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GLOBAL POSITIONING SYSTEMS (GPS) FOR USE IN ROTORCRAFT FOR EN-ROUTE NAVIGATION PURPOSES IN OFF-SHORE OPERATIONS BEYOND THE COVERAGE OF CONVENTIONAL NAVIGATION AIDS

1 Applicability

This Specification applies to GPS systems and integrated navigation systems (e.g. RNAV) utilising GPS as a sensor, when installed on rotorcraft for en-route navigation in off-shore operations beyond the coverage of conventional navigation aids. This Specification prescribes minimum performance standards and installation requirements for such systems. All rotorcraft conducting off-shore operations should meet this specification prior to obtaining an operational approval.

In showing compliance with this specification an operator should prepare a document, or complete the compliance checklist given in Annex 2 detailing how the GPS/RNAV installation complies with the Specification.

2 System Approval Requirements

2.1 Installation Criteria

The equipment and its installation should satisfy the following criteria:

NOTE: This criteria is based on EASA AMC20-4. (formerly JAA TGL2, Rev1 and JAA GAI-20X4) for Airworthiness Approval for Basic Area Navigation (BRNAV).

2.1.1 Track Spacing and System Accuracy

A hazard analysis undertaken by Helios Technology Ltd has shown that for en-route operations in the North Sea the track spacing is 4 NM at 80 NM from where ground based navigational aid cover is lost. In order to not exceed this track spacing, a maximum full scale deflection of 1 NM on the aircraft deviation indicator is necessary. To achieve this 1 NM maximum deviation for control and monitoring of flight technical error, the GPS/RNAV equipment should be operated in the terminal mode. .

The navigation performance of the rotorcraft should have a track keeping accuracy equal to or better than +/- 1 NM for 95% of the flight time. This value includes signal source error, airborne receiver error, display system error and flight technical error.

This navigation performance assumes the necessary coverage provided by the satellites is available for the intended route to be flown.

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2.1.2 **Availability and Integrity**

Display of navigation information (excluding heading, airspeed, and clock data) in the cockpit is an essential function. The loss of all navigation information should be Remote (less than 10^{-5} per flight hour). Displaying hazardously misleading navigational or positional information on both pilots' displays for en-route flight should also be Remote (less than 10^{-5} per flight hour).

The minimum level of availability and integrity required for GPS systems or RNAV with integral GPS, to be used in en-route off-shore operations can be met by a single installed system comprising one or more sensors, GPS or RNAV computer (with GPS sensor), control display unit and navigation display(s) (e.g. ND, HSI or CDI). This assumes that the system is monitored by the flight crew and that in the event of a system failure there is an approved operational procedure, and that the availability of GPS integrity (RAIM) is first confirmed for the intended flight.

2.1.3 **Functional Criteria**

a) **Required Functions**

The following system functions are the minimum required to conduct en-route operations in an off-shore environment:

i) Continuous indication of rotorcraft position relative to track ($\pm$ 1 NM Full Scale Deflection) to be displayed to the pilot flying on a navigation display situated in his primary field of view.

In addition where the minimum flight crew is two pilots, indication of rotorcraft position relative to track to be displayed to the pilot not flying on a navigation display situated in his primary field of view.

ii) Display of distance and bearing to the active (To) waypoint.

iii) Display of ground speed or time to the active (To) waypoint.

iv) Storage of waypoints; minimum of 4.

v) Appropriate failure indication of the GPS system, or RNAV system including the sensors (e.g. fail flag, message alert with indication of associated message on GPS/RNAV control unit).

b) **Recommended Functions**

In addition to the requirements of paragraph 2.1.3 a), the following system functions and equipment characteristics are recommended:

i) Autopilot and/or Flight Director coupling

ii) Present position in terms of latitude and longitude

iii) "Direct To" function

iv) Indication of navigation accuracy (e.g. quality factor)

v) Automatic channel selection of radio navigation aids

vi) Navigation database

vii) Automatic leg sequencing and associated turn anticipation

viii) Input of pressure altitude to GPS or RNAV equipment (see paragraph 2.3.2 a))

ix) An automatic dead reckoning (DR) facility to mitigate flight crew workload in the event of no GPS position fix being available.

2.1.4 **Rotorcraft Flight Manual - MMEL (Master Minimum Equipment List)**

The basis for certification should be stated in the Rotorcraft Flight Manual (RFM), together with any GPS/RNAV system limitations. The RFM should also provide the appropriate GPS/RNAV system operating and abnormal procedures applicable to the equipment installed, including, where applicable, reference to required modes and systems configuration necessary to support an RNP capability.

