SECTION 2. GROUND OPERATIONAL CHECKS FOR AVIONICS EQUIPMENT (ELECTRICAL)

12-8. GENERAL. When the operating or airworthiness regulations require a system to perform its intended function, the use of the Technical Standard Order (TSO) equipment or the submission of data substantiating the equipment performance is strongly recommended. An operation check of avionics is the responsibility of the pilot in command. However, it is recommended that after replacement of equipment during 100 hour or annual inspections, an operational check of avionics equipment be performed. The accomplishments of these checks must be done in accordance with the recommendations and procedures set forth in the aircraft's flight manual instructions published by the avionics equipment manufacturers.

12-9. INSPECTION OF AVIONICS SYSTEMS.

a. The inspection shall include the following:

(1) Inspect the condition and security of equipment including the proper security of wiring bundles.

(2) Check for indications of overheating of the equipment and associated wiring.

(3) Check for poor electrical bonding. The bonding requirements are specified by equipment manufacturers. Installation cabling should be kept as short as possible, except for antenna cables which are usually precut or have a specific length called out at installation. Proper bonding on the order of 0.003 ohms is very important to the performance of avionics equipment.

(4) Check to assure that the radios and instruments are secured to the instrument panel.

(5) Check that all avionics are free of dust, dirt, lint, or any other airborne contaminates. If there is a forced air cooling system, it must be inspected for proper operation. Equipment ventilation openings must not be obstructed.

(6) Check the microphone headset plugs and connectors and all switches and controls for condition and operation. Check all avionics instruments for placards. Check lightening, annunciator lights, and cockpit interphone for proper operation.

(7) The circuit breaker panel must be inspected for the presence of placarding for each circuit breaker installed.

(8) Check the electrical circuit switches, especially the spring-load type for proper operation. An internal failure in this type of switch may allow the switch to remain closed even though the toggle or button returns to the OFF position. During inspection, attention must be given to the possibility that improper switch substitution may have been made.

b. Check antennas for:

(1) broken or missing antenna insulators

(2) lead through insulators

(3) springs

(4) safety wires

(5) cracked antenna housings

(6) missing or poor sealant at base of antenna

(7) correct installation

(8) signs of corrosion, and

(9) the condition of paint/bonding and grounding.

(10) Check the bonding of each antenna from mounting base to the aircraft skin. Tolerance: .1 ohm, maximum.

(a) Test Equipment:

1 1502B Metallic Time Do Main Reflectometer or equivalent.

2 Thruline Wattmeter.

(b) Perform the antenna evaluation check using the domain reflectometer to determine the condition of the antenna and coax cables. Refer to manufacturer's maintenance procedures.

(c) Use thruline wattmeter as needed for addition evaluation. Refer to manufacturer's maintenance procedures. Check for the following:

1 Resistance.

2 Shorts.

3 Opens.

c. Check the static dischargers/wicks for:

(1) physical security of mounting attachments, wear or abrasion of wicks, missing wicks, etc.,

(2) assurance that one inch of the inner braid of flexible vinyl cover wicks extends beyond the vinyl covering,

(3) assurance that all dischargers are present and securely mounted to their base,

(4) assurance that all bases are securely bonded to skin of aircraft, in order to prevent the existence in voltage level differences between two surfaces,

(5) signs of excessive erosion or deterioration of discharger tip,

(6) lighting damage as evidenced by pitting of the metal base, and

(7) megohm value of static wick itself as per manufacturer's instructions. It should not be open.

d. Subsequent inspection must be made after a maintenance action on a transponder. Refer to Title 14 of the Code of Federal Regulations (14 CFR) part 91, sections 91.411 and 91.413.

e. Inspection of the emergency locator transmitter operation, condition and date of the battery.

f. Perform a function check of the radio by transmitting a request for a radio check. Perform a function check on navigation equipment by moving the omni bearing selection (OBS) and noting the needle swing; and the TO/FROM flag movement.

12-10. COMMUNICATION SYSTEMS. Ground operation of communication systems in aircraft may be accomplished in accordance with the procedures appropriate for the airport and area in which the test is made, and the manufacturer's manuals and procedures. Check system(s) for side tone, clarity of transmission, squelch, operations using head phones, speaker(s), and hand microphone. If a receiver or transmitter is found to be defective, it should be removed from the aircraft and repaired.

