KINGDOM OF BAHRAIN
Ministry of Transportation and Telecommunications

مملكة البحرين
وزارة المواصلات والاتصالات

CIVIL AVIATION PUBLICATION

CAP 33

HEAD-UP DISPLAYS (HUD)

AND

ENHANCED VISION SYSTEMS (EVS)

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1. INTRODUCTION

1.1 Definitions

Head-up display (HUD). A display system which presents flight information into the pilot's forward external field of view and which does not significantly restrict the external view.

Enhanced vision system (EVS). An electronic means of displaying a real-time image of the external scene through the use of imaging sensors.

1.2 References

ANTR OPS 1and 3, Subpart E

The Manual of All-Weather Operations (ICAO Doc 9365)

1.3 General

The material in this CAP provides guidance for certified automatic landing systems, HUD, equivalent displays and vision systems intended for operational use in aeroplanes engaged in international air navigation. These systems and hybrid systems may be installed and operated to reduce workload, improve guidance, reduce flight technical error and enhance situational awareness and/or to obtain an operational credit by establishing minima below the aerodrome operating minima, for approach ban purposes, or reducing the visibility requirements or requiring fewer ground facilities as compensated for by airborne capabilities. Automatic landing systems, HUD, equivalent displays and vision systems may be separately or together as part of a hybrid system. Any operational credit for their use requires a specific approval from the BCAA.

Note 1: "Vision systems" is a generic term referring to the existing systems designed to provide images, i.e. enhanced vision systems (EVS), synthetic vision systems (SVS) and combined vision systems (CVS).

Note 2: Operational credit can be granted only within the limits of the airworthiness approval.

Note 3: Currently, operational credit has been given only to vision systems containing an image sensor providing a real-time image of the actual external scene on a HUD.

2. HUD

2.1 General

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

Flight information shall be presented on a HUD or an equivalent display, as required for the intended use. 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 pitch references;

(h) course and glide path with deviation indications;

(i) status indications (e.g. navigation sensor, autopilot, flight director); and

(k) alerts and warning displays (e.g. ACAS, wind shear, ground proximity warning).

2.2 HUD Operational Applications

Flight operations with a 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 instrument and visual 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.

A 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; or

(b) as a primary flight display if certified for this purpose:

(1) 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

(2) 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.

An approved HUD, when used as the primary flight reference, may qualify for operations with reduced visibility or reduced RVR or replace some parts of the ground facilities such as touchdown zone and/or centre line lights. Examples and references to publications in this regard can be found in the Manual of All-Weather Operations (ICAO Doc 9365).

The functions of a HUD may be provided by a suitable equivalent display. A HUD equivalent display is one that has at least the following characteristics:

(a) a head-up presentation not requiring transition of visual attention from head down to head up;

(b) displays sensor-derived imagery that conforms with the pilot's external view;

(c) presents required aircraft flight symbology, and the external view; and

(d) has display characteristics and dynamics that are suitable for manual control of the aircraft.

A HUD equivalent may also permit the simultaneous view of the EVS sensor imagery and/or computer-generated imagery. The appropriate airworthiness and specific approvals must be obtained before such systems can be used.

Equivalent performing display refers to a display system that is certified to provide performance levels equivalent with a HUD. An equivalent performing display conforms with the pilot's external view and presents required aircraft symbology, display characteristics, and dynamics suitable for manual control of the aircraft. The appropriate airworthiness and specific approvals must be obtained before such systems can be used.

2.3 HUD Training

The operator shall comply with the training and recent experience requirements for operations using HUD or equivalent displays as established by the BCAA in accordance with Appendix 1 to ANTR OPS 1.450 Low Visibility Operations – Training & Qualifications. Training programmes shall be approved by the BCAA and the implementation of the training shall be subject to oversight by the BCAA.

Some training elements may require adjustments based on whether the aeroplane has a single or dual HUD installation.

The training shall address all flight operations for which the HUD or equivalent display is used:

(a) an understanding of the HUD, its flight path, energy management concepts and symbology. This shall include operations during critical flight events (e.g. ACAS Traffic Advisory/Resolution Advisory upset and wind shear recovery, engine or system failure);

(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 shall 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 on crew performance;

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

(f) crew coordination, monitoring and verbal call -out procedures for dual HUD installations with use of a 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 tunnelling or attention tunnelling);

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

(i) HUD airworthiness requirements.

3. Vision Systems

3.1 General

Vision systems can display electronic real -time images of the actual external scene achieved through the use of image sensors (i.e. EVS) or display synthetic images, which are derived from the on-board avionic systems (i.e. SVS). Vision systems can also consist of a combination of these two systems, called combined vision systems (i.e. CVS). Such a system may display electronic real-time images of the external scene using the EVS component of the system.

