**Attachment "AE"**

**HEAD-UP DISPLAYS (HUD) AND ENHANCED VISION SYSTEMS (EVS)**

_Supplementary to Chapter 6, 6.23_

**Introduction**

The material in this Attachment provides guidance for HUD and EVS intended for installation and operational use in aircraft engaged in international air navigation. HUD and EVS may be installed and operated to enhance situational awareness or to obtain an operational credit such as lower minima for approach and landing operations. HUD and EVS may be installed separately or together as part of a hybrid system. Any use of these systems and any operational credit gained from their use requires approval from Kuwait DGCA.

*Note:* Operational credit can only be granted within the limits of the design approval.

1. **HUD**

1.1 **General**

1.1.1 A HUD presents flight information into the pilot’s forward external field of view without significantly restricting that external view.

1.1.2 A variety of flight information may be presented on a HUD depending on the intended flight operation, flight conditions, systems capabilities and operational approval. A HUD may include, but is not limited to, the following:

   a) airspeed;  
   b) altitude;  
   c) heading;  
   d) vertical speed;  
   e) angle of attack;  
   f) flight path or velocity vector;  
   g) attitude with bank and/or pitch references;  
   h) course and glide path with deviation indications;  
   i) status indications (navigation sensor, autopilot, flight director, etc.); and  
   j) alerts and warning displays (ACAS, wind shear, ground proximity warning, etc.).
1.2 HUD Operational Applications

1.2.1 Flight operations with HUD can improve situational awareness by combining flight information located on head-down displays with the external view to provide pilots with more immediate awareness of relevant flight parameters and situation information while they continuously view the external scene. This improved situational awareness can also reduce errors in flight operations and improve the pilot’s ability to transition between visual and instrument references as meteorological conditions change. Flight operations applications may include the following:

a) enhanced situational awareness during all flight operations, but especially during taxi, take-off, approach and landing;

b) reduced flight technical error during take-off, approach and landing especially in all-weather operations; and

c) improvements in performance due to precise prediction of touchdown area, tail strike awareness/warning and rapid recognition and recovery from unusual attitudes.

1.2.2 HUD may be used for the following purposes:

a) to supplement conventional flight deck instrumentation in the performance of a particular task or operation. The primary cockpit instruments remain the primary means for manually controlling or manoeuvring the aircraft; and

b) as a primary flight display;

I. information presented by the HUD may be used by the pilot in lieu of scanning head-down displays. Operational approval of a HUD for such use allows the pilot to control the aircraft by reference to the HUD for approved ground or flight operations; and

II. information presented by the HUD may be used as a means to achieve additional navigation or control performance. The required information is displayed on the HUD. Operational credit, in the form of lower minima, for HUD used for this purpose may be approved for a particular aircraft or automatic flight control system. Additional credit may also be allowed to conduct operations with HUD in situations where automated systems are otherwise used.

1.3 HUD Training

1.3.1 Training requirements should be established, monitored and approved by the State of the Operator. These training requirements should include requirements for recent experience if the State determines those requirements are significantly different than current requirements for the use of conventional head-down instrumentation.
1.3.2 HUD training should address all flight operations for which the HUD is designed and operationally approved. Some training elements may require adjustments based on whether the aeroplane has a single or dual HUD installation. Training should include contingency procedures required in the event of head-up display degradation or failure. HUD training should include the following elements as applicable to the intended use:

a) an understanding of the HUD, its flight path and energy management concepts, and symbology. This should include operations during critical flight events (ACAS TA/RA, upset and wind shear recovery, engine or system failure, etc.);

b) HUD limitations and normal procedures, including maintenance and operational checks performed to ensure normal system function prior to use. These checks include pilot seat adjustment to attain and maintain appropriate viewing angles and verification of HUD operating modes;

c) HUD use during low visibility operations, including taxi, take-off, instrument approach and landing in both day and night conditions. This training should include the transition from head-down to head-up and head-up to head-down operations;

d) failure modes of the HUD and the impact of the failure modes or limitations upon crew performance;

e) crew coordination, monitoring and verbal call out procedures for single HUD installations with head-down monitoring for pilot-not-equipped with HUD and head-up monitoring for pilot-equipped with HUD;

f) crew coordination, monitoring and verbal call-out procedures for dual HUD installations with use of HUD by the pilot flying the aircraft and either head-up or head-down monitoring by the other pilot;

g) consideration of the potential for loss of situational awareness due to "tunnel vision" (also known as cognitive tunneling or attention tunneling);

h) any effects that weather, such as low ceilings and visibilities, may have on the performance of a HUD; and

i) HUD airworthiness requirements.

