EASA European Union Aviation Safety Agency	**Consultation paper** **Special Condition**	Doc. No. : SC-HMD29-01 Issue : 1 Date : 23 Mar 2022 Proposed ☒ Final ☐ Deadline for comments: 22 Apr 2022

SUBJECT	:	**Installation of a Head Mounted Display on a CS 29 rotorcraft**
REQUIREMENTS incl. Amdt.	:	**CS 29.773 Amdt 10**
ASSOCIATED IM/MoC[1]	:	Yes☒ / No ☐
ADVISORY MATERIAL	:	AMC 25-11, SAE ARP6377, SAE ARP 5288, SAE AS8055, AC29-2C Ch 7 MG19

INTRODUCTORY NOTE:

The following Special Condition (SC) has been classified as important and as such shall be subject to public consultation in accordance with EASA Management Board decision 12/2007 dated 11 September 2007, Article 3 (2.) which states:

"*2. Deviations from the applicable airworthiness codes, environmental protection certification specifications and/or acceptable means of compliance with Part 21, as well as important special conditions and equivalent safety findings, shall be submitted to the panel of experts and be subject to a public consultation of at least 3 weeks, except if they have been previously agreed and published in the Official Publication of the Agency. The final decision shall be published in the Official Publication of the Agency.*"

IDENTIFICATION OF ISSUE:

EASA received an application for approval of a Supplemental Type Certificate (STC) for the installation of a Head Mounted Display (HMD) system on a CS 29 rotorcraft.

According to the applicant's statement, the installation of the HMD system is aimed at improving situational awareness and reducing workload for day and night VFR operations. The HMD is carried as a monocle mounted on the pilot's and co-pilot's helmet, in the direct view of the right eye, and interfaced to the aircraft systems, allowing the crew to "bring the Primary Flight Display (PFD) with him/her" when turning the head to look to the side and down. The monocle-type HMD can be used stand-alone or combined with Night Vision Goggles (NVG). The Night Vision Imaging System (NVIS) certification is however, for the time being, excluded from this Special Condition. The information provided to the crew includes flight and navigation instruments, powerplant parameters, navigation information and annunciators.

There is an absence of EASA Certification Specifications that contain adequate or appropriate safety standards for HMD installations in CS 29 rotorcraft, as this design is novel to civil applications (there is a good level of experience in military designs).

The Federal Aviation Administration (FAA) with Amendment 29-57 has recently added FAR 29.773 (c) to lay down requirements for "vision systems with transparent displays".

[1] In case of SC, the associated Interpretative Material and/or Means of Compliance may be published for awareness only and they are not subject to public consultation.

In addition, SAE ARP 5288 and SAE AS8055 contain recommended design practices and performance standards for Head-Up Display (HUD) systems. Where relevant, these guidelines may be adopted, with or without adaptation due to the technological uniqueness, to provide performance guidelines for HMD systems. Specific guidance for design, testing, development and intended functions of the HMD are being developed by SAE.

In such a context, applicants are therefore required to provide EASA with a detailed description of the intended function of their installation, including the envisaged RFM limitations (air speed, altitude, flight phases, etc.) and operational procedures.

As a general principle, EASA's position is that the HMD is a vision system with a transparent display surface located in the pilot's outside field of view equivalent to a HUD, as the information is presented head-up and does not require transition of visual attention to the Head-Down Displays (HDD). Therefore, the system shall be considered as a PFD while being used by the pilot and shall provide the pilot with reliable and unmistakable information and have characteristics and dynamics suitable with the aircraft type in order to allow the crew to perform their tasks from their normal position. The displayed information, in particular attitude, shall be conformal with the pilot's external view regardless of the crew head position.

It is EASA's position that the HMD installation, in addition to all applicable CS 29 requirements affected by the change, shall meet the requirements included in the Special Condition proposed below.