The information from vision systems may be displayed head-up and/or head-down. When enhanced vision imagery is displayed on a HUD, it shall be presented to the pilot's external field of view without significantly restricting that external view. Operational credit may be granted to vision systems which are appropriately qualified.

The increased situational awareness provided by SVS may provide additional safety for all phases of flight especially low visibility taxi, take-off, approach and landing operations.

Light emitting diode (LED) lights may not be visible to infrared (IR)-based vision systems, e.g. current EVS, due to the fact that LED lights are limited to specific light spectrums, whereas incandescent lights operate over a broad spectrum that includes near infrared range.

The current EVS is highly dependent on the heat signature of the aerodrome lighting systems. The EVS uses the light patterns to provide guidance, typically from about 60 m (200 ft) down to 30 m (100 ft). In the near future some States may allow these vision systems to provide guidance all through the landing. The main aspect of the proposed change to the ICAO Standard for white light is the expansion to the colour blue.

Another significant element is the brightness. Recent flight-testing by several original equipment manufacturers and one cargo airline has resulted in adverse comments on the characteristics of some LED lights. These comments relate both to the colours and the intensity of the LED lights resulting in significant glare and concerns about operational suitability. These concerns are applicable to various conditions of light and weather phenomena. LED lights operate in a narrower wavelength band than incandescent lights, even when being within the colour definitions in ICAO Annex 14.

This may create problems with colour perception for some pilots even when they are considered to have a normal colour perception based on today's medical requirements, which in turn are based on the existing colour definitions for incandescent lights. Work is being done by some States to explore possible mitigations that will improve the performance of EVS with respect to LED lights.

An example of a possible mitigation is the addition of a heating element to the LED light which will increase its IR signature. An additional benefit of the heating element will be to help melt freezing precipitation that may accumulate around the light. Operators of EVS will therefore need to acquire information about the LED implementation programmes at aerodromes where they operate and plan accordingly.

3.2 Operational Applications

Flight operations with EVS allow the pilot to view an image of the external scene obscured by darkness or other visibility restrictions. The use of EVS will also allow acquisition of an image of the external scene earlier than with natural ~~or~~ unaided vision, hence providing for a smoother transition to references by natural vision. The improved acquisition of an image of the external scene may improve situational awareness. It may also qualify for operational credit if the information from the vision system is presented to the pilots in a suitable way and the necessary airworthiness approval and specific approval by the State of the Operator have been obtained for the combined system.

Vision system imagery may also enable pilots to detect other aircraft on the ground, terrain or obstructions on or adjacent to runways or taxiways. A vision system image can also provide visual cues to enable earlier runway alignment and a more stabilized approach.

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 natural visual references. Advanced guidance displays supplemented with a computer-generated image may facilitate the transition from the instrument segment to the visual segment and direct the visual search for the runway.

The CVS concept involves a combination of an SVS and an EVS. Some examples of a CVS include database-driven synthetic vision images combined with real-time sensor images superimposed and correlated on the same display. The angular extent of the external scene presented on the display is called field of regard (FOR). The FOR of a typical enhanced vision system is approximately 40 degrees x 25 degrees but may vary slightly by manufacturer. Due to the limited FOR of most EVSs, the addition of a synthetic database-driven image may increase the pilot's situational awareness and aid in acquiring the runway environment.

An example of how a combined system might be used during an approach would be to rely on the synthetic database-generated image until the aircraft approaches the point where the EVS becomes effective. The image would then gradually and smoothly transition from synthetic to enhanced vision. A CVS can provide increased situational awareness, but may not necessarily be used for operational credit. In order to receive operational credit, the system used to provide the enhanced vision image must be certified for that specific operation. More information on operational credit is in Section 5, Operational Credits.

3.3 Vision Systems Training

The operator shall comply with the training and recent experience requirements as established by the BCAA. Training programmes shall be approved by the BCAA and the implementation of the training shall be subject to oversight by the BCAA.

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

(a) an understanding of the system characteristics and operational constraints;

(b) normal procedures, controls, modes and system adjustments (e.g. sensor theory including radiant versus thermal energy and resulting images);

(c) operational constraints, normal procedures, controls, modes and system adjustments;

(d) limitations;

(e) airworthiness requirements;

(f) vision system 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;

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

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

(i) transition from enhanced imagery to visual conditions during runway visual acquisition;

(j) rejected landing: with the loss of visual cues of the landing area, touchdown zone or rollout area;

(k) any effects that weather, such as low ceilings and visibilities, may have on the performance of the vision system; and

(l) effects of aerodrome lighting using LED lights.

