بسم الله الرحمن الرحيم

CIVIL AVIATION DEPARTMENT
Ministry of Transport and Civil Aviation
Male'
Republic of Maldives

AIR SAFETY CIRCULAR

No. OPS 16
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Global Navigation Satellite System Operations

1.0 Applicability

1.1 This Air Safety Circular prescribes the conditions and requirements for the use of GNSS equipment under Instrument Flight Rules (IFR).

1.2 The conditions and procedures contained in this Air Safety Circular are additional to any other applicable requirements specified in Civil Aviation Regulations (CAR), Maldivian Airworthiness Requirements (MARs) and Air Safety Circulars (ASCs).

2.0 Purpose

2.1 The purpose of this ASC is to inform the operators engaged in IFR operations in the Maldives of the requirements for the use of Global Positioning System (GPS) as an approved IFR Supplemental Means Navigation System and as a Primary Means Navigation System for Enroute and Non-Precision Approaches.

2.2 This ASC constitutes the approval for the use of a GPS system, fitted and operated in accordance with the provision of references in 1.2, within Male' Flight Information Region only.

3.0 Background

3.1 GPS approaches can only be flown with a TSO C-129 A1 receiver. Non TSO equipment does not provide the required level of intergrity protection, CDI scaling and alarm indications.

4. Glossary

The following are explanations of terms relevant to this Air Safety Circular:

GPS database: an electronic memory containing information on airports, Navigation Aids, Reporting Points, Standard Instrument Departures, Standard Instrument Arrivals, Instrument Approaches, Special Use Airspace and other items of value to the pilot.

GLONASS: Russian segment of GNSS.

GNSS: Global Navigation Satellite System.

GPS: Global Positioning System.

GPS sensor: a single GPS unit used for navigation within a Flight Management System (FMS).

NANU: Notice Advisory to NAVSTAR User (GPS NOTAM).

CDI: Course Deviation Indicator.

Primary-means Navigation System: a navigation system approved for a given operation or phase of flight that must meet accuracy and integrity requirements, but need not meet full availability and continuity of service requirements. Safety is achieved by limiting flights to specific time periods, and through appropriate procedural restrictions.

RAIM (Receiver Autonomous Integrity Monitoring): a function whereby the airborne GPS receiver/processor detects a position error that exceeds the GPS position integrity performance requirements of the TSO for that phase of flight. It gives a visual and/or aural warning when appropriate.

RAIM Warning (RAIM not available message): a warning that the integrity of the navigation position solution from GPS satellites may be unreliable.

Sole-means Navigation System: a navigation system approved for a given operation or phase of flight that must allow the aircraft to meet for that operation or phase of flight, all four navigation system performance requirements; accuracy, integrity, availability, and continuity of service.

Integrity: The quality which relates to the trust that can be placed in the correctness of information supplied by a system. It includes the ability of a system to provide timely warnings to users when the system should not be used for navigation.

Supplemental-means Navigation System: A navigation system that must be used in conjunction with a sole means navigation system.

Initial Approach Waypoints usually a selection of three points that allow flying of the approach without use of a sector entry procedure. The initial point marks the start of the approach.

Intermediate Waypoint ; the waypoint at which alignment with the final approach course is achieved.

Final Approach Waypoint ; the point where the receiver has completed transition to the approach mode (CDI scale and RAIM tolerance goes to 0.3 nm)

Missed Approach Waypoint: the MAP of the approach is normally at the runway threshold. The missed approach mode must be manually selected at or prior to this point for the receiver to give missed approach tracking information. On selection, the receiver CDI scale and RAIM to tolerance reverts to 1.0 nm.

Intermediate, Final and Missed Approach Segments can only be flown in that sequence.