The (Master) Minimum Equipment List MMEL/MEL should identify the minimum equipment required for dispatch to satisfy the criteria defined in paragraphs 2.1.1, 2.1.2 and 2.1.3 a)

2.1.5 **Acceptable Means of Compliance**

GPS/RNAV systems which are installed on rotorcraft in accordance with the advisory material contained within EASA AMC20-4 (JAA TGL2 Rev 1 or JAA GAI-20 ACJ 20X4), FAA AC 90-45A, AC 20-130(), AC 20-138 or AC 25-15, are acceptable for en-route operations in an off-shore environment. Where reference is made in the RFM to either the above advisory material or the specific levels of available navigation performance (RNP), no further compliance statements to section 2 of this Specification will be required.

Compliance may be based also on the lateral navigation standards defined in FAA TSO-C115(), ETSO-C129(), FAA TSO-C129( ), or RTCA DO-187/ED-58. However, qualification of the equipment to these standards, in itself, is not considered as sufficient for the airworthiness approval. To obtain the airworthiness approval the installer should have shown compliance with the appropriate airworthiness requirements of the rotorcraft (e.g. JAR (CS)27, JAR(CS) 29 or BCAR Section G).

2.2 **Limitations for En-route Off-shore Operations**

The GPS or RNAV systems incorporating GPS sensors, although offering an RNAV capability, have limitations for their use in off-shore operations. These are outlined below:

2.2.1 **GPS**

The use of GPS to perform off-shore en-route operations is limited to equipment approved to ETSO-C129 () or FAA TSO-C129 () and which include the minimum system functions specified in paragraph 2.1.3 a). Integrity should be provided by Receiver Autonomous Integrity Monitoring (RAIM) or an equivalent means within a multi-sensor navigation system. The equipment should be approved in accordance with the AMC20-5 (Formerly JAA TGL 3, or JAA GAI-20 ACJ 20X5). In addition, GPS stand-alone equipment should include the following functions:

a) Pseudo-range step detection

b) Health word checking.

These two additional functions are required to be implemented in accordance with FAA TSO-C129a criteria.

Traditional navigation equipment (e.g. VOR, DME and ADF) will need to be installed and be serviceable, so as to provide the means of navigation when flying in areas offering coverage of these navigation aids.

NOTE: Where GPS stand-alone equipment provides the only RNAV capability installed onboard the aircraft, this equipment, on its own, may be incompatible with a future airspace infrastructure such as Precision RNAV routes, terminal procedures, and where implementation of an augmented satellite navigation system will allow, the decommissioning of traditional ground based radio navigation aids.

2.3 Guidance for Operational Approval of GPS Equipment

2.3.1 General

GPS equipment approved in accordance with this Specification, may be used for en-route purposes in off-shore operations, subject to the operational limitations contained herein. Such equipment should be operated in accordance with procedures acceptable to the Authority (paragraph 5 refers). The flight crew should receive appropriate training in the use of GPS based equipment for the normal and abnormal operating procedures detailed in paragraphs 2.3.2 and 2.3.3.

2.3.2 Normal Procedures

The procedures for the use of navigational equipment on off-shore routes should include the following:

a) During the pre-flight planning phase, given a GPS constellation of 23 satellites or less (22 or less for GPS stand-alone equipment that incorporate pressure altitude aiding), the availability of GPS integrity (RAIM) should be confirmed for the intended flight (route and time). This should be obtained from a prediction program either ground-based, or provided as an equipment function (see Annex 1), or from an alternative method that is acceptable to the Authority.

Dispatch should not be made in the event of predicted continuous loss of RAIM of more than 5 minutes for any part of the intended flight.

b) Where a navigation data base is installed, the data base validity (current AIRAC cycle) should be confirmed before the flight.

c) All previous waypoints manually generated by the crew to be deleted.

d) Traditional navigation equipment (e.g. VOR, DME and ADF) should be selected to available aids so as to allow immediate cross-checking or reversion in the event of loss of GPS navigation capability.

2.3.3 Abnormal Procedures in the event of loss of GPS navigation capability

The operating procedures should identify the flight crew actions required in the event of the GPS stand-alone equipment indicating a loss of the integrity monitoring detection (RAIM) function or exceedance of integrity alarm limit (erroneous position). The operating procedures should include the following:

a) In the event of loss of the RAIM detection function, the GPS stand-alone equipment may continue to be used for navigation. The flight crew should attempt to cross-check the aircraft position, with VOR, DME,NDB or dead reckoning information, to confirm an acceptable level of navigation performance.If an acceptable level of navigation performance cannot be confirmed, the flight crew should revert to an alternative means of navigation.

b) In the event of exceedance of the alarm limit, the flight crew should revert to an alternative means of navigation.

3 Other Considerations

3.1 Rotor Effects

3.1.1 A CAA research study has shown that a helicopter's main or tail rotors can interfere with and affect the GPS signals being received by the antenna. Therefore, it is important to establish the acceptability of the location of the GPS antenna on the rotorcraft. The results of this study are given in CAA Paper 2003/7 "Effect of Helicopter Rotors on GPS Reception."