Note 1: LED runway lighting may not be visible to crews using HUD/EVS due to the fact that LEDs are non-incandescent lights.

Note 2: Examples of training, checking and recency requirements for HUD and EVS can be found in Appendix 1.

3.4 Operational Concepts

Instrument approach operations that involve the use of vision systems include an instrument phase and a visual phase. The instrument phase ends at the published MDA/H or DA/H unless a missed approach is initiated. Using the EVS or CVS does not change the applicable MDA/H or DA/H. The continued approach to landing from MDA/H or DA/H will be conducted using visual references.

This also applies to operations with vision systems. The difference is that the visual references will be acquired by use of an EVS or CVS, natural vision or the vision system in combination with natural vision (see Figure 1-1 below).

Down to a defined height in the visual segment, typically at or above 30 m (100 ft), the visual references may be acquired solely by means of the vision system. The defined height depends on the airworthiness approval and specific approval by the BCAA. Below this height the visual references shall be solely based on natural vision.

In the most advanced applications, the vision system may be used down to touchdown without the requirement for natural vision acquisition of visual references. Using the EVS or CVS does not change the classification of an instrument approach procedure, since the published DA/H remains unchanged and manoeuvring below DA/H is conducted by visual references acquired by means of the an EVS or CVS.

This means that such a vision system may be the sole means of acquiring visual references and can be used without natural vision.

In addition to the operational credit that EVS/CVS is able to provide, these systems may also provide an operational and safety advantage through improved situational awareness, earlier acquisition of visual references and smoother transition to references by natural vision. These advantages are more pronounced for Type A approach operations than for Type B approach operations.

The use of a vision system for operational credit requires the appropriate airworthiness and specific operational approvals.

