



# **EAC**

## **No. 21\_2**

**TABLE of CONTENTS**

<b>ITEM</b>	<b>TITLE</b>
<b><u>EAC21-2:</u></b>	<b><u>Portable Global Positioning System (GPS)</u></b>
21-2.1	Purpose
21-2.3	Related Egyptian civil aviation regulations
21-2.5	Related reading materials
21-2.7	GPS navigation background
21-2.9	Portable units
21-2.11	Installation approvals
21-2.13	Airworthiness certification considerations
21-2.15	Application process

## **Portable Global Positioning System (GPS)**

### **21-2.1 Purpose**

This advisory circular (AC) establishes an acceptable means of obtaining ECAA approval of Portable Global Positioning System (GPS) equipment for use as a supplemental navigation system during VFR operations. This document addresses only the approval of portable GPS units that are not integrated into any other aircraft navigational or display systems.

### **21-2.3 Related Egyptian civil aviation regulations**

Egyptian Civil Aviation Regulations parts 21, 43, 65, 91, and 121.

### **21-2.5 Related reading materials**

- (a) International Civil Aviation Organization Annexes 6 Operation of Aircraft, 8 Airworthiness of Aircraft and 10 Communications.
- (b) United States Federal Aviation Administration (FAA)/Technical Standard Order (TSO) C129, Airborne Supplemental Navigation Equipment Using the Global Positioning System (GPS). Copies may be obtained from the Department of Transportation, FAA, Aircraft Certification Service, Aircraft Engineering Division, AIR-130, 800 Independence Avenue, SW, Washington, DC 20591.
- (c) RTCA, Inc. Document No. DO-160C, Environmental Conditions and Test Procedures for Airborne Equipment; Document No. DO-178B, Software Considerations in Airborne Systems and Equipment Certification; Document No. DO-200, Preparation, Verification and Distribution of User Selectable Navigation Data Bases; Document No. DO-201, User Recommendations for Aeronautical Information Services; and Document No. DO-208, Minimum Operational Performance Standards for Airborne Supplemental Navigation Equipment Using Global Positioning System (GPS). Copies may be purchased from RTCA, Inc., 1140 Connecticut Avenue, NW, Suite 1020, Washington, DC 20036.
- (d) Department of Defense Interface Control Document (ICD) ICD-GPS-200B, Navstar GPS Space Segment/Navigation User Interface. Copies of the civil version of this document may be requested from the GPS Joint Program Office, SSD/CZ, Los Angeles AFB, CA 90006.
- (e) Defense Mapping Agency (DMA) Technical Report DMA TR 8350.2, Department of Defense World Geodetic System 1984, Its Definition and Relationships With Local Geodetic Systems. Copies of this document may be requested from the Defense Mapping Agency, Systems Center (SG), 8613 Lee Highway, Fairfax, VA 22031-2138.

### **21-2.7 GPS navigation background**

GPS is a satellite-based radio navigation system that uses precise range measurements from GPS satellites to determine a precise position anywhere in the world. The GPS constellation consists of 24 satellites in various orbital planes approximately 11,000 nautical miles (NM) above the earth. The satellites broadcast a timing signal and data message that the airborne equipment processes to obtain satellite position and status data, and to measure how long each satellite's radio signal takes to reach the receiver. By knowing the precise location of each satellite and precisely matching timing with the atomic clocks on the satellites, the receiver can accurately measure the time the signal takes to arrive at the receiver and thus determine the satellite's precise position. A minimum of three satellites must be in view to determine a two-dimensional position. Four satellites are required to establish an accurate three-dimensional position. GPS equipment determines its position by precise measurement of the distance from selected satellites in the system and the satellite's known location. The accuracy of GPS position data can be affected by various factors. Many of these accuracy errors can be reduced or eliminated with mathematics and sophisticated modeling, while other sources of errors cannot be corrected. The following are examples of those errors that cannot be corrected:

- (a) Atmospheric propagation delays can cause relatively small measurement errors, typically less than 100 feet. Ionospheric propagation delays can be partially corrected by sophisticated error-correction capabilities