12-11. VHF OMNI-DIRECTIONAL RANGE (VOR). A VOR operates within the 108.0 to 117.9 MHz frequency band. The display usually consists of a deviation indicator and a TO/FROM indicator. The controls consist of a frequency selector for selecting the ground station and an OBS, which is used for course selection. An ON/OFF flag is used to determine adequate field strength and presence of a valid signal. There are numerous configurations when integrated into flight directors and/or when using a slaved compass system which uses an additional indicator that points continually to the selected omni station regardless of OBS selection. In order to determine the accuracy specified in a functional check, a ground test set must be used in accordance with the manufacturer's specifications. For the purpose of this inspection/maintenance activity, the following operational check can be accomplished to determine if the equipment has the accuracy required for operation in instrument flight rules (IFR) environment. Verify audio identification, OBS operation, flag operation, radio magnetic indicator (RMI) interface, and applicable navigation (NAV) switching functions. The operational check is also published in the AIM, section 1-1-4. This check is required by 14 CFR part 91, section 91.171 before instrument flight operations.

12-12. DISTANCE MEASURING EQUIPMENT (DME). The operation of DME consists of paired pulses at a specific spacing, sent out from the aircraft (this is what is called interrogation), and are received by the ground station, which then responds with paired pulses at the specific spacing sent by the aircraft, but at a different frequency. The aircraft unit measures the time it takes to transmit and then receive the signal, which then is translated into distance. DME operates on frequencies from 962 MHz to 1213 MHz. Because of the curvature of earth, this line-of-sight signal is reliable up to 199 nautical mile (NM) at the high end of the controlled airspace with an accuracy of 1/2 mile or 3 percent of the distance. DME inspection/maintenance on the aircraft is most commonly limited to a visual check of the installation, and if there have been previously reported problems, the antenna must be inspected for proper bonding and the absence of corrosion, both on the mounting surface, as well as the coax connector. Accuracy can be determined by evaluating performance during flight operations, as well as with ground test equipment. If a discrepancy is reported and corrected, it is good practice to make the accuracy determination before instrument flight. Tune the DME to a local station, or use the proper ground test equipment to check audio identification, and DME hold function verify correct display operation.

12-13. AUTOMATIC DIRECTION FINDER (ADF). The ADF receivers are primarily designed to receive nondirectional beacons (NDB) in the 19 to 535 kHz amplitude modulation (AM) broadcast low band. The receivers will also operate in the commercial AM band. The ADF display pointer will indicate the relative bearing to a selected AM band transmitter that is in range. An ADF system must be checked by tuning to an adequate NDB or commercial AM station. Verify proper bearing to station, audio identification and tone/beat frequency oscillator (BFO), correct operation in closed circuit (LOOP) and sense modes. Note the orientation of the selected station to the aircraft using an appropriate chart. Observe the ADF relative bearing reading, and compare to the chart. Slew the needle and observe how fast (or slowly) it returns to the reading. ADF performance may be degraded by lightning activity, airframe charging, ignition noise and atmospheric phenomena.

12-14. INSTRUMENT LANDING SYSTEMS (ILS). The ILS consist of several components, such as the localizer, glide slope, marker beacon, radio altimeter, and DME. Localizer and glide slope receivers and marker beacons will be discussed in this section.

a. Localizer receiver operates on one of 40 ILS channels within the frequency range of 108.10 to 111.95 MHz. These signals provide course guidance to the pilot to the runway centerline through the lateral displacement of the VOR/localizer (LOC) deviation indicator. The ground transmitter is sighted at the far end of the runway and provides a valid signal from a distance of 18 NM from the transmitter. The indication gives a full fly left/right deviation of 700 feet at the runway threshold. Identification of the transmitter is in International Morse Code and consists of a three letter identifier preceded by the Morse Code letter I (two dots). The localizer function is usually integral with the VOR system, and when maintenance is performed on the VOR unit, the localizer is also included. The accuracy of the system can be effectively evaluated through normal flight operations if evaluated during visual meteorological conditions. Any determination of airworthiness after reinstallation before instrument flight must be accomplished with ground test equipment.

