direct observation of crew behaviour and/or subjective data through inspection, dialogue, debriefing or questionnaire. A guide to best practises can be found in paragraph 3.3.2 of AMC to CS27.1302.

For a scenario-based evaluation the HF Evaluation plan should describe the evaluation, the principles that are meant to be addressed, the number and profiles of the UAS crew to be included (min 3 representative crews for future users), the scenarios expected to be run and the practical organisation of the assessment. Each crew is exposed to real operational conditions in a test bench or a simulator, or in the real operation.

The resulting HF Analysis should provide:

- An In-depth analysis of the observed HFs findings;
- Conclusions regarding the related HFs test objectives; and
- A description of the proposed way to mitigate the HFs findings by a design modification, improvements in procedures, and/or additional training actions.
- All HF- concerns, even not directly related to the objective of the assessment, should be recorded, adequately investigated and analysed in the test report.

Based on the HF inspection report, and/or the System HF Analysis and/or the HF Analysis the compliance to the OSOs #19&20 may be declared.

9. ANNEX I: Declaration of Compliance

DECLARATION OF COMPLIANCE IN ACCORDANCE WITH MOC OSO #19 AND OSO #20

(*insert model name*)

Hereby, I, ________ (*insert name of the accountable manager of UAS' manufacturer), accountable manager of the company (insert name of the company*) declare under my sole responsibility that:

1) The UAS ______ (*insert UAS model name*), manufactured by the _________ (*insert name of the company as above*) with hardware and software configuration as defined by documents (*insert documents numbers and version*): __________ is compliant with the EASA MoC OSO #19&#20, issue 1 of XX.YY.ZZZZ;

2) Systems detecting and/or recovering from human errors are developed according to industry best practices;

3) The UAS information and control interfaces are clearly and succinctly presented and do not confuse, cause unreasonable fatigue, or contribute to remote crew errors that could adversely affect the safety of the operation.

I moreover declare that the design requirements of the MoC have been reviewed and that

☐ A reference HF evaluation performed by the manufacturer is available, and is representative as:

- the UAS design does not include new functions or new design items that affect crew member tasks, and
- no procedures and tasks are introduced in which a single human error can lead to a loss of control of the operation or where immediate crew action is required to prevent a loss of control.

The reference HF evaluation as defined by documents (*insert documents numbers and version*):

____

____

or

☐ a Human Factor Evaluation Process has been performed in accordance with the evidence detailed in the attached checklist.

Evidence

The above referenced documents as well as any document referenced in the attached checklist have been developed in accordance with the relevant chapters of the MoC and will be made available in the case they will be requested by the competent authority for oversight purposes. Further evidence may be requested by the competent authority for oversight purposes. Please note that several product harmonisation legislations may apply to your product when placed or made available on the EU market. For instance the *Radio Equipment Directive 2014/53/EU*, *Low Voltage Directive 2014/35/EU*, *Electromagnetic Compatibility Directive 2014/30/EU*, Regulation 2023/1230/EU - machinery | Safety and health at work EU-OSHA (europa.eu) , *RoHS Directive 2011/65/EU*, etc. It is your responsibility to identify applicable legislations and requirements. Once conformity to all applicable requirements has been demonstrated, manufacturers shall draw up an EU declaration of conformity and affix the CE marking on their product.

_______________ ______________________________________

Place, date | The accountable manager of (*insert name of the company*)

10. Annex II - Compliance Checklist

Manufacturers should properly assess the following table and where necessary incorporate a tailored and probably amended version, filling the table accurately, as required and under their sole responsibility and attach it to their compliance declaration.

The column "applicable / compliance yes / no" needs to indicate if the paragraph is applicable and if it is complied with. In case a "no" is reported in the first column, the second column should indicate the compensating measures to provide an equivalent level of safety.

The third column should identify the document name (including chapter/subchapter) and document version that provides the evidence of compliance. Referenced documents have to be kept available for the authority in case a review is performed.