- (b) Slight inaccuracies in the atomic clocks on the satellites can cause a small position error of approximately 2 feet
- (c) Receiver processing (such as mathematical rounding and electrical interference) may cause errors that are usually either very small (which may add a few feet of uncertainty into each measurement) or very large (which are easy to detect). Receiver errors are typically on the order of 4 feet
- (d) Conditions that cause signal reflections before the satellite's transmitted signal gets to the receiver can cause small errors in position determination or momentary loss of the GPS signal. While advanced signal processing techniques and sophisticated antenna design are used to minimize this problem, some uncertainty can still be added to a GPS measurement
- (e) A satellite's exact measured orbital parameters (ephemeris data) can contain a small error of approximately 4 feet.
  - (1) System Operation
    - (i) The United States Department of Defense (DOD) is responsible for operating the GPS satellite constellation and constantly monitors the GPS satellites to ensure proper operation. Every satellite's ephemeris data are sent to each satellite for broadcast as part of the data message sent in the GPS signal. The GPS is a system of Cartesian earth-centered, earth-fixed coordinates as specified in the DOD World Geodetic System 1984 (WGS-84). Navigation values, such as ground speed and distance and bearing to a waypoint, are computed from the aircraft's latitude/longitude and the location of the waypoint. Course guidance is usually provided as a linear deviation from the desired track of a great circle course between defined waypoints.
    - (ii) GPS navigation capability from the 24-satellite constellation is available 24 hours a day anywhere in the world. GPS status is broadcast as part of the data message transmitted by the satellites. Additionally, system status is planned to be available through Notices to Airmen (NOTAM). Status information is also available by means of a telephone data service from the United States Coast Guard. The GPS status recording is available 24 hours a day by phoning (202) 313-5906. Availability of suitable navigation capability from the satellite constellation is expected to approach 100 percent.
    - (iii) GPS signal integrity monitoring will be provided by the GPS navigation receiver using receiver autonomous integrity monitoring (RAIM). For GPS sensors that provide position data only to an integrated navigation system (e.g., FMS, multi-sensor navigation system), a level of GPS integrity equivalent to that of RAIM may be provided by the integrated navigation system.
  - (2) Selective Availability (SA). SA is essentially a method by which DOD can artificially create a significant clock and ephemeris error in the satellites. This feature is designed to deny an enemy nation or terrorist organization the use of precise GPS positioning data. SA is the largest source of error in the GPS system. When SA is active, the DOD guarantees horizontal position accuracy will not be degraded beyond 100 meters 95 percent of the time, and beyond 300 meters 99.99 percent of the time.
  - (3) Receiver Autonomous Integrity Monitoring (RAIM). A technique whereby a civil GPS receiver/processor determines the integrity of the GPS navigation signals using only GPS signals or GPS signals augmented with altitude. This determination is achieved by a consistency check among a series of satellites being tracked. At least one satellite in addition to those required for navigation must be in view for the receiver to perform the RAIM function.
  - (4) System Availability. The percentage of time (specified as 98 percent) that at least 21 of the 24 satellites must be operational and providing a usable navigation signal.

### 21-2.9 Portable units

All portable electronic systems and portable GPS units must be handled in accordance with the provisions of Part 91.21. The operator of the aircraft must determine that each portable electronic device will not cause interference with the navigation and

communications systems of the aircraft on which it is to be used. Portable GPS units which are attached by Velcro tape or hard yoke mount that require an antenna (internally or externally mounted) are considered to be portable electronic devices and are subject to the provisions of Part 91.21. All portable GPS equipment attached to the aircraft by a mounting device must be installed in an approved manner and in accordance with Part 43. Any questions concerning installation should be referred to Flight Safety Standards Sector (FSSS). A critical aspect of any GPS installation is the installation of the antenna. Shadowing by the aircraft structure can adversely affect the operation of the GPS equipment. FSSS approval of avionic components, including antennas, requires an evaluation of the applicable aircraft certification regulations prior to approval of an installation. The regulations require that the components perform their intended functions and be free of hazards in and of themselves and to other systems as installed. Pilots and Engineers should be aware that a GPS signal is weak, typically below the value of the background noise. Electrical noise or static in the vicinity of the antenna can adversely affect the performance of the system. It is required that system installations be flight tested in conjunction with other navigation equipment. Unless a portable GPS receiver is TSO C-129 approved, it can not be used as a basis for approval of IFR operations.

### 21-2.11 Installation approvals

**Note:** When the installation duplicates a previously Supplemental Type Certificate (STC) approved installation of the SAME EQUIPMENT on SAME MODEL and TYPE aircraft, or when it consists of the SAME EQUIPMENT that was installed in a DIFFERENT MODEL and TYPE aircraft and the installation is similar, a new STC for the installation need not be issued and will be considered "follow-on" approval. Any Airplane or Rotorcraft Flight Manual Supplement (AFMS/RFMS) or Supplemental AFM change, if required, will be considered part of the installation approval. An operational check as it applies to the alteration must be performed and documented.