b. The glide slope receiver operates on one of 40 channels within the frequency range 329.15 MHz, to 335.00 MHz. The glide slope transmitter is located between 750 feet and 1250 feet from the approach end of the runway and offset 250 to 650 feet. In the absence of questionable performance, periodic functional flight checks of the glide slope system would be an acceptable way to ensure continued system performance. The functional flight test must be conducted under visual flight rules (VFR) conditions. A failed or misleading system must be serviced by an appropriately-rated repair station. Ground test equipment can be used to verify glide slope operation.

c. Localizer/Glide Slope (LOC/GS) may have self test function, otherwise the proper ground test equipment must be used. Refer to manufacturer's or aircraft instruction manual.

12-15. MARKER BEACON. Marker beacon receivers operate at 75 MHz and sense the audio signature of each of the three types of beacons. The marker beacon receiver is not tunable. The blue outer marker light illuminates when the receiver acquires a 75 MHz signal modulated with 400 Hz, an amber middle marker light for a 75 MHz signal modulated with 1300 Hz and, a white inner marker light for a 75 MHz signal modulated with 3000 Hz. The marker beacon system must be operationally evaluated in VFR when an ILS runway is available. The receiver sensitivity switch must be placed in LOW SENSE (the normal setting). Marker audio must be adequate. Ground test equipment must be used to verify marker beacon operation. Marker beacon with self test feature, verify lamps, audio and lamp dimming.

12-16. LONG RANGE NAVIGATION (LORAN). The LORAN has been an effective alternative to Rho/Theta R-Nav systems.

Hyperbolic systems require waypoint designation in terms of latitude and longitude, unlike original R-Nav (distance navigation) systems, which define waypoints in terms of distance (Rho) and angle (Theta) from established VOR or Tacan facilities. Accuracy is better than the VOR/Tacan system but LORAN is more prone to problems with precipitation static. Proper bonding of aircraft structure and the use of high-quality static wicks will not only produce improved LORAN system performance, but can also benefit the very high frequency (VHF) navigation and communications systems. This system has an automatic test equipment (ATE).

NOTE: Aircraft must be outside of hangar for LORAN to operate.

Normally self test check units, verification of position, and loading of flight plan will verify operation verification of proper flight manual supplements and operating handbooks on board, and proper software status can also be verified.

12-17. GLOBAL POSITIONING SYSTEM (GPS). The GPS is at the forefront of present generation navigation systems. This space-based navigation system is based on a 24-satellite system and is highly accurate (within 100 meters) for establishing position. The system is unaffected by weather and provides a world-wide common grid reference system. Database updating and antenna maintenance are of primary concern to the GPS user.

NOTE: Aircraft must be outside of hangar for ground test of GPS.

12-18. AUTOPILOT SYSTEMS. Automatic Flight Control Systems (AFCS) are the most efficient managers of aircraft performance and control. There are three kinds of autopilot; two axes, three axes, and three axes with coupled approach capability. Attention must be given to the disconnect switch operation, aural and visual alerts of automatic and intentional autopilot disconnects, override forces and mode annunciation, servo operation, rigging and bridle cable tension, and condition. In all cases the manufacturer's inspection and maintenance instructions must be followed.

12-19. ALTIMETERS. Aircraft conducting operations in controlled airspace under instrument flight rule (IFR) are required to have their static system(s) and each altimeter instrument inspected and tested within the previous 24 calendar months. Frequent functional checks of all altimeters and automatic pressure altitude reporting systems are recommended.

a. Examine the altimeter face for evidence of needle scrapes or other damage. Check smoothness of operation, with particular attention to altimeter performance during decent.

b. Contact an appropriate air traffic facility for the pressure altitude displayed to the controller from your aircraft. Correct the reported altitude as needed, and compare to the reading on the altimeter instrument. The difference must not exceed 125 feet.