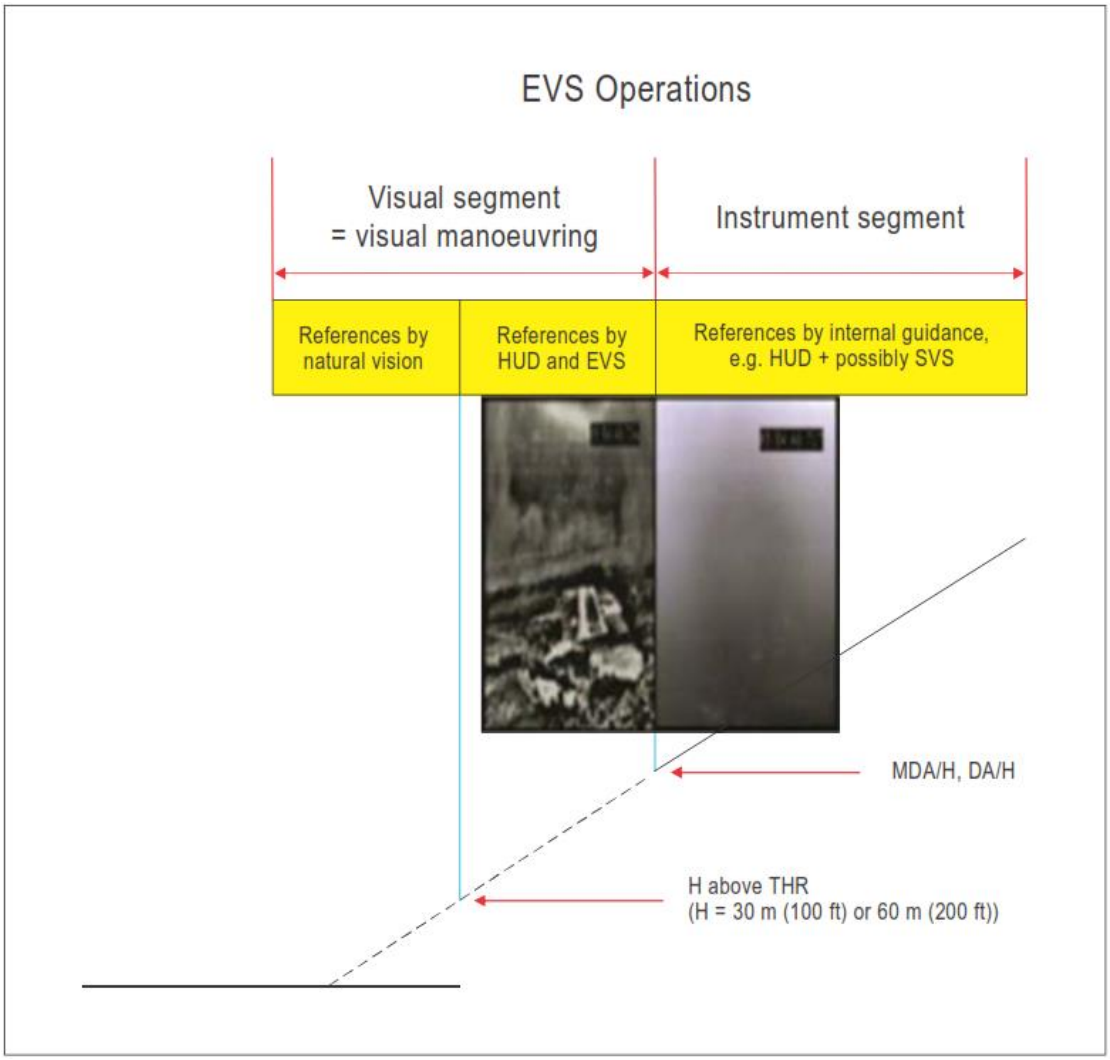

Figure 1-1. EVS operations

3.5 Visual references

In principle, the required visual references do not change due to the use of an EVS or CVS, but those references are allowed to be acquired by means of either vision system until a certain height during the approach as described in paragraph (b) (3).

In States that have developed requirements for operations with vision systems, the use of visual references are indicated in Table 1-1.

Table 1-1. Sample requirements for operations with EVS

OPERATIONS BELOW DA/H OR MDA/H	
Example 1	*Example 2*

For operations designed to support Type A operations, the following visual references for the intended runway must be distinctly visible and identifiable:
• approach lighting system, or
• the runway threshold identified by at least one of the following:
  • the beginning of the runway landing surface;
  • the threshold lights; or
  • runway end identifier lights;
and
• the touchdown zone, identified by at least one of the following:
  • the runway touchdown zone landing surface;
  • the touchdown zone lights;
  • the touchdown zone markings; or
  • the runway lights.
	For operations designed to support 3D Type A and Type B Cat I operations, the following visual references should be displayed and identifiable to the pilot on the EVS image:
	• elements of the approach light; or
	• the runway threshold, identified by at least one of the following:
	  • the beginning of the runway landing surface;
	  • the threshold lights, the threshold identification lights;
	or
	• the touchdown zone, identified by at least one of the following:
	  • the runway touchdown zone landing surface;
	  • the touchdown zone lights;
	  • the touchdown zone markings; or
	  • the runway lights.

Operations below 60 m (200 ft) above touchdown zone elevation — Example 1	*Operations below 60 m (200 ft) above threshold elevation — Example 2*
No additional requirements apply at 60 m (200 ft).	For procedures designed to support 3 D Type A operations, the visual references are the same as those specified below for Type B Cat I operations.
Operations below 30 m (100 ft) above touchdown zone elevation — Example 1	*Operations below 30 m (100 ft) above threshold elevation — Example 2*
The flight visibility must be sufficient for the following to be distinctly visible and identifiable to the pilot without reliance on the EVS: • the lights or markings of the threshold; or • the lights or markings of the touchdown zone.	For procedures designed to support Type B Cat I operations, at least one of the visual references specified below should be distinctly visible and identifiable to the pilot without reliance on the EVS: • the lights or markings of the threshold; or • the lights or markings of the touchdown zone.

4. Hybrid systems

A hybrid system generically means that two or more systems are combined. The hybrid system typically has improved performance compared to each of the component systems, which in turn may qualify for operational credit. Vision systems are normally part of a hybrid system, e.g. EVS is typically combined with a HUD. The inclusion of more systems in the hybrid system normally enhances the performance of the system.

Table 1-2 provides some examples of hybrid systems. Any combination of the listed systems may constitute a hybrid system. The degree of operational credit that may be given to a hybrid system depends on its performance (accuracy, integrity and availability) as assessed and determined by the certification and operational approval processes.

Table 1-2. Examples of hybrid system components

Systems based on image sensors	Systems not based on image sensors
EVS • Passive infrared sensors • Active infrared sensors • Passive millimetre wave radiometer • Active millimetre wave radar	SVS
	Autoflight systems, flight control computers, automatic landing systems
	Systems for position fixing
CVS (where the EVS component as above qualifies for operational credit)	CVS (the SVS component)
	HUD, equivalent display
	ILS, GNSS

5. Operational Credits

Aerodrome operating minima are expressed in terms of minimum visibility/RVR and MDA/H or DA/H. When aerodrome operating minima are established, the combined capability of the aeroplanes equipment and on-ground infrastructure shall be taken into account. Better equipped aeroplanes may be able to operate into lower natural visibility conditions, lower DA/H and/or operate with less ground infrastructure. Operational credit means that the aerodrome operating minima may be reduced in case of suitably equipped aeroplanes. Another way to grant operational credit is to allow visibility requirements to be fulfilled, wholly or partly, by means of the on-board systems. HUD, automatic landing or vision systems were not available at the time when the criteria for aerodrome operating minima were originally established.