Prescription	Compliance Yes/No or N/A	Compensating measures for any aspect not compliant	Justification or Elements utilized for the substantiation
Manufacturer input towards OSO #8,9,16 and 17[1]			
A1 OSO #8: Operational procedures appropriate for the proposed operation are defined and as a minimum cover the following elements - Flight planning, - Pre- and post-flight inspections, - Procedures to evaluate environmental conditions before and during the mission, - Procedures to cope with unintended adverse environmental conditions, - Normal procedures, - Contingency procedures, - Emergency procedures, - Pre-flight procedures including briefing of any involved persons			
A2 OSO#9 Remote crew trained and current The required theoretical and practical knowledge is identified and - is adequate for the operation, i.e., allows the remote crew to control the normal, abnormal and emergency situations potentially resulting from technical issues with the UAS or external systems supporting UAS			

[1] The assessment of these OSO's is not in the scope of OSO#19 and #20 but the manufacturer needs to provide in the Flight Manual the appropriate information.

Prescription	Compliance Yes/No or N/A	Compensating measures for any aspect not compliant	Justification or Elements utilized for the substantiation
operation, human errors or critical environmental conditions. - specifies proficiency requirements and training recurrence.			
A3 OSO#16 Multi Crew Coordination Procedures to ensure coordination between the crew members and robust and effective communication channels are available and at a minimum cover: - assignment of tasks to the crew, and - establishment of step-by-step communications, including a proper phraseology.			
A4 OSO #17 Remote crew is fit to operate The manufacturer has a policy defining the criteria and the means for the remote crew to declare themselves fit before starting their duty.			
B Human Factor Evaluation			
B0 A HF Process has been established			
B0.1 The Process covers the full scope of the design of the system. The CMU is considered in the context of the overall UAS and its operation as they are integrated physically and functionally into the UAS and interact with other UAS systems and external systems.			
B0.2 Pre- and post-flight tasks and involved external systems are considered.			
B0.3 Manufacturer input towards other OSO's in accordance with Annex II A is included in the HF process and the Human Factors impacts assessed and addressed.			
B0.4 A methodological approach has been established to assure the identification and management of design related HF Issues at a system level.			
B0.5 The process allows for the identification of the degree of novelty, complexity, integration, and criticality of each system the UAS crew is expected to operate.			
B0.6 The Level of scrutiny has been determined from the HF Analysis and is described in relation to inspection or scenario-based assessments. The level of scrutiny will be driven by the most constraining outcome of this assessment. Higher scrutiny			

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Prescription	Compliance Yes/No or N/A	Compensating measures for any aspect not compliant	Justification or Elements utilized for the substantiation
level are required where responses show greater levels of novelty, complexity, integration or criticality.			
B0.7 The process allows representative users and operational scenarios to be described.			
B1 Inspection/Analysis based Human Factor Evaluation			
B1.1 A reference HF evaluation performed by the manufacturer is available, and is representative as: - the UAS design does not include new functions or new design items that affect crew member tasks no procedures and tasks are introduced in which a single human error can lead to a loss of control of the operation or where immediate crew action is required to prevent a loss of control.			
B1.2 The appropriateness of the reference HF evaluation is confirmed and deviations are assessed and justified in respect of the concept of operations, i.e. a UAS repurposed from one application to a different application requiring a revised CONOPS may also require a HF evaluation.			
B.2 Scenario Based HF Evaluation Process			
B2.1 An analysis of the intended function of each system and the tasks expected to be performed by the crew has been performed.			
B.2.2 The scope of the scenario based HF evaluation is identified and includes new functions or new design items and new procedures and tasks in which a single human error can lead to a loss of control of the operation or where immediate crew action is required to prevent a loss of control.			
B.2.2 A <u>comprehensive</u> list of HF design principles is established and is appropriate to the design and the operation based on chapter C of this Annex I. Additional elements identified during the analysis, design and development of the UAS are considered.			
B.2.3 The HF assessment collects objective data through direct observation of crew behaviour and/or subjective data through dialogue, debriefing or questionnaire. A guide to best practises can be found in paragraph 3.3.2 of AMC to CS27.1302.			
B.2.4 Evaluated scenarios should be operationally representative with realistic task sharing and workflows.			
B.2.5 A HF Evaluation plan describes the evaluation, the HFs objectives, the number, and profiles of the crew			