- (a) Persons wishing to obtain original airworthiness certification of a GPS installation limited to VFR use only shall obtain approval of the installation by TC or STC. "Follow-on" field approvals can be obtained after an original TC or STC has been awarded.
- (b) Flight Safety Standards Sector has stipulated that "follow-on" GPS installations of portable GPS and external antenna for VFR supplemental navigation are major. If the Aircraft Maintenance Organization has determined and can show that the installation of the GPS navigation equipment, including the antenna installation, does not impact the certificated properties of the aircraft type design, this would permit the installation of the equipment to be declared as a minor alteration.
- (c) It is the responsibility of the person(s) performing the alteration to ensure that the equipment and its installation satisfies all interference immunity requirements and that mutual compatibility with other equipment and systems is maintained. The applicant must show evidence that such tests and/or analyses were satisfactorily conducted to ensure interference immunity and mutual compatibility.
- (d) A placard stating "GPS not approved for IFR" must be installed in clear view of and readable by the pilot-in-command. Such placard must be identified on the modification documentation for purposes of reviewing and approving the installation of the placard.
- (e) The above installations intended for "VFR use only" do not require that the GPS equipment comply with TSO-C129, but the accuracy criteria (0.124 nmi, 95 percent probability) should be demonstrated. The GPS equipment should be installed according to the instructions and limitations provided by the manufacturer of the equipment. Another acceptable method, technique and practice such as US FAA AC 43.13-2A, Acceptable Methods, Techniques, and Practices - Aircraft Alterations may be used, if relevant and not contrary to the approved data or the original STC, as a basis for consideration by the FSSS for approval.
- (f) Functional ground and flight check to ensure correct operation and accuracy will be conducted and recorded, in VFR conditions, by an Aircraft Maintenance Organization and an appropriately rated pilot and monitored by the FSSS Inspectors. A flight check is not required if a GPS VFR installation is made in a manner similar to one that has been previously demonstrated in another approved alteration on the

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SAME TYPE and MODEL of aircraft. The approval for return to service must be signed by one of the entities noted in ECAR Part 65.

### **21-2.13 Airworthiness certification considerations**

GPS equipment approved for VFR use only does not require TSO-C129 authorization, however it must at least meet the system accuracy criteria of 0.124 nmi, 95 percent probability. Airworthiness considerations during approval should include the following:

- (a) Electromagnetic Compatibility. The GPS equipment installation does not interfere with the normal operation of other equipment installed in the aircraft.
- (b) Environmental Conditions. The GPS equipment is appropriate to the aircraft environment in which it is installed.
- (c) Equipment Mounting. The installation of the GPS equipment, including antenna, must be sufficient to meet all structural mounting, dynamic, and emergency landing loads appropriate to the aircraft. Installation data from the manufacturer or the methods in US FAA AC 43.13-2A, "Acceptable Methods, Techniques, and Practices - Aircraft Alterations" may be used to demonstrate satisfactory compliance with this paragraph.
- (d) Operators wishing to obtain approval of :
  - (1) The initial (first time airworthiness approval) certification of a GPS navigation system should be accomplished via the TC or STC approval process in Part 21.
  - (2) Subsequent (follow on) installations of the same GPS navigation system (hardware and software) in other aircraft are approved using a less extensive evaluation process since the basic engineering design of the GPS equipment has already been evaluated. The extent of required evaluations depends upon similarity between the initial and follow on aircraft models.

### **21-2.15 Application process**

The applicant requesting a follow on portable GPS equipment installation limited to VFR use should:

- (a) Prepare and present ECAA Form 1120-104 with all required data to the FSSS.

Note: The applicant should contact either the manufacturer or organization responsible for obtaining the first time airworthiness approval of the GPS equipment in order to obtain all required data and a sample airplane or rotorcraft flight manual supplement (or supplemental flight manual), if required for the aircraft.
- (b) Schedule a meeting with FSSS to review all required data and obtain FSSS verification of the equipment approval status, including antenna, software, etc. If satisfactory, the FSSS will approve and monitor the installation.
- (c) The applicant will conduct a functional ground and flight evaluation with FSSS participation.
- (d) Provide the FSSS with the final data and installation package that includes all test results.