Credits related to visibility/RVR can be given using at least three concepts. The first concept is to reduce the required RVR which will allow the aircraft to continue the approach beyond the approach ban point with a reported RVR lower than what was established for the approach procedure.

Where a minimum visibility is prescribed, a second concept to grant operational credit may be used. In this case, the required minimum visibility is kept unchanged, but it is satisfied by means of the on-board equipment, typically an EVS.

A third concept is to give operational credit by allowing operations in visibility/RVR which are not lower than those established for the approach procedure, but the approach operation is conducted with less facilities on the ground. One example of the latter is to allow category II operations without touchdown and/or centre line lights, compensated by additional on-board equipment, e.g. a HUD.

The result of the first two concepts is that operations are allowed in meteorological conditions where otherwise they would not be possible. A third concept is to give operational credit by allowing operations in visibility/RVR which are not lower than those established for the approach procedure, but the approach operation is conducted with less facilities on the ground. One example of the latter is to allow category II operations without touchdown and/or centre line lights, compensated by additional on-board equipment, e.g. a HUD.

The granting of operational credits does not affect the classification (i.e. Type or Category) of an instrument approach procedure since they are designed to support instrument approach operations conducted using aeroplanes with the minimum equipment prescribed.

In order to provide optimum service, the ATS may have to be informed about the capabilities of the better-equipped aircraft, e.g. which is the minimum RVR required.

In addition to the operational credit that HUD, vision systems and hybrid systems are able to provide, these systems will also provide an operational and safety advantage through improved situational awareness, earlier acquisition of visual references and smoother transition to references by natural vision. These advantages are more pronounced for 3D Type A approach operations than for Type B approach operations.

The relation between the procedure design and the operation can be described as follows. The OCA/H is the end product of the procedure design which does not contain any RVR or visibility values. Based on the OCA/H and all the other elements such as available runway visual aids, the operator will establish MDA/H or DA/H and RVR/visibility, i.e. the aerodrome operating minima. The values derived shall not be less than those prescribed by the State of the Aerodrome.

6. Operational Procedures

The operator shall develop suitable operational procedures associated with the use of an automatic landing system, a HUD or an equivalent display, vision systems and hybrid systems. These procedures shall be included in the operations manual and cover at least the following:

(a) any limitations that are imposed by the airworthiness or operational approvals;

(b) the effect of operational credits, if approved

(c) flight planning with respect to destination and alternate aerodromes;

(d) ground and airborne operations;

(e) flight execution, e.g. approach ban and minimum visibility;

(f) crew resource management that takes into account the equipment configuration, e.g. the pilots may have different presentation equipment;

(g) standard operating procedures e.g. use of autoflight systems, call-outs that may be particular to the vision system or hybrid system, criteria for stabilized approach; and

(h) ATS flight plans and radio communication.

It is not prohibited to use vision systems in connection with circling. However, due to the system layout of a vision system and the nature of a circling procedure, key visual references can be obtained only by natural vision, and operational credit is not feasible for existing vision systems. The vision system may provide additional situational awareness.

7. Approvals

An operator that wishes to conduct operations with an automatic landing system, a HUD or equivalent display, a vision system or a hybrid system will need to obtain certain approvals as prescribed in ANTR OPS 1.785. The extent of the approvals will depend on the intended operation and the complexity of the equipment.

Systems that are not used for an operational credit or otherwise critical to the aerodrome operating minima, e.g. vision systems used to enhance situational awareness, may be used without a specific approval. However, the standard operating procedures for these systems shall be specified in the operations manual. An example of this type of operation may include an EVS or an SVS on a head-down display that is used only for situational awareness of the surrounding area of the aeroplane 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 the operation of the vision system does not interfere with normal procedures or the operation or use of other aircraft systems. In some cases, modifications to these normal procedures for other aircraft systems or equipment may be necessary to ensure compatibility.

When a vision system or a hybrid system with vision systems imagery is used for operational credit, operational approvals will typically require that the imagery be combined with flight guidance and presented on a HUD. Operational approvals may require that this information also be presented on a head-down display. Operational credit may be applied for any flight operation, but credit for instrument approach and take-off operations is most common.

Operators should be aware that some States may require information about the specific credits which have been granted by the BCAA. Typically the approval from the State of the Operator will have to be presented and, in some cases, the State of the Aerodrome may wish to issue an approval or to validate the original approval.

