EUROPEAN AVIATION SAFETY AGENCY - EASA

OPERATIONAL EVALUATION BOARD
REPORT

ROCKWELL COLLINS MODEL 6605 HEAD-UP DISPLAY (HUD) SYSTEM
and
ENHANCED VISION SYSTEM (EVS)

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OEB Chairman
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<td>Revision 0</td>
<td>October 1st 2009</td>
<td>All (draft)</td>
<td></td>
<td>October 15th 2009</td>
</tr>
<tr>
<td>Revision 1</td>
<td>February 22nd 2010</td>
<td>All</td>
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<tr>
<td>AFCS</td>
<td>Automatic Flight Control System</td>
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<td>Above Ground Level</td>
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<td>AOC</td>
<td>Air Operator Certificate</td>
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4.0 EXECUTIVE SUMMARY

4.0 Background

4.1 The European Aviation Safety Agency (EASA) participated in an evaluation of the Rockwell Collins Model 6605 Head-up Display System (HUD) and the Rockwell Collins Model 6605 Enhanced Vision System (EVS) in August 2009 using a Bombardier Challenger CL-605 Level D simulator and CL-605 aircraft. At Bombardier’s Flight Test facility in Wichita, KS.

4.2 The evaluation was carried out by a team of 4 experts. Participating in this team were: Operational Evaluation Board of Transport Canada Civil Aviation (TCCA), Flight Standardisation Board of the Federal Aviation Administration (FAA) and Operational Evaluation Board of the European Aviation Safety Agency (EASA). The 3 individual boards are responsible for reporting their findings to their National Authorities in separate reports. This report is the EASA OEB report.

4.3 This report consists of two parts:

PART 1 HEAD-UP DISPLAY (HUD)

PART 2 ENHANCED VISION SYSTEM (EVS)

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EASA Certifications        Manager OEB
Flight Standards Manager     Business jets.
PART 1 HEAD-UP DISPLAY (HUD)

1.0 ROCKWELL COLLINS MODEL 6605 HEAD-UP DISPLAY (HUD) SYSTEM

1.1 The European Aviation Safety Agency participated in an evaluation of the Rockwell Collins Model 6605 Head-up Display System (HUD) in August 2009 using a Bombardier Challenger CL-605 Level D simulator and CL-605 aircraft. At Bombardier’s Flight Test facility in Wichita, KS, the OEB completed numerous HUD approaches at several different airports, using CAT I procedures during day and night,

1.2 EASA found the Rockwell Collins Model 6605 HUD operationally suitable for all phases of flight and for CAT I operations.

1.2.2 Low visibility takeoff and CAT II operations using the HUD were not evaluated.

2. PREREQUISITES FOR HUD TRAINING

2.1 Unless the HUD training is integrated with, or occurs sequentially preceding an initial type rating skill test, a prerequisite to HUD training in a Bombardier Challenger CL-605 airplane, is prior training, type rating and currency in the Bombardier Challenger CL-605.

3.0 HUD TRAINING - GENERAL

3.1 The HUD pilot training requirements consist of those related to initial and recurrent ground and flight training. It should be noted that the HUD training program focuses principally upon training events flown in the left seat by the Pilot-In-Command (PIC) as Pilot Flying (PF). Nevertheless, HUD training of Pilot Not Flying (PNF) duties in the right seat is required, where there are procedural differences for the PNF, and when the PF is heads up (compared to heads down). PNF HUD familiarization flown in the left seat is recommended.

3.2 Flight crewmember training must be accomplished using a CL-605 Level C simulator with a daylight visual display, or a CL-605 Level D simulator, or a CL-605 aircraft equipped with a Rockwell Collins Model 6605 Head-up Display System. EASA has determined that each pilot in command should receive a minimum of 3 hours of HUD ground school training, followed by a minimum of 3 hours of HUD flight training, in the left seat, in either an approved CL-605 Level C or D simulator or CL-605 aircraft. (The 3 hours of ground and 3 hours of flight training is an initial requirement only.)

3.3 A person who progresses satisfactorily through flight training, is recommended by an instructor, and successfully completes the appropriate HUD proficiency check by a
person authorized by the Administrator, need not complete the recommended 3 hours of flight training.