Considering all the above, the following Special Condition is proposed:

Special Condition for installation of a Head Mounted Display on a CS 29 Rotorcraft

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A vision system with a transparent display surface located in the pilot's outside field of view, such as a head-up display, head mounted display, or other equivalent display, must meet the following requirements in non-precipitation and precipitation conditions:

1) While the vision system display is in operation, it must compensate for interference with the pilot's outside field of view such that the combination of what is visible in the display and what remains visible through and around it, allows the pilot compartment to satisfy the requirements of CS 29.773 (a) and (b).
2) The pilot's view of the external scene may not be distorted by the transparent display surface or by the vision system imagery. When the vision system displays imagery or any symbology that is referenced to the imagery and outside scene topography, including attitude symbology, flight path vector, and flight path angle reference cue, that imagery and symbology must be aligned with, and scaled to, the external scene.
3) The vision system must provide a means to allow the pilot using the display to immediately deactivate and reactivate the vision system imagery, on demand, without removing the pilot's hands from the primary flight and power controls, or their equivalent.
4) When the vision system is not in operation it must permit the pilot compartment to satisfy the requirements of CS 29.773 (a) and (b).

Associated Interpretative Material / Means of Compliance

The associated Interpretative Material / Means of Compliance is published for awareness only and is not subject to public consultation.

1. Crew safety

a. The HMD system should be designed and installed to prevent the possibility of pilot injury in the event of an accident or any other foreseeable circumstance (such as turbulence, hard landing, etc.).

b. Additionally, the HMD installation should ensure compliance with the occupant injury requirements and the retention requirements established in CS 29.785.

c. The installation of the HMD, including wired connections, should not adversely affect the emergency egress provisions for the crew, or significantly interfere with crew access to other systems or the performance of emergency tasks. The system, including wired connections, should not hinder the crew's movement while conducting any flight procedures.

d. HMD single and multiple failure conditions are expected to be properly addressed in the showing of compliance to CS 29.1309. Special consideration should be given to those failure conditions, if existing, that may result in an image that prevents the view from one eye (full blank or excessively distorted imagery, etc.). If, in addition, the failure is such that the crew cannot deactivate the image by using the means required by point 3) of the Special Condition above, as a mitigation, the HMD may be provided with a stowed position, so that pilots can easily remove the monocular away from their field of view without the need to detach it from the helmet.

2. Helmet Mounting

a. Wearing of the HMD should not impose undue restrictions to the pilot's head movement nor hinder the performance of pilot's duties. The mass and fit of the HMD on the pilot's head should be sufficiently comfortable, balanced and secure so that frequent or extended wear does not create neck or muscular stress or discomfort, eye strain, distraction, or workload.

b. The equipment should provide the means to satisfactorily adjust the equipment to the dimensions of any pilot's head to enable a comfortable and stable fit for the intended duration of use.

c. The HMD mounting adjustments should provide satisfactory eye relief and alignment to the display line of sight, accounting for interpupillary breadth, head breadth, head length and head circumference, such that the pilot's eye will be easily positioned at the exit pupil of the HMD optics.

d. Normal pilot head and body movements and normally occurring dynamic flight conditions should not cause a shift of the displayed image or misalignment of the pilot's view of the HMD display.

e. If the monocular is provided with both stowed and operating positions, then the monocular should lock in place in each position. Also, when in a stowed position, the monocular should not be powered unless it can be otherwise demonstrated that this does not impair pilot's view and normal system performance can be maintained. In addition, when the monocular assembly is restored to its operating position from the stowed position, then the monocular assembly should maintain its original adjustment prior to stowage.

3. HMD controls

a. The HMD controls should comply with the point 3) of the Special Condition above and with the requirements of CS 29.777 and CS 29.1301. In particular:

   i. The crew should be able to see, identify, reach and operate the means of controlling the HMD, including its configuration and display modes, from the normal seated position.

   ii. Inadvertent operations of HMD controls should be prevented.

b. The HMD should have adequate means to control HMD luminance (i.e. brightness) so that displayed data is always visible and readable to the pilot in all foreseeable operating and ambient lighting conditions.

c. HMD controls, including the controls to change or select HMD modes, should be implemented to minimise crew workload for data selection or data entry and allow the pilot to easily view and perform all mode control selections from the normal seated position with seat/shoulder belt fastened.

