



EUROPEAN AVIATION SAFETY AGENCY



Operational Evaluation Board Report

Rockwell Collins Head-Up Guidance System (HGS) 4200 for Bombardier CRJ Aircraft Models

Report

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Rockwell Collins
Head-Up Guidance System (HGS) 4200
for
Bombardier CRJ Aircraft Models

Operational Evaluation Board (OEB) - OPS / FCL Subgroup



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Acronyms

AFCS	Automatic Flight Control System
AFM	Airplane Flight Manual
AGL	Above Ground Level
AOC	Air Operator Certificate
AOM	Airplane Operations Manual
AP	Autopilot
AT	Auto Throttle
AWO	All Weather Operations
DA	Decision Altitude
EICAS	Engine Indicating and Crew Alerting System
FAF	Final Approach Fix
FCL	Flight Crew Licensing
FCOM	Flight Crew Operating Manual
FD	Flight Director
FMS	Flight Management System
FPS	Flight Path Symbol
FSTD	Flight Simulation Training Device
HC	Head-Up Guidance System Computer
HCP	Head-Up Guidance System Control Panel
HUDLS	Head-up Guidance Landing System
HGS	Head-up Guidance System
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IRS	Inertial Reference System
LPV	Localizer Plus Vertical Guidance
LRU	Line Replaceable Unit
LVTO	Low Visibility Takeoff
OEI	One Engine Inoperative
OHU	Overhead Unit
PIC	Pilot In Command
PF	Pilot Flying
PFD	Primary Flight Display
PNF	Pilot Not Flying
QRH	Quick Reference Handbook
RO	Rollout
RTO	Rejected Takeoff
S/N	Serial Number
T/O	Takeoff
TCAS	Traffic Alert Collision Avoidance System
TOGA	Takeoff Go Around (also TO/GA)
TRTO	Type Rating Training Organization
T/W	Tailwind
VFR	Visual Flight Rules
VNAV	Vertical Navigation
XW	Crosswind (also XW)
YD	Yaw Damper

Preamble

This report provides recommendations on training, checking and currency requirements for the operation of the Rockwell Collins HGS 4200 Dual Head-Up Guidance System on Bombardier aircraft models CL-600-2C10 (CRJ700), CL-600-2D15(CRJ705), CL-600-2D24(CRJ900) and CL-600-2E25 (CRJ1000).

The operation of the CL-600-2B19 (CRJ 100/200) with the HGS 4200 has not been evaluated.

LPV Approaches have not been evaluated.

These recommendations apply to commercial air transport operations. EASA proposes that other operations should also follow these recommendations, as applicable.

Subject to the recommendations contained in this report, EASA found the Rockwell Collins HGS Model 4200 operationally suitable for all Phases of flight and for CAT I,II, IIIa and LVTO operations as addressed in Appendix 1 to Regulation 859/2008 ('EU-OPS') with regard to HUDLS operations.

This evaluation was conducted in compliance with the applicable EASA OEB Handbook and Common Procedure Document (CPD) for conducting Operational Evaluation Boards.

Executive Summary

1. Background

1.1 The European Aviation Safety Agency (EASA) participated in an evaluation of the Rockwell Collins Model 4200 Head-up Guidance System (HGS) in October 2010 using the Bombardier CL-600-2E25 (CRJ 1000), Aircraft Nr. 19991, Registration C-FRJX at Bombardier's Flight Test Center (BFTC) in Wichita, KS.

1.2 The evaluation was carried out jointly by EASA and the FAA, by a team of 5 experts. Participating in this team were:

- Gene Hartman (FAA AEG)
- Pat Morris (FAA Flight Test Branch)
- Paul Mulcahy (EASA Flight Test Pilot)
- Phil Gibbons (EASA, Avionics Expert)
- Joachim Puff (EASA Flight Inspector).

1.3 This report constitutes the recommendations by the EASA OEB.

2. Scope of the evaluation

2.1 This evaluation was conducted for the use of the HGS 4200 on Bombardier aircraft models CL-600-2C10 (CRJ700), CL-600-2D15(CRJ705), CL-600-2D24(CRJ900) and CL-600-2E25 (CRJ1000). This evaluation did not include the operation of the CL-600-2B19 (CRJ 100/200) with a HGS.

2.2 LPV Approaches were not evaluated.

2.3 This OEB report applies to commercial air transport operations. EASA proposes that other operations should also follow these recommendations, as applicable.