4.0 HUD INITIAL GROUND TRAINING

4.1 The initial HUD ground training program should include the following elements:

a. Classroom instruction covering HUD operational concepts, crew duties and responsibilities and operational procedures including preflight, normal and abnormal operations, Glideslope angle modification in the FMS, EICAS messages, use of AFMS, QRH, and checklists, miscompare, and failure flags.

b. Classroom instruction or Computer Based Training (CBT) on the HUD symbology set and its inter-relationship with airplane aerodynamics, inertial factors, environmental conditions and comparison to the Primary Flight Display (PFD).

   NOTE: Actual HUD video should be used to reinforce training in the following areas:

   (1) **Take off and Go Around.** Use of the Takeoff Reference Line Indicator (which is not immediately visible) and the Aircraft Reference symbol for takeoff and go around rotation and the transition to the Flight Path Symbol (FPS) and the Flight Director Guidance Cue (FD).

   (2) **Unusual Attitudes.** Transitions to and from the decluttered display, and the use of the Aircraft Reference symbol during the recovery and when to transition back to the FPS.

   (3) **Approach to Stall and Stall Recovery.** Use of the Angle-of-Attack Limit Indicator for approach to stall awareness and its use with respect to the FPS during stall recoveries.

   (4) **Glideslope Reference Line.** Use of the Glideslope Reference Line and the FPS as the sole final visual approach reference.

   c. A Rockwell Collins Model 6605 Head-Up Guidance (HGS) pilot guide, Model 6605 HUD/EVS Aircraft Flight Manual Supplement (AFMS), or equivalent materials (ex. Flight Crew Operations Manual (FCOM), which explain HUD limitations, modes of operation, descriptions of HUD symbology, limit conditions and failures, and which define crew procedures that delineate PF and PNF duties, responsibilities, and call-outs during all phases of flight in which HUD operations are conducted.
d. Special Emphasis ground training shall be conducted in the following areas:

(1) Crew Coordination
(2) Crew Briefings and Callouts
(3) Duties of flying and non-flying pilots; and
(4) EICAS messages and use of the Quick Reference Handbook (QRH) and checklists applicable to HUD operations.

5.0 HUD INITIAL FLIGHT/SIMULATOR TRAINING

5.1 Unless integrated with CL-605 initial type rating training, flight training dedicated to HUD familiarization and proficiency is in addition to other required training elements.

5.2 All required approaches, utilizing the HUD, should begin no closer than the final approach fix (FAF) for instrument approaches, and should begin no closer than approximately 1,000 feet AGL (3-4 NM) to the runway threshold for visual approaches.

5.3 The following HUD flight training program is generic in nature and should be considered as a minimum training requirement only.

a. **Ground Operations:**
   (1) Deployment of HUD and stowage, including installation and removal of the HUD sun-visor and,
   (2) Taxi using HUD under various lighting and visibility conditions.

b. **Airwork:**
   (1) Straight and level flight, accelerations and decelerations,
   (2) Normal and steep turns, climbs and descents,
   (3) Wind Effects on HUD display,
   (4) Approach to stall recovery; and
   (5) Recovery from unusual attitudes.

c. **Visual Take-offs, Approaches and Landings**
   (1) Crosswind take-off and landing,
   (2) Visual approaches to runways at night with minimal lighting (“black hole” approaches) and use of FPS and Glideslope Reference Line to achieve desired descent angle,
   (3) Engine failure on take-off,
   (4) One Engine Inoperative (OEI) landing
   (5) OEI go-around;
d. Instrument Approaches:
   (1) Approaches to the lowest authorized minima including an approach and landing with OEI,
   (2) Missed approach OEI
   (3) Non-precision, and circling approaches (if applicable).
NOTE: It is desirable to fly visual and instrument approaches with dissimilar approach and lighting systems.

e. Abnormal/Emergency Operations: (as applicable)
   (1) Wind shear escape,
   (2) TAWS escape,
   (3) TCAS Resolution Advisory,
   (3) HUD failure on approach and its effect on pilot workload and PF/PNF duties and responsibilities,
   (5) Approaches with the aircraft in a non-normal flap configuration.