The use of an automatic landing system, a HUD, an equivalent display, EVS, SVS or CVS or any combination of those systems into a hybrid system, shall be approved by the BCAA when those systems are used "for the safe operation of an aeroplane". When operational credits have been granted by the BCAA, the use of that system becomes essential for the safety of such operations and is subject to a specific approval. The use of these systems solely for enhanced situational awareness, reduced flight technical error and/or reduced workload is an important safety feature but does not require a specific approval.

Any operational credit that has been granted shall be reflected in the operation specifications for the type or individual aeroplane as applicable.

Note: When the application for a specific approval relates to operational credits for systems not including a vision system, the guidance on approvals in this CAP may be used to the extent applicable as determined by the BCAA.

8. Specific Approvals for Operational Credit

To obtain a specific approval for operational credit the operator will need to specify the desired operational credit and submit a suitable application. The content of a suitable application shall include:

(a) *Applicant details required for all approval requests*. The official name and business or trading name(s), address, mailing address, e -mail address and contact telephone /fax numbers of the applicant.

Note: For AOC holders, the company name, AOC number and e-mail address shall be required.

(b) *Aircraft details required for all approval requests*. Aircraft make(s), model(s) and registration mark(s).

(c) *Operator's vision system compliance list*. The contents of the compliance list are included in Table 1-3. The compliance list shall include the information that is relevant to the approval requested and the registration marks of the aircraft involved. If more than one type of aircraft/fleet is included in a single application a completed compliance list shall be included for each aircraft/fleet.

(d) *Documents to be included with the application.*Copies of all documents referred to in column 4 of the operator's vision system compliance list (Table 1-3) shall be included when returning the completed application form to the civil aviation authority. There is no need to send complete manuals; only the relevant sections/pages will be required.

(e) *Name, title and signature*.

The following items shall be covered in a vision systems compliance list:

(a) reference documents used in compiling the submission for approval;

(b) flight manual;

(c) feedback and reporting of significant problems;

(d) requested operational credit and resulting aerodrome operating minima;

(e) operations manual entries including MEL and standard operating procedures;

(f) safety risk assessments;

(g) training programmes; and

(h) continuing airworthiness

Table 1-3. Example of an AOC vision system compliance list

Main heading	Expanded areas to be addressed by the	Sub-requirements	Operator's operations manual reference or document reference
1.0 Reference documents used in compiling the submission	The submission shall be based on current up-to-date regulatory material. A compliance statement showing how the criteria of the applicable regulations and requirements have been satisfied.		
2.0 Aircraft flight manual (AFM)	A copy of the relevant AFM entry showing the aircraft certification basis for the vision system and any operational conditions.		
3.0 Feedback and reporting of significant problems	An outline of the process for the reporting of failures in the operational use of procedures. *Note: In particular, significant problems with the vision system / HUD system, reporting on circumstances / locations where the vision system was unsatisfactory.*		
4.0 Instrument approach chart provider and operating minima	The name of the provider of the relevant instrument approach charts. Confirmation that all aerodrome operating minima are established in accordance with the method acceptable to the relevant authority.		

Main heading	Expanded areas to be addressed by the	Sub-requirements	Operator's operations manual reference or document reference
5.0 Operations manual entries and standard operating procedures	Manufacturer/operator-developed. Manufacturer's procedures are recommended as a starting point and shall include at least the items in the sub-requirements column.	Definitions. Check that crew members are qualified for vision system/HUD operations. MEL handling. Equipment required for vision system operations. Types of approach where vision systems can be used. Statement that the autopilot/flight director shall be used whenever possible. Minimum visual references for landing. Approach ban and RVR. Stabilized approach criteria. Correct seating and eye position. Crew coordination, e.g. duties of the pilot flying and the pilot not flying: • limitations; • designation of handling and non-handling pilots; • use of automatic flight control system; • checklist handling; • approach briefing; • radio communications handling; • monitoring and cross-checking of instruments and radio aids; and • use of the repeater display by the pilot not flying. Contingency procedures including: • failures above and below decision height; • ILS deviation warnings; • autopilot disconnect; • auto-throttle disconnect; • electrical failures; • engine failure; • failures and loss of visual references at or below decision height; • vision system/HUD failure below normal decision height; • wind shear; • ACAS warnings; • EGPWS warnings.	
6.0 Safety risk assessment		Operator's safety risk assessment.	

9. Conditions for the use of Autoland Systems, HUD, Equivalent Display, EVS, SVS, CVS or any combination of these systems for the safe operation of an aeroplane

The BCAA, when autoland systems, HUD or equivalent display, EVS, SVS, CVS, or any combination of these systems are used "for the safe operation" of the aircraft, requires the operator to be approved under the normal process the BCAA would carry out to authorise an application to undertake or modify a flight operation that has been submitted by an operator.