Prescription	Compliance Yes/No or N/A	Compensating measures for any aspect not compliant	Justification or Elements utilized for the substantiation
members involved, the scenarios expected to be run and the practical organisation of the assessment. and any assessment that is performed			
B.2.6 A representative UAS test configuration is identified, and deviations are justified.			
B.2.7 A sample of at least 3 crews that are representative of the future users, are exposed to real operational conditions in a test bench or a simulator, or in the real operation.			
B.2.8 HFs test protocols identify any deviation from the evaluation plan and include a description of the data gathered with the link to the HFs objectives;			
B.2.9 The HF Analysis provides - An analysis of the observed HFs findings; - Conclusions regarding the related HFs test objectives; and A description of the proposed way to mitigate the HFs findings by a design modification, improvements in procedures, and/or additional training actions.			
B.2.10 HF- concerns, even not directly related to the objective of the evaluation, are recorded, adequately investigated, and analysed.			
C UAS HF Design Principles			
C.1 Environment and Ergonomics			
C.1.1 The ergonomic standards of the CMU should ensure that the crew works in an environment that is fit for purpose: - The environment does not create distractions; - It provides a suitable and comfortable environment for the expected range of human crew members in terms of access and reach to the controls and visibility and readability of the displays and labels; - Dedicated workspace requirements for desks, seating etc have been described; - It allows the crew to maintain alertness throughout a shift period; and The ergonomic constraints of 'handheld' CMU's are considered, when applicable.			
C1.2 Considering external systems, operation of mission related systems and interactions due to the operational environment. - All foreseeable physical operating environments have been taken into consideration; wind, humidity, precipitation, temperature; illumination, noise etc			

Prescription	Compliance Yes/No or N/A	Compensating measures for any aspect not compliant	Justification or Elements utilized for the substantiation
- Specific items of PPE necessary to operate the UAS, have been used during the assessments. Typical items of clothing required to be worn during foreseen operational deployments were used during assessments.			
C1.3 The integration of the UAS within its wider system operating environment has been assessed and supports the deployment scenario. - Systems are integrated physically and functionally into the UAS and may interact with other UAS systems. The design of any system the CMU should be considered in the context of the overall UAS and its operation. Integration aspects include where a display or control is installed, how it interacts with other systems, and whether information is presented in a consistent manner.			
C.2 Controls			
C2.1 Controls have been designed and assessed and support the operation of the UAS and tasks it is intended to fulfil. - The function and operation of each control is clear, unambiguous, appropriate in resolution and precision, accessible, and usable. - The crew member can identify and select the current function. Controls are distinguishable and predictable. - Labels are readable from the crew member's normal working positions, in all lighting and environmental conditions. Cockpit controls having a sense of motion similar to the system they control, should be designed so that they operate in a consistent axis and direction with the UAS system.			
C2.2 Crew are expected to interact with multiple control simultaneously - Multiple controls for one function are provided to the crew members, and there is sufficient information to make the crew members aware of which control is currently functioning - crew members know which crew member's input has priority when two cursor-control devices can access the same display Special attention is given when multiple functions are allocated to a single control interface (e.g. click/double click/hold of a button).			