12-20. TRANSPONDERS. There are three modes (types) of transponders that can be used on various aircraft. Mode A provides a (non altitude-reporting) four-digit coded reply; Mode C provides a code reply identical to Mode A with an altitude-reporting signal; and Mode S has the same capabilities as Mode A and Mode C and responds to traffic alert and collision avoidance system (TCAS)-Equipped Aircraft.

a. Ground ramp equipment must be used to demonstrate proper operation. Enough codes must be selected so that each switch position is checked at least once. Low and high sensitivity operation must be checked. Identification operation must be checked. Altitude reporting mode must be demonstrated. Demonstrate that the transponder system does not interfere with other systems aboard the aircraft, and that other equipment does not interfere with transponder operation. Special consideration must be given to other pulse equipment, such as DME and weather radar.

b. All transponders must be tested every 24-calendar months, or during an annual inspection, if requested by the owner. The test must be conducted by an authorized avionics repair facility.

12-21. EMERGENCY LOCATOR TRANSMITTERS (ELT). The ELT must be evaluated in accordance with TSO-C91a, TSO-C126 for 406 MHz ELT's, or later TSO's issued for ELT's. ELT installations must be examined for potential operational problems at least once a year (section 91.207(d)). There have been numerous instances of interaction between ELT and other VHF installations. Antenna location should be as far as possible from other antennas to prevent efficiency losses. Check ELT antenna installations in close proximity to other VHF antennas for suspected interference. Antenna patterns of previously installed VHF antennas could be measured after an ELT installation. Testing of an ELT must be performed within the first 5 minutes of an hour, and only three pulses of the transmitter should be activated. For example, a test could be conducted between 1:00 p.m. and 1:05 p.m., with a maximum of three beeps being heard on a frequency of 121.5 MHz.

12-22. INSPECTION OF ELT. An inspection of the following must be accomplished by a properly certified person or repair station within 12-calendar months after the last inspection:

a. Proper Installation.

(1) Remove all interconnections to the ELT unit and ELT antenna. Visually inspect and confirm proper seating of all connector pins. Special attention should be given to coaxial center conductor pins which are prone to retracting into the connector housing.

(2) Remove the ELT from the mount and inspect the mounting hardware for proper installation and security.

(3) Reinstall the ELT into its mount and verify the proper direction for crash activation. Reconnect all cables. They should have some slack at each end and should be properly secured to the airplane structure for support and protection.

b. Battery Corrosion. Gain access to the ELT battery and inspect. No corrosion should be detectable. Verify the ELT battery is approved and check its expiration date.

c. Operation of the Controls and Crash Sensor. Activate the ELT using an applied force. Consult the ELT manufacturer's instructions before activation. The direction for mounting and force activation is indicated on the ELT. A TSO-C91 ELT can be activated by using a quick rap with the palm. A TSO-C91a ELT can be activated by using a rapid forward (throwing) motion coupled by a rapid reversing action. Verify that the ELT can be activated using a watt meter, the airplane's VHF radio communications receiver tuned to 121.5 MHz, or other means (see NOTE 1). Insure that the "G" switch has been reset if applicable.

d. For a Sufficient Signal Radiated From its Antenna. Activate the ELT using the ON or ELT TEST switch. A low-quality

AM broadcast radio receiver should be used to determine if energy is being transmitted from the antenna. When the antenna of the AM broadcast radio receiver (tuning dial on any setting) is held about 6 inches from the activated ELT antenna, the ELT aural tone will be heard (see NOTE 2 and 3).

e. Verify That All Switches are Properly Labeled and Positioned.

f. Record the Inspection. Record the inspection in the aircraft maintenance records according to 14 CFR part 43, section 43.9. We suggest the following:

I inspected the Make/Model ______________ ELT system in this aircraft according to applicable Aircraft and ELT manufacturer's instructions and applicable FAA guidance and found that it meets the requirements of section 91.207(d).

Signed: ______________________
Certificate No. ______________________
Date: ______________________

NOTE 1: This is not a measured check; it only indicates that the G-switch is working.

NOTE 2: This is not a measured check; but it does provide confidence that the antenna is radiating with sufficient power to aid search and rescue. The signal may be weak even if it is picked up by an aircraft VHF receiver located at a considerable distance from the radiating ELT. Therefore, this check does not check the integrity of the ELT system or provide the same level of confidence as does the AM radio check.

NOTE 3: Because the ELT radiates on the emergency frequency, the Federal Communications Commission allows these tests only to be conducted within the first five minutes after any hour and is limited in three sweeps of the transmitter audio modulation.