3.1.2 When installing a GPS antenna in a new location, the organisation designing the installation should assess this CAA Paper and show that with the rotors turning the GPS reception at the receiver is not significantly affected, and satellites are not lost due to the rotors. The organisation should justify and agree the position with the authority. If the rotors significantly affect the performance, the antenna should be relocated.

As existing installations have previously been approved and under EASA are approved throughout the countries of the European Union, no reassessment is considered necessary. If the operator or the authority suspects there are problems with the antenna installation, then further investigation work may be necessary.

NOTE: It is appreciated that the Research study used laboratory test equipment that may not be available to many organisations. However an adequate test may be accomplished by reviewing the Navigation pages of the GPS or RNAV system, and by cross reference to a GPS constellation simulator that can identify the satellites that the receiver should be tracking at a given location and time of day. The test procedure to be used should be agreed with the Authority in advance.

3.2 Overall System Performance

3.2.1 Extensive research conducted by CAA (see CAA Papers 2000/05 and 2003/02) has indicated that the availability of an integrity assured navigation solution may be inadequate in some instances, or may become so in the future with changes in the GPS constellation. For these reasons, and in accordance with ICAO recommendations (ref. ICAO Annex 10 paragraph 2.4.3.1), the status of the RAIM available (loss of RAIM) flag should be recorded and analysed on a continuous basis in service to confirm that the requirements of paragraph 2.1.2 are, and continue to be, met.

3.2.2 Monitoring of RAIM availability should be performed on at least a representative sample of the operator's fleet, and may be conveniently accomplished using the Flight Data Measurements facility in the Helicopter Operations Monitoring Programme (HOMP) - see CAA Paper 2002/02.

4 Continued Airworthiness and Maintenance Issues

Consideration should be given to the GPS/RNAV system for continued airworthiness requirements, and the appropriate instructions for inclusion in the maintenance manuals. The assessment should consider but not be limited to:

a) GPS Antenna bonding

b) GPS Antenna Erosion

c) Antenna Coax cable inspection.

d) Database loading procedures.

5 Operational Issues

Notwithstanding the airworthiness aspects contained within this CAA Specification, the use of GPS in en-route off-shore operations is subject to compliance with mandatory operating procedures. Details of operational approval can be obtained from CAA Flight Operations Department:

Safety Regulation Group
Flight Operations Policy
1W, Aviation House
Gatwick Airport South
W Sussex
RH6 0YR.

Tel : 01293-573520 Fax: 01293-573991

ANNEX 1

GPS Integrity Monitoring (RAIM) Prediction Program

Where a GPS Integrity Monitoring (RAIM) Prediction Program is used as a means of compliance with paragraph 2.3.2 a) of this document, it should meet the following criteria:

1 The program should provide prediction of availability of the integrity monitoring (RAIM) function of the GPS equipment, suitable for conducting Basic RNAV operations in designated European airspace.

2 The prediction program software should be developed in accordance with at least RTCA DO 178B/EUROCAE 12B, level D guidelines.

3 The program should use either a RAIM algorithm identical to that used in the airborne equipment, or an algorithm based on assumptions for RAIM prediction that give a more conservative result.

4 The program should calculate RAIM availability based on a satellite mask angle of not less than 5 degrees, except where use of a lower mask angle has been demonstrated to be acceptable to the Authority.

5 The program should have the capability to manually designate GPS satellites which have been notified as being out of service for the intended flight.

6 The program should allow the user to select:

a) the intended route and declared alternates

b) the time and duration of the intended flight

7 Alternatively the operator may use the ECAC Augur tool available on :

http://augur.ecacnav.com

Annex 2

Compliance Checklist

In respect of a specification compliance checklist submitted by, or on behalf of an operator.

Rotorcraft Type: .....Reg'n: .....

Spec Paragraph	Title/Detail	Means of Compliance
2.1.1	Accuracy	
2.1.2	Availability and Integrity	
2.1.3 a)	Required Functions	
2.1.3 b)	Recommended Functions	
2.1.4	RFM and MMEL	
2.1.5	Acceptable Means of Compliance	
2.2 /2.2.1	Limitations on the Use of GPS	
2.3.1	Guidance for Operational Approval for the Use of GPS Equipment (General)	
2.3.2	Normal Procedures	
2.3.3	Abnormal Procedures	
3.1	Rotor Effects New Antenna Installations	
3.2	Overall System Performance	
4	Continued Airworthiness/ Maintenance Considerations	
5	Operational Issues	

Prepared by .....(Print Name)

....(Signature)

Approved by .....(Print Name)

....(Signature)

Organisation .....

Design Approval Number (BCAR/DOA) .....