Prescription	Compliance Yes/No or N/A	Compensating measures for any aspect not compliant	Justification or Elements utilized for the substantiation
C2.3 Feedback from controls following operation is clear and unambiguous - Clear and unambiguous feedback for the operation of controls provides the crew with awareness of their effects of their actions, e.g. a switch position or a positive indication that a numerical input has been accepted on a graphical control. - Means are established to prevent inadvertent operation of controls that may lead to a loss of control (e.g. FTS activation). Acceptable ways to prevent errors include switch guards, interlocks, or confirmation actions. - Layering of information, with menus or multiple displays, does not hinder the crew from identifying the location of the desired control. Accessibility is shown in conditions of system failures or contingency operation. - When there is a large spatial separation between a control and its associated display, the use of the control for the associated task(s) is acceptable. - Where a control is used to move an actuator through its range of travel, the equipment provides, if needed, within the time required for the relevant task, operationally significant feedback of the actuator's position within its range - The type, duration and appropriateness of feedback has been defined to support the crew member's task and the specific information required for successful operation. Controls used while the user is looking elsewhere provide tactile or other feedback that the user can detect.			
C.3 Presentation of information			
C3.1 Information presented to the crew is: - Clear - Unambiguous - Appropriate in resolution and precision - Accessible Usable			
C3.2 Information provided to the crew: - is adequate for feedback to assure crew awareness The system must provide the crew with appropriate information to monitor and control its operation.			
C3.3 The information provided is suitable for the control of the UA			

Prescription	Compliance Yes/No or N/A	Compensating measures for any aspect not compliant	Justification or Elements utilized for the substantiation
- The CMU shall include specific feedback to compensate the lack of natural perception by the crew of the UA answer to any control. Crew members, in their normal work position and using normal head movement, should be able to see and read display format features such as fonts, symbols, icons and markings. In some cases, cross-cockpit readability may be required to meet the intended function that other crew members must be able to access and read the display.			
C3.4 The display screen design is uncluttered and clear.			
C3.5 The colour scheme used on displays follows a standard specified by the manufacturer and does not create crew confusion or provide misleading information.			
C.3.6 Warning indication should be provided utilizing the following colour codes: - red, for warning information (information indicating a condition which may require immediate corrective action); - amber, for caution information (information indicating the possible need for future corrective action); and green, for safe operation information.			
C3.7 Layering of information on a display does not add to confusion or clutter as a result of the colour standards and symbols used.			
C3.8 In the event of system failures the crew can still access information necessary to manage the UAS safely.			
C3.9 System status data is available to the crew - The flight and navigation data that should be displayed in the CMU at an update rate and with a precision consistent with safe operation, depending on the degree of automation. - The propulsion system data that should be displayed in the CMU at an update rate consistent with safe operation. - As a minimum, information concerning the C2 Link such as strength and integrity (bit error rate) of the uplink and downlink should be provided and continuously monitored at a refresh rate consistent with safe operation. See also the published MoC to OSO#6 for SAIL III compliance. - In the event of degraded or total breakdown in the communication link the status of the lost link will be displayed to the remote pilot. The expected behaviour of the UA is displayed and/or known.			

Prescription	Compliance Yes/No or N/A	Compensating measures for any aspect not compliant	Justification or Elements utilized for the substantiation
Information concerning external systems deterioration modes (e.g., loss of GNSS) that would lead to a loss of operation is provided and appropriate contingency procedures are available to the crew.			
C3.10 System alerts and warnings and the actions required can be understood by the crew.			
C3.11 In manual direct piloting mode, the remote pilot should be alerted with sufficient margin when approaching any unsafe condition and made aware of any flight envelope protection engaged to limit his control.			
C.4 System behaviour & automated system behaviour			
C4.1 Crew members are able to perform all the tasks allocated to them, considering: - Normal, abnormal/malfunction and emergency operating conditions, - Within the bounds of an acceptable workload and Without requiring undue concentration or causing undue fatigue.			
C4.2 The system enables the crew members to understand the situation and enables timely failure detection and crew member intervention when appropriate.			
C4.3 System or system-mode behaviour should be unambiguous and predictable to the crew.			
C4.4 Provision must be made for the remote pilot to be able to intervene and initiate contingency or emergency procedures as appropriate (e.g. return home, abort take-off, go around).			
C4.5 The system provides system state and intention information that enables supervision and maintains crew member awareness of the system by providing feedback on: - The entries made by the crew members into the system so that the crew members can detect and correct errors; - The present state of the automated system or its mode of operation (What is it doing?); - The actions taken by the system to achieve or maintain a desired state (What is it trying to do?); - Future states scheduled by the automation (What is it going to do next?); and Transitions between system states.			