Note: Information about specific approvals for operational credits and approvals of the use of these systems or criteria for the use of these systems is contained in Chapter 8.

The use of vision systems solely for enhanced situational awareness, improved navigational accuracy and/or reduced workload is an important safety feature, but the system does not require a specific operational approval if it is not necessary for the kind of operation, i.e., an operational credit.

Operational credits based on the use of autoland systems, HUD or equivalent display, EVS, SVS, CVS, or any combination of these systems into a hybrid system, will require a specific approval.

When considering an application for operational credits, in addition to the requirements described in Section 8, the use of the qualifying system must be assessed and becomes an integral part of the specific approval. The specific approval for the operational credit is issued by the BCAA, and it is reflected in the Operator's Operations Specifications (OPS SPEC).

Any system installed on an aircraft must have an airworthiness approval. The airworthiness aspects are handled through the type certificate or supplementary type certificate.

10. Application and Approval Process

10.1 Application

An application for the approval for the use of HUD/EVS must be made using the application form on the BCAA website.

10.2 Documents Required

The documents listed below must accompany the application for grant of approval for HUD/EVS:

(a) The copies of Supplemental Type Certificates (STC) for each type of equipment fitted on each aircraft respectively, which cover the following aspects:

(1) minimum level of integrity and availability; and

(2) functional criteria.

(b) Maintenance programme/approved maintenance schedule for each aircraft. (i.e. transit, periodical inspection and test).

(c) Equipment lists (MMEL and MEL) that identify the minimum equipment necessary for HUD/EVS operations in respect of each aircraft.

(d) Part of the Aircraft Flight Manuals (AFMs) for each aircraft that specifies the following:

(1) the basis for certification together with any HUD/EVS system limitations; and

(2) the appropriate HUD/EVS system operating and emergency procedures applicable to the equipment installed:

(i) Normal procedure for operating the equipment;

(ii) Equipment operating limitations; and

(iii) Emergency operating procedures.

(e) Training programmes in respect of the HUD/EVS equipment installed in each aircraft for:

(1) Maintenance personnel; and

(2) Flight crew. All operators must submit training syllabi and other appropriate material to show that the operational practices and procedures and training items related to HUD/EVS operations are incorporated in training programmes where applicable (e.g. initial, upgrade, recurrent).

(i) The ground school training syllabus shall indicate the following:

- EVS Theory
- Interpretation of images.
- Display characteristics.
- Calibration checks.
- Visual anomalies.
- Eye and seat position.
- Weather/fog characteristics.
- Low visibility operations.
- Crew briefings/callouts.
- Duties of PF/PNF and CRM.

- Actions at DA and 100 ft agl.
- Transition from EVS imagery to non-EVS visual.
- Use of clear switch.
- Recognition of malfunctions.
- AFM performance and obstacle clearance on go-around.
- Use of auto-flight systems and minimum engage height.
- AFM limitations and system failures.

(ii) The simulator training shall be to Appendix 1 to ANTR OPS 1.450 standard.

(iii) Line training under supervision & recurrent training must be addressed.

(f) Operators must revise their operations manual and checklists to include information/guidance on standard operating procedures. Manuals and checklists must be submitted for review as part of the application process. Practices and procedures in the following areas must be standardised and include ground and flight procedures and flight crew qualification requirements.

- Definitions.
- Check that the crews are qualified for EVS/HUD operations.
- MEL handling.
- Equipment required for EVS operations.
- Types of approach where EVS can be used.
- Statement that autopilot/flight director shall be used whenever possible.
- Minimum visual references for landing.
- Approach Ban and RVR.
- Stabilised Approach Criteria.
- Correct seating and eye position.
- Crew co-ordination, e.g. duties of PF and PNF such as:
  - designation of handling and non-handling pilots;
  - use of automatic flight control system;

- checklist handling;
- approach briefing;
- radio communications handling;
- monitoring and cross-checking of instruments and radio aids; and
- use of the repeater display by PNF.

• Contingency procedures including:

- failures above and below decision height;
- ILS deviation warnings;
- autopilot disconnect;
- auto-throttle disconnect;
- electrical failures;
- engine failure;
- failures and loss of visual references at or below decision height; and
- EVS/HUDLS failure below normal decision height.

• Failure reporting procedures and records

(g) Evidence that approach plates are in accordance with Appendix 1 to ANTR OPS 1.430.

Note: Refer to paragraph 2.3, HUD Training and paragraph 3.3, Vision Systems Training.

10.3 Approval

Approval to utilise HUD/EVS will be issued on the Operations Specifications (OPS SPECS).

Operational credit such as lower minima for approach and landing operations will also be stated on the Operations (OPS SPECS).