2. EVS

2.1 General

2.1.1 EVS present a real-time electronic image of the external scene through the use of image sensors. This information should be displayed on a head-up or head-down display. When enhanced vision imagery is displayed on a HUD, it should be presented to the pilots’ forward external field of view without significantly restricting that external view.
2.1.2 A variety of image sensors may be used individually or in combination to present a real-time electronic image of the external scene. Image sensors may include sensors using low-level light intensification, thermal emissions, radar or other electronic emissions.

2.2 Operational Applications

2.2.1 Flight operations with enhanced vision image sensors allow the pilot to view an image of the external scene obscured by darkness or other visibility restrictions. When the external scene is partially obscured, enhanced vision imaging may allow the pilot to acquire an image of the external scene earlier than with natural or unaided vision. The improved acquisition of an image of the external scene may improve situational awareness.

2.2.1.1 This enhanced imagery may also allow pilots to detect terrain or obstructions on the runway or taxiways. An enhanced image can also provide visual cues to enable earlier runway alignment and a more stabilized approach.

2.2.1.2 The enhanced vision images may also be used to obtain approval to use reduced visibility minima when the images are presented into the pilot’s external field of view on a HUD without significantly restricting that view. The approval also requires specific aircraft performance parameters and navigation guidance to be presented on the HUD. The combined display of aircraft performance, guidance and imagery may allow the pilot to maintain a more stabilized approach and smoothly transition from enhanced visual references to standard visual references.

2.3 EVS Approval

2.3.1 Approval requirements differ based on whether the intended function of the system is to increase situational awareness or to obtain operational credit.

2.3.1.1 When enhanced vision imagery is used to improve situational awareness, operational approval requirements may be limited. An example of this type of operation may include an EVS on a head-down display that is only used for situational awareness of the surrounding area of the aircraft during ground operations where the display is not in the pilot’s primary field of view. For enhanced situational awareness, the installation and operational procedures need to ensure that EVS operations do not interfere with normal procedures or the operation or use of other aircraft systems. In some cases, modifications to these normal procedures, other systems or equipment may be necessary to ensure compatibility.
2.3.1.2 When enhanced vision imagery is used for operational credit, operational approvals may require that the imagery be combined with flight guidance and presented on a HUD. Operational approvals may also require that this information be presented on a head-down display. A pilot could use this system to continue an instrument approach below published minimum altitudes using the enhanced visual imagery combined with flight guidance on the HUD. When EVS is used for operational credit, operational approval standards should ensure the credit for the individual image sensor or combination of sensors is appropriate. Operational credit may be applied for any flight operation, but credit for instrument approach and landing operations is most common.

2.4 EVS Training

2.4.1 Training requirements should be established, monitored and approved by the Kuwait DGCA.

2.4.2 EVS training should address all flight operations for which the enhanced vision display is approved. This training should include contingency procedures required in the event of system degradation or failure. Training for EVS used for situational awareness should not interfere with other required operations. Training for EVS used for operational credit should also require training for the applicable HUD used to present the enhanced visual imagery. EVS training should include the following elements as applicable:

a) an understanding of the system characteristics and operational constraints. Normal procedures, controls, modes, and system adjustments;

b) EVS limitations;

c) EVS airworthiness requirements;

d) enhanced vision display during low visibility operations, including taxi, take-off, instrument approach and landing. System use for instrument approach procedures in both day and night conditions;

e) failure modes of the EVS and the impact of the failure modes or limitations upon crew performance, in particular, for two-pilot operations;

f) crew coordination and monitoring procedures and pilot call-out responsibilities;

g) transition from enhanced imagery to visual conditions during the runway visual acquisition;

h) rejected landing: loss of visual cues of the landing area, touchdown zone, or rollout area; and

i) any effects that weather, such as low ceilings and visibilities, may have on the performance of an EVS.

Note: LED runway lighting may not be visible to crews using HUD/EVS due to the fact that LEDs are non-incandescent lights. The effect of LED runway lighting on HUD/EVS is being evaluated, and the results will be included in a subsequent revision to Attachment AE.