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C4.6 Any automated operations keep the crew aware and informed of what is being done: - Indications of the commanded and actual values should enable the crew members to determine whether the automated systems will perform according to the crew members' expectations; - If the automated system nears its operational authority or is operating abnormally for the given conditions, or is unable to perform at the selected level, it should inform the crew members, as appropriate for the task; - The automated system should support crew coordination and cooperation by ensuring that there is shared awareness of the system status and the crew members' inputs to the system; and The automated system should enable the crew to review and confirm the accuracy of the commands before they are activated. This is particularly important for automated systems because they can require complex input tasks.			
C5 Management of Error			
C5.1 There should be means to indicate to the crew the active mode of control of the flight. Un-commanded mode changes and reversions should have sufficient annunciation, indication, or display information to provide awareness.			
C5.2 Information is provided to the crew so that they can become aware of an error, that is adequately detectable, and shows a clear relationship between the crew action.			
C5.3 The design ensures that the effects of crew errors on the UAS functions or capabilities are evident to the crew members, and continued safe flight and landing is possible.			
C5.4 When an error or its effects are detected, controls and indications exist that can be used either to reverse an erroneous action directly, or to mitigate the effect in some way so that the UAS is returned to a safe state.			
C6 Considerations for multiple CMU & Multiple UAS			
C6.1. Design provisions and procedures for safe transfer of control within and between CMU's, crew handovers, and control link switchovers as foreseen for the operation can be effectively performed by the crew.			

Prescription	Compliance Yes/No or N/A	Compensating measures for any aspect not compliant	Justification or Elements utilized for the substantiation
C6.2. Handovers are accomplished in a safe and consistent manner and include the following elements: - Offer of control; - Exchange of all relevant information; - Acceptance of control; Confirmation of successful handover or recovery of control in the event of a not successful handover			
C6.3. Procedures exist for the exchange of information between remote pilots (co-located or remotely located) and ensure the receiving pilot has complete knowledge of the following: - Flight Mode - UAS flight parameters and aircraft status; - UAS sub-system status (energy, engine, communications, autopilot etc); - Aircraft position, flight plan and other airspace related information (relevant NOTAMs etc.); - Weather; - The current ATC clearance and frequency in use; Positions of any relevant CMU control settings to ensure that those of the accepting CMU are correctly aligned with the transferring CMU.			
C6.4. The minimum crew has been established in scenarios where a CMU is designed to command and control multiple UA: - The minimum crew must be established so that it is sufficient for safe operation of each UA and emergency condition. - The UA data must be displayed in the CMU in a manner that prevents confusion and inadvertent operation. - The UA controls must be available to the crew for each UA of which it has command and control, in a manner that prevents confusion and inadvertent operation. All indicators and warnings must be available to the UA crew for each UA, in a manner that prevents confusion and inadvertent operation.			
C6.5. There is a clear means to indicate to the UAS crew the UA over which it has command and control.			
C6.6. Controls are available to the crew for each UA of which the CMU is designed to command *and* has command and control in a manner that prevents confusion and inadvertent operation.			

Prescription	Compliance Yes/No or N/A	Compensating measures for any aspect not compliant	Justification or Elements utilized for the substantiation
C6.7. Where a CMU is designed to command and control multiple UASs, information is displayed in a manner that the crew can easily understand to which UA they relate.			
C8 Flight Manual			
C8.1 The Flight Manual provided to the UAS remote crew must clearly and unambiguously define all the operating limitations and other information necessary for safe operation			

11. Remarks

1. This EASA Proposed Certification Memorandum will be closed for public consultation on the **19th of August 2024**. Comments received after the indicated closing date for consultation might not be taken into account.
2. Official comments to the proposed CM are to be filed through the EASA Comment Response Tool.
3. For any question concerning the technical content of this EASA Certification Memorandum, please contact:

4. Name, First Name: RONIG, Stefan — KILNER, Andrew
5. Function: UAS section manager — ATM/ANS Expert
6. E-mail: stefan.ronig@easa.europa.eu — andrew.kilner@easa.europa.eu