5. Pilot Qualification

5.1 A pilot-in-command shall not carry out an instrument approach procedure under IFR using a GPS receiver unless they have had certified in their pilot's logbook by a flight examiner that they have satisfactorily demonstrated competency in the use of that make and model of GPS receiver, including any flight management systems used for GPS instrument approach. Pilot training syllabus for use of GPS is attached in the Appendix-A. part II

5.2 The certification entered in the pilot's personal logbook shall be in the form specified below:

> Form: XY Jones has satisfactorily completed a course of ground Instruction in GPS principles and operation in accordance with the syllabus contained in Appendix-A, part II of ASC OPS 16 and I consider him/her competent in the operation of ..... type of GPS equipped for the purpose specified in .....
>
> AB Smith (ARN .....) 31 December 1998

5.3 A flight examiner shall endorse a pilot's log book for a make and model of GPS receiver or flight management system if the pilot has satisfactorily completed a flight test demonstrating his/her knowledge and competency, on a GPS non-precision approach procedure to a standard acceptable to the Director, using that GPS receiver or Flight Management System (FMS).

6. Airworthiness Requirements

The following Airworthiness requirements must be satisfied:

a. GPS receivers must be installed in all Maldivian registered aircraft engaged in IFR operations.

b. GPS navigation equipment used for IFR must be certified in accordance with FAA (Technical Standard Order) TSO C-129 A1.

c. GPS modifications intended for IFR operations shall be approved by the Director.

d. The equipment shall be installed in a position where its controls that are normally adjusted in flight are readily accessible and properly labeled as to their function.

e. Any interface with other aircraft equipment shall be designed such that normal or abnormal navigational equipment operation is not adversely affected by the operation of other equipment, nor shall normal or abnormal operation of other equipment adversely affect the RNAV equipment operation.

f. The display screen shall be located in the normal visual scan of the pilot, such that all display and controls are readable under all normal cockpit conditions (total darkness to bright reflection of sunlight). All displays and controls shall be arranged to facilitate equipment usage.

g. GPS Flight Evaluation form shall be submitted for approval of its use on IFR flights and a further evaluation will be required for the C of A. Flight Evaluation form is attached in Appendix C1

7. Operational Requirements

The following operational requirements must be satisfied:

a. Operating instructions for GPS navigation equipment must be:

i) carried onboard.

ii) incorporated into the Operations Manual for commercial operations.

b. GPS navigation equipment must be operated in accordance with the operating instructions, and any additional requirements specified in the approved aircraft flight manual or flight manual supplement.

c. In addition to GPS, aircraft must be equipped with serviceable radio navigation systems as specified in MAR Series C9 and the Minimum Equipment List (MEL) for that aircraft.

d. GPS must not be used to satisfy any of the alternate requirements of CAR, MARs or ASCs.

e. ATC may require GPS equipped aircraft to establish on, and track with reference to a particular VOR radial or NDB track for separation.

f. GPS must not be used as a navigation reference for flight below the MSA, except as provided in 11.51 and 11.52 of CAR or as otherwise authorised by the Director.

8. Operation without RAIM

8.1 GPS systems normally provide three modes of operation:

a. Navigation (Nav) Solution with RAIM.

b. 2D or 3D Nav Solution without RAIM.

c. Dead Reckoning (DR), or Loss of Nav Solution

8.2 ATS services, and in particular ATC separation standards, are predicated on accurate navigation and position fixing. If RAIM is lost, the accuracy of the system is assumed not to meet the required standard for both navigation and application of ATC separation. Accordingly, when RAIM is lost, the following procedures must be adopted:

a. Aircraft tracking must be closely monitored against other on board systems.

b. In controlled airspace, ATC must be advised if:

i. RAIM is lost for periods greater than 10 minutes, even if GPS is still providing positional information; or

ii. RAIM is not available when ATC request GPS distance, or if an ATC clearance or requirement based on GPS distance is imposed; or

iii. the GPS receiver is in DR mode, or experiences loss of navigation function, for more than one minute; or

iv. indicated displacement from track centreline is found to exceed 2nm.