4. Visual Display Characteristics

a. The design of the HMD installation should be such that the HMD functions as intended in all anticipated flight attitudes, aircraft configurations and environmental conditions for which it is approved.

b. The display luminance (brightness) should be satisfactory in the presence of dynamically changing background (ambient) lighting conditions, so that the HMD data is visible.

c. The HMD should be free of glare and reflections that could interfere with the normal duties of the crew.

d. The system operation should not be adversely affected by manoeuvring or changes in attitude encountered in normal service.

e. Motion of Symbols. The accuracy of positioning of symbols should be commensurate with their intended use.

f. Motion of both conformal and non-conformal symbols should be smooth, not sluggish or jerky, and consistent with rotorcraft control response. Symbols should be stable with no discernible flicker or jitter.

g. The visual display design should not cause perceptual or cognitive problems or undue eye strain for the user in any lighting conditions, including night or day operations, both in visual

and, where appropriate, instrument meteorological conditions. In cases where, for operational or safety reasons, the pilot should transition from the HMD view to the outside natural scene, the visual display design should not hinder this transition.

5. Display of primary flight information

a. As the HMD displays primary flight information, it is considered a de facto PFD while the pilot is using it, even if it is not the pilot's sole display of this information. The pilot should be able to easily interpret the primary flight information; it should not be ambiguous or confusing when compared to the information on other flight deck displays.

b. Primary flight information displayed on the HMD should comply with all the requirements associated with such information in CS 29, with particular regard to CS 29.1303 for flight and navigation instruments and CS 29.1333(b) for the operational requirements of those systems. CS 29.1321 specifies the requirements for arranging primary flight information.

c. Additional flight information. The HMD should also display additional flight parameters information if required to enable the pilot to operate the rotorcraft during phases of flight for which the HMD is approved. Displayed information should be such to avoid continuous scanning by the pilot between the head-down and the head-up display in order to achieve the required level of information needed for accomplishment of his tasks.

6. HMD and HDD Display Compatibility

a. The content, arrangement, symbology, and format of the information on the HMD should be sufficiently compatible with the HDDs to preclude pilot confusion, misinterpretation, increased cognitive workload, or crew error. This includes:

   i. HMD symbols that have similar shape and appearance as HDD symbols should have the same meaning.

   ii. Conversely, symbols that have the same meaning should have the same shape and appearance on the HMD and HDDs.

   iii. When the symbology shape and/or appearance between the HDD and HMD differ, the compatibility of the information provided to the crew should be assured by an appropriate human factors evaluation.

b. Transition between HMD and HDD, and vice versa, should be always possible in any flight condition sought for certification of the HMD system, without creating confusion, misinterpretation, unacceptable delay, or otherwise hinder the pilot's transition between the two displays.

c. Sensor system sources for instrument flight information (e.g., attitude, heading, track, altitude, and airspeed) should be the same between the HMD and the HDDs used by the same pilot.

7. Indications and alerts

a. If the HMD is a monochrome device, indication of warning, cautions and advisory alerts cannot be implemented as prescribed by the CS 29.1322. In this case, caution and warning information, if presented on the HMD display, should be achieved through the use of attention-getters that are appropriate to the level of the severity of the message conveyed in order to compensate for the lack of colour coding.

8. Display clutter

a. Notwithstanding the need to minimise the display clutter, the displayed information should allow the pilot to satisfactorily perform the task, while keeping the rotorcraft under control and all the system within the operating limits.

b. Any de-clutter function should be such to permit the pilot to maintain or readily find and regain the view of primary flight information on demand.

9. Display of information

a. For those phases of flight where airworthiness approval is predicated on the use of the HMD, or when it can be reasonably expected that the crew will operate primarily by reference to the HMD, the HMD should adequately provide the following information and cues:

   i. Flight State and Position. The HMD should provide information to permit the pilot to instantly evaluate the rotorcraft flight state and position. This information should be adequate for manually controlling the rotorcraft and for monitoring, if needed, the performance of the powerplant system.

   ii. Attitude Cues. Attitude cues in the HMD should enable the pilot to make accurate, easy, quick glance interpretation of any attitude situation, immediately recognize unusual attitudes when they occur and not hinder unusual attitude recovery.

b. Formats with digital-only display of primary flight and powerplant information should be demonstrated to provide at least one of the following:
   i. A satisfactory level of task performance.
   ii. A satisfactory awareness of proximity to limit values.
   iii. A satisfactory means to avoid violating such limits.

c. Changes in the display format and primary flight data arrangement should be minimised to prevent confusion and to enhance the crew's ability to interpret vital data.

d. Information regarding the current HMD system mode, reference data, status state transition and alert information should be made always available to the crew. This same information that is displayed to the pilot using the HMD should also be displayed head-down to the other pilot. The display of this information for the other pilot should use consistent nomenclature to ensure unmistakable awareness of the HMD operation.