5.4 Special emphasis flight training shall be conducted in the following areas:

   (1) HUD unique symbology with the autopilot and flight director both off and on, i.e. Flight Path Symbol (FPS), Flight Path Acceleration Cue, speed error tape, low and high speed cues, flight mode annunciator, use of non-conformal symbology including the use of the FPS to recognize and recover from flight at high angles of attack, and excessive pitch chevrons.

   (2) Use of the Angle-of-Attack Limit Indicator and the FPS for approach to stall awareness and its use during a stall recovery.

   (3) Use of the unusual attitude display, the Aircraft Reference symbol, the change to a normal display, and when to transition to the FPS during recoveries.

   (4) Transitioning to Head Down Displays (HDD’s) and the inclusion of HDD’s in the crosscheck including EICAS displays and other cockpit indications.

   (5) Avoidance of fixation on HUD display and symbology elements, particularly during the landing flare maneuver and appropriate conditions to turn OFF the HUD display.

   (6) Use of the Takeoff Reference Line Indicator and the Aircraft Reference symbol for the pitch rotation target on takeoff and go-around,

   (7) Use of the Glideslope Reference Line and FPS for visual approaches, and in crosswind landing technique,

   (8) HUD brightness settings for different approach lighting systems.

   (9) Use of HUD in conjunction with the sun-visor.
6.0 HUD INITIAL CHECKING REQUIREMENTS

9.1 Upon completion of training, a PIC must be administered an Operators Proficiency Check (OPC) conducted in a CL-605 Level C simulator with a daylight visual display, or CL-605 Level D simulator, or on a Rockwell Collins Model 6605 HUD System equipped CL-605 aircraft. This proficiency check may be taken in conjunction with Skill Test according to Appendix 1 to JAR-FCL 1.240 or may be administered as a separate test.

6.2 Maneuvers to be evaluated during the HUD proficiency check include as a minimum:

   a. One takeoff
   b. One departure procedure
   c. One instrument approach procedure
   d. One missed approach
   e. One landing

6.3 SIC’s should be checked on PNF duties during HUD approaches and emergencies.

7.0 HUD RECURRENT TRAINING REQUIREMENTS

7.1 Selected HUD related ground training subjects as outlined in Paragraph 4.0 above should be reviewed on a recurrent basis.

7.2 As a minimum, selected HUD related flight training maneuvers as listed below should be reviewed on a recurrent basis.

   a. Stall recognition and recovery,
   b. Unusual attitude recovery from decluttered display,
   c. Takeoff with engine failure at V1,
   d. Approach, either precision or non-precision, with missed approach,
   e. Approach (with crosswind, if available) and landing,
   f. Selected abnormal/emergency maneuvers (ex., HUD AFM procedures, approach and landing with OEI, TCAS RA, TAWS escape, etc.)
8.0 HUD RECURRENT CHECKING REQUIREMENTS

8.1 At least annually, in conjunction with a pilot-in command proficiency check required by JAR-FCL 1.245, a PIC must demonstrate proficiency using the Rockwell Collins Model 6605 HUD system by satisfactorily performing the maneuvers listed under paragraph 6.2.

8.2 At least annually, co-pilots should be evaluated on crew resource management (CRM) responsibilities and procedures as the pilot-not-flying (PNF) when the pilot-flying (PF) is conducting HUD operations.

9.0 HUD CURRENCY REQUIREMENTS

PIC’s should have completed at least three takeoffs, approaches, and landings as the pilot flying (PF) using the Rockwell Collins Model 6605 HUD system in the Bombardier Challenger CL-605 airplane, or have completed three takeoffs, approaches, and landings as the PF using the Rockwell Collins Model 6605 HUD system in a CL-605 Level C simulator with a daylight visual display, or CL-605 Level D simulator, within the previous 90 days before acting as the PF using the HUD.

10.0 EASA CONCERN

10.1 EASA has concern regarding HUD during unusual attitude encounters and subsequent recoveries.

10.2 The Unusual Attitude (UA) display (Reference HGS pilot Guide figure 4-12) shows automatically on the Combiner when the aircraft’s attitude is not within the limits of its specified operations. The previous HUD Combiner display shows automatically after the pilot returns the aircraft attitude to its specified ranges for controlled flight.