ATC may then adjust separation.

c. If valid position information is lost (2D and DR mode), or non RAIM operation exceeds ten minutes, the GPS information is to be considered unreliable, and another means of navigation should be used until RAIM is restored and the aircraft is re-established.

d. Following re-establishment of RAIM, the appropriate ATS unit should be notified of RAIM restoration prior to using GPS information. This will allow ATC to reassess the appropriate separation standards.

e. When advising ATS of the status of GPS, the phrases “RAIM FAILURE” OR “RAIM RESTORED” must be used.

9. Sole Means GPS Operations

A person shall not operate an aircraft under IFR using a sole means navigation system, which uses only GPS sensors, within the Maldives Flight Information Region (FIR).

10. Primary Means of GPS Operations

Each person operating an aircraft under IFR using GPS equipment as a primary means navigation system shall:

a. ensure that: the GPS equipment is approved to level TSO C-129-A1;

b. operate the GPS equipment in accordance with the aircraft flight manual or aircraft flight manual supplement.

c. ensure, if the aircraft is operating within the Maldivian Flight Information Region (FIR), that the aircraft is equipped:-

i. for air transport operations, with at least 2 operable sole means navigation systems other than GPS receivers. The sole means navigation systems must be appropriate for the route being flown;

ii. for operations other than air transport operations, with at least one operable sole means navigation system other than GPS receiver. The sole means navigation system must be appropriate for the route being flown.

d. if intending to use a GPS based instrument approach procedure, obtain a RAIM prediction prior to departure for the expected time of arrival at the destination:-

i. using onboard GPS receiver; or
ii. from Air Traffic Services, and

e. ensure that en-route and terminal navigation is conducted:-

i. using a GPS database containing data that is current with respect to the current en-route and area charts applicable to the route being flown; and

ii. by cross checking each GPS database selected track and distance between reporting points, for accuracy and reasonableness by reference to current en-route and area charts; and

f. ensure all GPS instrument approaches are accomplished in accordance with approved instrument approach procedure using a GPS database containing data that is current with respect to the current published Instrument Approach Chart for the approach procedure being flown; and

g. if, when operating in the en-route phase, a RAIM warning has been displayed for more than ten minutes, or the GPS equipment has operated in the DR mode for more than one minute:-

i) advise the appropriate controlling ATC service; and

ii) verify the aircraft position every 10 minutes using another IFR approved navigation system; and

h. not commence an instrument approach while a RAIM warning is displayed; and

i. ensure that:-

i) the alternate is served by a fully operational radio navigation aid with a promulgated instrument approach procedure based on other than GPS navigation; and

i). the aircraft is equipped with navigation equipment capable of using that radio navigation aid.

11. Supplemental Means GPS Operations

11.1 No person shall operate an aircraft using a GPS receiver that does not comply with the requirements of paragraph 6.0 for navigation under IFR.

11.2 When operating under IFR, a person may only use a GPS receiver that does not comply with the requirements of paragraph 6.0 for providing supplementary information.

12. Documentation Requirements

12.1 The operator shall retain copies of the following documents

a. Operating instructions

b. Equipment limitations

c. Installation procedures and limitations (including any necessary sensor interface restrictions for Class B equipment)

d. Schematic drawings as applicable to the installation procedure.

e. Wiring diagrams as applicable to installation procedure.

f. Specifications.

g. List of major components (by part number) that make up the equipment system complying with the standards prescribed in this ASC.

12.2 The following documents shall be produced to CAD

a. Manufacturer's TSO qualification test report.

13. GPS Derived Distance Information

13.1 A pilot-in-command of an aircraft operating under IFR using GPS equipment as a primary means navigation system shall not provide GPS derived distance information if RAIM is currently unavailable and has been unavailable for the preceding 10 (ten) minutes.

13.2 The pilot shall, when providing distance information that is GPS derived, state the distance as a GPS Distance relative to a specified reference point that is contained in the GPS database.

13.3 A pilot shall not use GPS derived distance information on an ILS/DME or VOR/DME or NDB/DME instrument approach procedure.