3. Results

Subject to the recommendations contained in this report, EASA found the Rockwell Collins HGS Model 4200 operationally suitable for all Phases of flight and for CAT I,II, IIIa and LVTO operations as addressed in Appendix 1 to Regulation 859/2008 ('EU-OPS') with regard to HUDLS operations.

Note on references and reference texts:

Where references are made to requirements and where extracts of reference texts are provided, these are at the amendment state at the date of publication of the report. Readers should take note that it is impractical to update these references to take account of subsequent amendments to the source documents.

GENERAL

4.1 In October 2010, the European Aviation Safety Agency participated in an evaluation of the Rockwell Collins Model 4200 Head-up Guidance System (HGS) with HGS Computer P/N 1500-3250-00X installed in the Bombardier CRJ 1000 Aircraft 19991 at Bombardier's Flight Test Facility in Wichita, KS. The OEB completed numerous HGS approaches and Low Visibility Take Offs at the Wichita Mid-Continent Airport, KICT, using CAT I, II, IIIa and LVTO procedures during daytime only.

4.2 The general information in Chapter 1 of the Airplane Flight Manual (AFM) is applicable with the addition of information contained within the AFM Supplement applicable to HGS operations. The applicable AFMs are CSP B-012 for the CRJ700 and CSP C-012 for the CRJ705/900/1000.

The Rockwell Collins Flight Dynamics Model 4200 Head-Up Guidance System (HGS) is approved for use during all phases of flight. The HGS has been shown to meet requirements for Category IIIa approach, landing and rollout contained in JAA Informational Leaflets HUDS901, HUDS902, HUDS903 and EASA CS-AWO. It also meets the operational requirements contained in EU-OPS.

The EASA minimum landing Runway Visual Range (RVR) demonstrated is 200 meters and for LVTO, RVR demonstrated is 75 meters.

4.3 Test Equipment

The test aircraft was CRJ1000 S/N 19991, with the following configuration:

- Autopilot, IAPS equipment, Electronic Flight Displays and sensors (including IRS) was of, or functionally equivalent to, the latest design standard.
- Conformed HGS LRUs (OHU, Combiner, HCP and Computer) was installed.
- A Head-Up Guidance Computer with production standard software was installed
- The following test equipment had been installed:
 - HGS Video Recording Facility ("HGS Coffin" or similar) with Monitors at Racks 3
 - Rockwell Collins Data Collection Laptop (Rack 3) and connected to HGC via test cable
 - A View Limiting Device to restrict the external vision of the Pilot Flying (Safety Pilot had clear vision at all times).
- Existing external cameras were aimed to provide main landing gear touchdown point coverage with video recording.
- The camera field of view was calibrated in a manner similar to the instructions in Appendix B of RC Flight Test Plan document, 964-3584-001 so that runway touchdown position can be determined.

5. HGS TRAINING

5.1 Training – Prerequisites

Prior training, type rating and currency in the relevant Bombardier CRJ Model is required, unless the HGS training is integrated with, or occurs sequentially preceding an initial type rating skill test.

5.2 Training – General

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

5.2.2 Flight training must be accomplished using a CRJ700/705/900/1000 simulator approved to at least Level C, with a daylight visual display, or in a CRJ700/705/900/1000 aircraft equipped with a Rockwell Collins Model 4200 Head-up Guidance System.

5.2.3 For initial training, EASA has determined that each pilot in command should receive a minimum of 4 hours of HGS ground school training, followed by a minimum of 4 hours of HGS flight training as PF in the left seat.

If the HGS training is integrated with, or occurs sequentially within a type rating training and skill test, a separate initial HGS training and checking is not required.

5.3 Initial Ground Training

5.3.1 The initial HGS ground training programme should include the following elements:

- a. Classroom instruction covering HGS 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 the AFM Supplement applicable to HGS operations, QRH, and checklists, miscompare, and failure flags.
- b. Classroom instruction or Computer Based Training (CBT) on the HGS symbology set and its inter-relationship with airplane aerodynamics, inertial factors, environmental conditions and comparison to the Primary Flight Display (PFD).

NOTE: Actual HGS 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 4200 Head-Up Guidance (HGS) pilot guide, Model 4200 HGS Aircraft Flight Manual Supplement (AFMS), or equivalent materials (i.e. Flight Crew Operations Manual (FCOM), which explain HGS limitations, modes of operation, descriptions of HGS 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 HGS 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 HGS operations.