10.3 The possibility of several automatic changes from normal HUD display to the UA display and vice versa during unusual attitude encounters and subsequent recoveries could be confusing to the PIC and prevent correct recovery procedure to be performed.

11. EASA recommendation:

11.1 Once the HUD Combiner display has entered the UA display, the change back to the previous HUD Combiner display shall not be automatic but should be initiated by the left-seat pilot.
PART 2  ENHANCED VISION SYSTEM (EVS)

1.0  ROCKWELL COLLINS MODEL 6605  
ENHANCED VISION SYSTEM (EVS)

1.1 The European Aviation safety Agency (EASA) participated in an evaluation of the Rockwell Collins Model 6605 Enhanced Vision System (EVS) in August 2009 using a Bombardier Challenger CL-605 Level D simulator and Bombardier Challenger CL-605 aircraft. At Bombardier’s Flight Test facility in Wichita, KS, EASA conducted operations using the EVS to determine non-interference with the use of the Rockwell Collins Model 6605 Head-up Display (HUD), and also to evaluate the situational awareness capabilities of the EVS system.

1.2 EASA found the Rockwell Collins Model 6605 EVS operationally suitable for providing situational awareness for the crew during ground and flight operations. As of the date of this report, the Rockwell Collins Model 6605 EVS is limited to operations in Visual Meteorological Conditions (VMC) and has not been evaluated for suitability during Instrument Meteorological Conditions (IMC), nor for conducting operations in accordance with Annex to Commission Regulation (EC) 859/2008 chapter Appendix 1 (New) to OPS 1.430 (h) (Applies from 16 July 2011).

2.0  PREREQUISITES FOR EVS TRAINING

2.1 As a prerequisite for EVS training, pilots should have successfully completed Rockwell Collins Model 6605 HUD training in the Bombardier Challenger CL-605 Level C or D simulator, or CL-605 aircraft, These EVS requirements assume that a pilot entering an EVS training program is trained and proficient in the use of the Rockwell Collins Model 6605 HUD.

NOTE: This does not preclude the display of the EVS during initial HUD training for purposes of EVS familiarization. However, such familiarization is not creditable toward EVS training as specified in this Appendix.

3.0  EVS TRAINING - GENERAL

3.1 The EVS pilot training requirements consist of those related to initial and recurrent ground and flight training. It should be noted that the HUD and EVS training programs focus principally upon training events flown in the left seat by the Pilot-In-Command (PIC) as the Pilot Flying (PF). Nevertheless, EVS training in the duties of the Pilot Not Flying (PNF) in the right seat is required. PNF EVS familiarization flown in the left seat is recommended.

3.2 Flight crewmember training must be accomplished using a CL-605 Level C simulator with a daylight visual display, or a CL-605 Level D simulator, or a CL-605 aircraft equipped with a Rockwell Collins Model 6605 EVS. EASA has determined that each pilot in command should receive a minimum of 2 hours of EVS ground school training, followed by a minimum of 2 hours of EVS flight
training, in the left seat, in either an approved CL-605 Level C or D simulator or CL-605 aircraft. (The 2 hours of ground and 2 hours of flight training is an initial requirement only.)

4 EVS INITIAL GROUND TRAINING

4.1 The initial ground training program should include the following elements:

   a. Classroom instruction covering EVS operational concepts, crew duties and responsibilities and operational procedures including preflight, normal and abnormal operations, EICAS messages, use of AFMS, QRH, and checklists, and failure modes.

   b. Classroom instruction or Computer Based Training (CBT) on Enhanced Vision System annunciations, effect of environmental conditions on EVS image, and comparison of the EVS HUD imagery to that of the copilot’s Multifunction Display (MFD).

   c. A Rockwell Collins Model 6605 Head-up Guidance (HGS) pilot guide, Model 6605 HUD/EVS Aircraft Flight Manual Supplement (AFMS), or equivalent materials (ex. Flight Crew Operations Manual (FCOM), which explain EVS limitations, modes of operation, EVS annunciations, limit conditions and failures, and which define crew procedures that delineate PF and PNF duties, responsibilities, and call-outs during all phases of flight in which EVS operations are conducted.