Credits may be granted within the limits of the design approval and those described in Appendix 1 to ANTR OPS 1.430 Table 9-1.

The Operations Specifications (OPS SPECS) must be carried in the aircraft library on all flights.

10.4 Cancellation of HUD/EVS Approval

Operators are reminded that after an approval to utilise HUD/EVS and associated operational credit is issued, the BCAA conducts regular surveillance on all operations using this equipment. When appropriate, the BCAA may consider any error or operational deficiency reports in determining remedial action. Repeated occurrences, attributed to HUD/EVS, may result in cancellation of the approval and/or operational credit.

Information that indicates the potential for repeated errors may require a modification of an operator's training programme. Information that attributes multiple errors to a particular pilot crew may necessitate remedial training.

CIVIL AVIATION PUBLICATIONS

APPENDIX 1

Examples of Training, Checking and Recency Requirements for HUD and EVS

1. Initial ground training should consist of the following subjects:

(a) Applicable regulatory guidelines that relate to HUD and EVS flight operations and limitations, including aircraft flight manual limitations;

(b) HUD display, controls, modes, features, symbology, annunciations, and associated systems and components;

(c) EVS sensor performance, sensor limitations, scene interpretation, visual anomalies, and other visual effects;

(d) Pre-flight planning and operational considerations associated with using HUD and EVS during taxi, take-off, climb, cruise, descent, and landing phases of flight, including the use of HUD and EVS for instrument approaches, operating below DA/DH or MDA, executing missed approaches, landing, roll-out, and balked landings;

(e) Weather associated with low-visibility conditions and its effect on EVS performance;

(f) Normal, abnormal, emergency, and crew coordination procedures when using EVS; and

(g) Interpretation of approach and runway lighting systems and their display characteristics when using a HUD and EVS.

2. Initial flight training should consist of the following subjects:

(a) Pre-flight and inflight preparation of HUD and EVS equipment for operations, including set up and use of display, controls, modes, and associated systems, including adjustments for brightness and contrast under day and night conditions;

(b) Proper piloting techniques associated with use of HUD and EVS during taxi, take-off, climb, cruise, descent, landing, and roll-out, to include missed approaches and balked landings;

(c) Proper piloting techniques for the use of HUD and EVS during instrument approaches, to include operations below DA/DH or MDA in accordance with applicable State regulations, under both day and night conditions;

(d) Determining enhanced flight visibility;

(e) Identifying required visual references appropriate to EVS operations;

(f) Transitioning from EVS sensor imagery to natural vision acquisition of required visual references and the runway environment;

(g) Using EVS sensor imagery to touchdown and roll-out, if applicable; and

(h) Normal, abnormal, emergency, and crew coordination procedures when using a HUD and EVS, including crew procedures for using the pilot monitoring (PM) display.

3. Recurrent or differences training

Recurrent and differences training for EVS operations shall consist of the same subject areas covered by initial training. Differences training for a new EVS system shall also include special conditions or considerations associated with conducting EVS operations using the new system.

4. Recent flight experience

HUD and EVS operations are complex operations involving the use of a HUD with a sensor image that a pilot typically conducts in low-visibility conditions. Because the occurrence of low-visibility conditions is infrequent and because the skills necessary to operate this equipment under these conditions depreciate, recent HUD and EVS flight experience and training is necessary to prevent the loss of skill.

The purpose of requiring recent HUD and EVS flight experience is to ensure that a pilot remains proficient in the use of all HUD and EVS components and operating procedures and to ensure that the pilot conducts EVS operations safely. As EVS equipment evolves to permit operations in lower visibility environments than are currently permitted, and as the scope and number of EVS operations increases over time, the need for pilots to maintain recent flight experience becomes even more critical.

HUD and EVS operators whose policy is to use this equipment on nearly all operations can build experience and proficiency quicker than if they used it only during lower visibility operations. The HUD is an excellent safety enhancement in all-weather operations, and EVS systems can provide benefit in other than just low-visibility operations. For example, EVS can enhance safety in night operations especially in mountainous terrain in almost all weather conditions.

Some States require that a person who manipulates the controls of an aeroplane during an EVS operation or who acts as pilot-in-command of an aeroplane during an EVS operation, can do so only if, within six calendar months preceding the month of the flight, that person performed and logged six instrument approach operations as the sole manipulator of the controls using an EVS.

States do allow for recent flight experience to be met in an aircraft or in a simulator equipped with an EVS.

5. Proficiency check requirements

Some States will require a person acting as pilot-in-command or a person who is manipulating the controls of an EVS equipped aeroplane to pass a HUD and EVS proficiency check. A typical HUD and EVS proficiency check shall include a representative sample of the items that were covered during the initial ground and flight training for HUD and EVS.