5.4 Initial Flight/Simulator Training

5.4.1 Unless integrated with the initial type rating training on CL-600-2C10, CL-600-D15 or CL-600-2D24, flight training dedicated to HGS familiarization and proficiency is in addition to other required training elements.

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

5.4.3 The following HGS flight training programme is generic in nature and should be considered as a minimum training requirement only.

a. Ground Operations:

- (1) Deployment of HGS and stowage, including installation and removal of the HGS sun-visor and,
- (2) Taxi using HGS 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 HGS 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, LVTO and Roll Outs

- (1) Approaches to the lowest authorized minima including an approach and landing with OEI, use of Ground Roll Guidance symbology
- (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) TCAS Resolution Advisory,
- (3) HGS failure on approach and its effect on pilot workload and PF/PNF duties and responsibilities,
- (4) Approaches with the aircraft in a non-normal flap configuration.

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

- (1) HGS 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, excessive pitch chevrons, LVTO take off and roll out guidance symbology.
- (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 HGS display and symbology elements, particularly during the landing flare manoeuvre and appropriate conditions to turn OFF the HGS 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) HGS brightness settings for different approach lighting systems.
- (9) Use of HGS in conjunction with the sun-visor.

5.5 Operational Duties and Callouts

HGS operations and Flight operations procedures for the Head-Up Guidance System (HGS) Model 4200 on the Bombardier CRJ700, CRJ705, CTJ900 and CRJ1000 are identical and are contained in Rockwell Collins document *HGS Pilot Guide for the Bombardier CRJ Series Aircraft*.

6. RECOMMENDATIONS

6.1 EASA found the Rockwell Collins HGS Model 4200 operationally suitable for all Phases of flight and for CAT I,II, IIIa and LVTO operations.

6.2 HGS Initial Checking Requirements

6.2.1 Upon completion of training, a pilot-in-command (PIC) must receive a Proficiency Check conducted in a CRJ700/705/900/1000 simulator which is approved to at least Level C, with a daylight visual display, or on a Rockwell Collins Model 4200 HGS System equipped Bombardier CRJ 700/705/900/1000 aircraft. This proficiency check may be taken in conjunction with a Skill Test according to Appendix 1 to JAR-FCL 1.240, or may be administered as a separate test.

6.2.2 Manoeuvres to be evaluated during the HGS proficiency check include as a minimum:

- a. LVTO rejected take-off with ground roll guidance symbology,
- b. LVTO take-off and landing with ground roll guidance symbology,
- c. LVTO with engine failure at or after V1 with ground roll guidance symbology,
- d. CAT IIIa instrument approach and landing with ground roll guidance symbology,
- e. CAT IIIa instrument approach and landing, with OEI with ground roll guidance symbology
- f. missed approach following a CAT IIIa approach,
- g. missed approach following a CAT IIIa with OEI.

6.3 HGS Recurrent Training Requirements

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

6.3.2 As a minimum, selected HGS related flight training manoeuvres as listed below should be reviewed on a recurrent basis:

- a. Stall recognition and recovery,
- b. Unusual attitude recovery from de-cluttered display,
- c. LVTO Take-off with engine failure at or after V1,
- d. CAT I, II, III Approaches with missed approach,
- e. Approach (with crosswind, if available) and landing,
- f. Selected abnormal/emergency manoeuvres (ex., HGS AFM procedures, approach and landing with OEI, TCAS RA, etc.)
- g. Ground Roll Guidance symbology

6.4 HGS Recurrent Checking

6.4.1 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 4200 HGS system by satisfactorily performing the manoeuvres listed under paragraph 6.2.

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

6.4.3 HGS Recurrent Training and Checking when operating variants

The OEB recommends that recurrent training and proficiency checking may be alternated between any of the variants CRJ700/705/900/1000.

6.5 HGS Currency Requirements

6.5.1 Recent experience requirements for HGS operations

When acting as PF using the HGS, the PIC should complete at least three take-offs, approaches, and landings as pilot flying (PF) within the previous 90 days, using the Rockwell Collins Model 4200 HGS system in either:

- a. any of the variants CRJ700/705/900/1000, or
- b. in a CRJ700/705/900/1000 simulator approved to at least Level C, with a daylight visual display.

Note: Any additional recent experience requirements for operating variants must be met.