4.2 Special emphasis ground training shall be conducted in the following areas:

   a. Crew briefings, coordination, and callouts;
   b. Duties of pilot flying (PF) and pilot not flying (PNF);
   c. EICAS messages and use of QRH and checklists applicable to EVS operations;
   d. Transition from EVS imagery to non-EVS visual conditions. (Maximum use should be made of videos of actual HUD/EVS approaches. The relative luminosity between infrared imagery and that of approach lighting systems should be identified.)
   e. EVS Visual anomalies such as “noise” and “blooming”.
   f. Appropriate use of the Clear Switch;
   g. Importance of the “design eye position in acquiring the proper EVS image;
   h. Importance of cross-checking the HUD instrumentation presentations against the EVS visual scene to enable the pilot to recognize malfunctions of the ground based navigational equipment and improper presentation of elements in the visual scene during an approach;
   i. Instruction in the use of the autopilot with auto-throttle coupled approaches allowing for better pilot monitoring of the EVS image;
   j. Effective and appropriate monitoring by PNF of EVS imagery presented on the MFD.
5.0 EVS INITIAL FLIGHT/SIMULATOR TRAINING

5.1 Unless integrated with initial type rating training, flight training dedicated to EVS familiarization and proficiency is in addition to other required training elements.

5.2 All required approaches utilizing the EVS, should begin no closer than the final approach fix (FAF) for instrument approaches, and should begin no closer than approximately 1,000 feet AGL (3 - 4 NM) to the runway threshold for visual approaches.

5.3 The following EVS flight training program is generic in nature and should be considered as a minimum training requirement only.

   a. Ground Operations:

      (1) Initialization of EVS.

      (2) Taxi using EVS under various lighting and visibility conditions.

   b. Airwork:

      There is no requirement for airwork training using EVS.

   c. Visual Take-offs, Approaches and Landings

      (1) Normal takeoff and landing with crosswind.

      (2) Visual approaches at night with minimal lighting (“black hole” approaches) and use of FPS and Glideslope Reference Line to achieve desired descent angle.

   d. Instrument Approaches:

      Precision and non-precision straight-in approaches to the lowest published minima with missed approaches or landings (VMC day and night conditions).

   e. Abnormal/Emergency Operations: (as appropriate)

      Failure of EVS during approach.

5.4 Special emphasis flight training shall be conducted in the following areas:

   a. Proper use and setting of HUD contrast control and EVS video brightness control for various ambient conditions;

   b. Crew briefings and callouts with emphasis on the duties of the PF and pilot monitoring;

   c. Importance of the “design eye position” in acquiring the proper EVS image;
6.0 EVS INITIAL CHECKING REQUIREMENTS

In that EVS operations are only approved for use during VMC in support of pilot situational awareness, no checking is required.

7.0 EVS RECURRENT TRAINING REQUIREMENTS

7.1 Selected EVS related ground training subjects as outlined in Paragraph 4 above must be reviewed annually and documented in a manner acceptable to the Authority.

7.2 Selected EVS related flight training maneuvers as outlined in Paragraph 5 above must be reviewed annually and documented in a manner acceptable to the Authority. As a minimum, one instrument approach and landing using EVS must be completed.

8.0 EVS RECURRENT CHECKING REQUIREMENTS

In that EVS operations are only approved for use during VMC in support of pilot situational awareness, no checking is required.

9.0 EVS CURRENCY REQUIREMENTS

PIC’s should have completed at least one night takeoff, approach, and landing as the pilot flying (PF) using the Rockwell Collins Model 6605 EVS in a Bombardier Challenger CL-605 airplane, or have completed at least one takeoff, approach, and landing as the PF using the Rockwell Collins Model 6605 EVS in a CL-605 Level C simulator with daylight visual displays, or CL-605 Level D simulator, within the previous 90 days before acting as the PF during EVS operations. The EVS currency requirement may be obtained simultaneously with obtaining the currency requirements for Rockwell Collins Model 6605 HUD (ref PART 1 paragraph. 9.0).