14. Minimum Flight Altitude

Not withstanding the minimum flight altitude promulgated under this Rule, the minimum flight altitudes for an aircraft operating under IFR using GPS equipment as a Primary Means Navigation System or Supplemental Means Navigation System shall be:-

a. those assigned by an air traffic control clearance; or

b. for published routes shown on En-route, AREA Charts, the lowest altitude appropriate to the IFR table of cruising level that is:-

i) at or above the route Minimum Sector Altitude (MSA); and
ii) at or above a limiting minimum crossing altitude; and

15. Integrity and Interference Data Sheets

15.1 Operators or pilots using GPS for the purpose stated at paragraph 2.0 of this ASC are requested to provide GPS system information, as detailed below;

a. Private operators are requested to submit information on GPS interference as it occurs.

b. Commercial operators are requested to submit integrity reports to the first 30 flights after installation of approved GPS equipment. After this period, operators are requested to monitor and record the performance of GPS, and provide details of the system accuracy and reliability from time to time. In addition to these reports, operators are requested to submit information on GPS interference as it occurs.

15.2 Pilots should particularly note cases of GPS degradation / interference around airports, over populated areas, near radio or television transmission towers, and during radio or SATCOM transmit operations.

15.3 Data should be entered on System Varification Data Sheet, copies of which are available from the Civil Aviation Department, or may be copied from the attached Appendix-B.

16. Flight on Unevaluated Routes

A pilot-in-command of an aircraft operating within the Male' Flight Information Region under IFR using GPS equipment as a primary means navigation system is permitted random flight routing if operating;

a) at or above 2000 ft, and

b) authorised by ATC.

17. Flight Plans

17.1 A pilot-in-command shall only operate an aircraft under IFR using GPS equipment as a Primary Means Navigation System if the letter "G" is inserted in the block item 10 on the flight plan form published from ATS, Maldives Airports Authority (MAA).

17.2 No person shall enter the letter "G" in the block item 10 on the ICAO flight plans unless the requirement are complied with.

Mahamood Razee
DIRECTOR OF CIVIL AVIATION

Pilot Training Syllabus

I) Training syllabus for use of GPS equipment incorporating both GPS sensor and navigation capability.

Purpose: The purpose of this appendix is to prescribe the subject matter considered essential for the satisfactory operation of stand alone GPS receivers in operations conducted under Instrument Flight Rules.

1. GPS System Components and Principle of Operation.

Demonstrate an understanding of the GPS system and its principles of operation:

GPS system components, constellation, control and user.
Aircraft equipment requirements.
GPS satellite signal and pseudo random code.
Principle of position fixing.
Method of minimising receiver clock error.
Minimum satellites required for navigation functions.
Masking function.
Performance limitations of various equipment types.
GPS use of WGS84 co-ordinate system.

2. Navigation System Performance Requirements

Define the following terms in relation to a navigational system, and recall to what extent the GPS system meets the associated requirements:

Accuracy.
Integrity:
Means of providing GPS Integrity; RAIM; procedural systems integration.
Availability.
Continuity of service.

3. Authorisation and Documentation.

Recall the requirements applicable to pilots and equipment for GPS operations:

Pilot training requirements.
Log book certification.
Aircraft equipment requirements.
GPS NOTAM.

4. GPS Errors and Limitations.

Recall the cause and magnitude of typical GPS errors:

Ephemeris.
Clock.
Receiver.
Atmospheric/Ionospheric.
Multi-path.

SA
Typical Total error associated with C/A code.
Effect of PDOP/GDOP on position accuracy.
Susceptibility to interference.
Comparison of vertical horizontal errors.
Tracking accuracy and collision avoidance.

5. Human Factors and GPS.

Be aware of the human factors limitations associated with the use of GPS equipment. Apply GPS operating procedures which provide safeguards against navigational errors and loss of situational awareness due to these causes:

Mode errors.
Data entry errors.
Data validation and checking including independent cross checking. procedures.
Automation induced complacency.
Non-standardization processing and situational awareness.

6. GPS Equipment- Specific Navigation Procedures.

Recall and apply knowledge of appropriate GPS operating procedures to typical navigational tasks using a specific type of aircraft equipment.