12-23. FLIGHT DATA RECORDER. The flight data recorder is housed in a crush-proof container located near the tail section of the aircraft. The tape unit is fire resistant, and contains a radio transmitter to help crash investigators locate the unit under water. Inspection/Operational checks include:

a. Check special sticker on front of the flight data recorder for the date of the next tape replacement, if applicable.

b. Remove recorder magazine and inspect tape for the following:

(1) broken or torn tape,

(2) proper feed of tape, and

(3) all scribes were recording properly for approximately the last hour of flight.

c. Conditions for tape replacement (as applicable):

(1) There is less than 20 hours remaining in the magazine as read on the *tape remaining* indicator.

(2) Tape has run out.

(3) Broken tape.

(4) After hard landings and severe air turbulence have been encountered as reported by the pilots.

(5) After the same tape has been in use 1 year (12 months), it must be replaced.

(6) Ensure that a correlation test has been performed and then recorded in the aircraft records.

d. Refer to the specific equipment manufacturer's manuals and procedures.

e. The state-of-the art Solid-State Flight Data Recorder (SSFDR) is a highly flexible model able to support a wide variety of aeronautical radio, incorporated (ARINC) configurations. It has a Built-In Test Equipment (BITE) that establishes and monitors the mission fitness of the hardware. BITE performs verification after storage (read after write) of flight data and status condition of the memory. These recorders have an underwater acoustic beacon mounted on its front panel which must be returned to their respective manufacturer's for battery servicing. For maintenance information refer to the equipment or aircraft manufacture's maintenance instruction manual.

12-24. COCKPIT VOICE RECORDERS (CVR). CVR's are very similar to flight data recorders. They look nearly identical and operate in almost the same way. CVR's monitors the last 30 minutes of flight deck conversations and radio communications. The flight deck conversations are recorded via the microphone monitor panel located on the flight deck. This panel is also used to test the system and erase the tape, if so desired. Before operating the erase CVR mode, consult the operational manual of the manufacturer for the CVR.

a. Playback is possible only after the recorder is removed from the aircraft.

b. Refer to the specific equipment manufacturer's manuals and procedures.

c. The Solid State Cockpit Voice Recorder system is composed of three essential components a solid state recorder, a control unit (remote mic amplifier), and an area microphone. Also installed on one end of the recorder is an Under water Locator Beacon (ULB). The recorder accepts four separate audio inputs; pilot, copilot, public address/third crew member, and cockpit area microphone and where applicable, rotor speed input and flight data recorder synchronization tone input. For maintenance information refer to the equipment manufacturer's maintenance manual.

12-25. WEATHER RADAR. Ground performance shall include antenna rotation, tilt, indicator brilliance, scan rotation, and indication of received echoes. It must be determined that no objectionable interference from other electrical/electronic equipment appears on the radar indicator, and that the radar system does not interfere with the operation of any of the aircraft's communications or navigation systems.

CAUTION: Do *not* turn radar on within 15 feet of ground personnel, or containers holding flammable or explosive materials. The radar should never operate during fueling operations. Do not operate radar system when beam may intercept larger metallic objects closer than 150 feet, as crystal damage might occur. Do *not* operate radar when cooling fans are inoperative. Refer to the specific Radar System equipment manufacturer's manuals and procedures.

12-26. RADOME INSPECTION. Inspection of aircraft having weather radar installations should include a visual check of the radome surface for signs of surface damage, holes, cracks, chipping, and peeling of paint, etc. Attach fittings and fastenings, neoprene erosion caps, and lightening strips, when installed, should also be inspected.

12-27. DATA BUS. Data Buses provide the physical and functional partitioning needed to enable different companies to design different avionics boxes to be able to communicate information to each other. It defines the framework for system(s) intergration. There are several types of data bus analyzers used to receive and review transmitted data or to transmit data to a bus user. Before using an analyzer, make sure that the bus language is compatible with the bus analyzer. For further information refer to ARINC specifications such as 429 Digital Information Transfer System, Mark 33 which offers simple and affordable answers t data communications on aircraft.

12-28.—12-36. [RESERVED.]