Select appropriate operational modes.
Recall categories of information contained in the navigational database.
Predict RAIM availability.
Enter and check user defined waypoints.
Enter/retrieve and check flight plan data.
Interpret typical GPS navigational displays LAT/LONG, distance and bearing to way point, CDI.
Intercept and maintain GPS defined tracks.
Determine TMG, GS, ETA, time and distance to WPT, WV in flight.
Indications of way point passage.
Use of direct to function.
Use of nearest airport function.
Use of GPS in GPS and DME/GPS arrival procedures.

7. GPS Equipment Checks.

For the specific type of aircraft equipment, carry out the following GPS operational and serviceability checks at appropriate times:

TSO status.
Satellites acquired.
RAIM status.
PDOP/GDOP status.
IFR Database currency.
Receiver serviceability
CDI sensitivity.
CDI sensitivity.
Position Indication.

8. Warning and Messages
For the specific type of aircraft equipment, recognise and take appropriate action for GPS warnings and messages, including the following:

Loss of RAIM.
2D navigation.
In Dead Reckoning mode.
Database out of date.
Database missing.
GPS fall.
Barometric input fail.
Power/battery fall.
Parallel offset on.
Satellite fails.

II) Pilot training syllabus for use of GPS equipment where the GPS receiver is one sensor of a multi-sensor navigation system.

1. Purpose: The purpose of this appendix is to prescribe the subject matter considered essential for the satisfactory operation of Flight Management System incorporating a GPS sensor when used in operations conducted under Instrument Flight Rules.

2. Objective. The objective of the training is to ensure that the pilot can

(a) demonstrate satisfactory knowledge of:

i) GPS system components, constellation, control and user;
Aircraft equipment requirements.
The composition of the satellite constellation.
Minimum number of satellites required for 2D and for 3D navigation.
The basic concept of satellite ranging.
The type of code used.
Method of elimination of clock error.
Masking function.
The effect of earth ionosphere on the accuracy of GPS signals.
The WGS84 datum and the effect of using any other datum.

ii) navigation system performance requirements, the extent to which GPS meets these requirements and any method of achieving acceptable levels of performance.

iii) the human factors applicable to the use of GPD and how errors may be reduced or eliminated.

iv) demonstrate the ability to satisfactorily predict RAIM availability.

(b) carry out the following operational and serviceability checks and appropriate times:

i) TSO status, including class of approval and its significance.
ii) Satellites acquired and if available, serviceability checks at the appropriate times.

iii) RAIM status.
iv) PDOP/GDOP status.
v) if available, current likely position error.
vi) database currency.
vii) receiver serviceability.
viii) CDI sensitivity.
ix) position indication, including, if available;

c. recognise and take appropriate action for GPS warnings and messages, where provided and appropriate, including:

i. loss of RAIM.
ii. 2D navigation.
iii. In Dead Reckoning (DR) mode.
iv. Database out of date.
v. GPS fail.
vi. barometric input fails.
vii. “power offset on”.
viii. “satellite fail”.

Global Positioning System (GPS) System Verification Data Sheet

A. GENERAL

Name: ----------Company: ----------

Address:----------

Telephone/Facsimile:----------

(Address is only used in the event of clarification. Please report each occurrence separately)

Make and type of receiver and any special features in use at the time that may have affected its performance:----------

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B. INTERFERENCE REPORT

Purpose for which GPS was being used (survey, navigation, etc.) and its mode of use (e.g.: stationary vehicle, at sea, aircraft in flight, etc.):

Location of receiver antenna (e.g.: remote mounted on vehicle):

Date, time and nature of GPS malfunction and variation with time/distance travelled:

Geographical location of malfunction (map reference or Lat/Long):

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description of location (e.g.: town, airfield) noting any potential sources of interference (e.g.: satellite signals shadowed from rising ground, reflections from other sources):

Did you try to establish a cause for the malfunction? If so, what did you do, and what were your conclusions?:

C. INTEGRITY / RAIM LOSS REPORT

RAIM Mode: Enroute/Terminal/Approach	Date and Time	Period of Loss	Location

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APPENDIX-C1

CIVIL AVIATION DEPARTMENT
MINISTRY OF TRANSPORT AND CIVIL AVIATION
Male'
Republic of Maldives

FLIGHT EVALUATION SCHEDULE

For GPS IFR Approval

Aircraft Descriptions | 8Q

GPS Description Manufacturer | Model | TSO-C129 Class

Modification Details

Modification Number | STC Number | CAD Approval Number

Flight Manual Supplement AIR No. | Supplement No. | Date

Flight Evaluation Details

Date of Flight Evaluation | Location

Name of Pilot | Name of Observer

I *(Name)* ..... certify that 8Q -..... meets the requirements of *(insert reference)* and that the GPS installationis suitable for IFR enroute/non-precision approach navigation.

Signature..... Date: .....

Delete as applicable

CAD Use Only

GPS Approved for enroute/non-precision approach* IFR

Signature..... Date: .....

Flight Evaluation Checklist	Comments	✓ ✗ N/A
1. Evaluation of all operating modes of the GPS equipment. Particular attention should be given to mode switching and transition requirements associated with the approach mode for class A1 equipment. Refer also to Item 15.		
2. Evaluation of the interface (function) of other equipment connected to the GPS equipment.		
3. Review of various failure modes and associated annunciations such as loss of electrical power, loss of signal reception, GPS equipment failure, auto-pilot / flight director response to GPS flags, etc. Detail how the losses were initiated and the responses.		
4. Evaluation of steering response while autopilot and/or flight director is coupled to the GPS equipment during a vaiety of different track and mode changes. This evaluation shall include, as applicable, transition from en route to approach transition to approach modes and vice versa. Additionally, all available display sensitivities shall be evaluated.		
5. Evaluation of displayed GPS navigation parameters on interfaced cockpit instruments such as HSI, CDI, distance display, electronic flight instruments system (EFIS), moving maps, fuel management systems, etc.		
6. Assessment of all switching and transfer functions, including electrical bus swiching, pertaining to the GPS installation. Detail the functions evaluated and the responses.		
7. Evaluation to determine satisfactory EMC between the GPS installation and other onboard equipment (this test maybe accomplished as a ground test.)		
8. Evaluation of the accessibility of all controls pertaining to the GPS installation.		
9. Evaluation of the accessibilityof all controls, displays, and annunciators relating to the GPS installation during day and night lighting conditions. No distracting cockpit glare or reflections may be introuduced and all controls must be illuminated for identification and ease of use. Night lighting shall be consistent with other cockpit lighting.		
10. Evaluation of crew workload when operating the GPS equipment in association with other piloting requirements.		
11. Demonstrate GPS navigational performance has not been adversely affected by the installation in the aircraft.		

Flight Evaluation Checklist	Comments	✓ ✗ N/A
12. Validate GPS accuracy in each operating mode by at least 5 low altitude overflights of one or more surveyed locations (ensure surveypoint coordinates are relative to WGS-84). List locations used, WGS84 co-ordinates and GPS determined positions: 1. ..... 2. ..... 3. ..... 4. ..... 5.		
13. Verify continuity of naviagation data during normal aircraft manoeuvring, including holding patterns and turns at up to at least 30 degrees of bank for one minute. Give location(s) at which these manoeuvres were conducted:		
14. Verify that flight technical error (FTE) can be maintained at less than 2.0 NM for en route, 1.0 NM for approach transition, and 0.25 NM for approach modes on a 95 percent basis.		
15. Class A1 equipment, conduct a sufficient number of approaches using the navigation data base to verify the proper operation of annunciations, waypoint squencing, and display sensitivity changes in accordance with the requirements specified in TSO-C129. This demostration shall include procedure turns, holding patterns, and missed approaches. List the approaches conducted, whether a missed approach followed, pilot evaluation of accuracy at MAP and of missed approach procedure.		