U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: AIRWORTHINESS APPROVAL OF VERTICAL NAVIGATION (VNAV) SYSTEMS FOR USE IN THE U.S. NATIONAL AIRSPACE SYSTEM (NAS) AND ALASKA

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1. PURPOSE. This advisory circular establishes an acceptable means, but not the only means, of obtaining airworthiness approval of an airborne vertical navigation system for use under VFR (visual flight rules) and IFR (instrument flight rules) within the conterminous United States, Alaska, and surrounding U.S. waters. Like all advisory material, this advisory circular is not, in itself, mandatory and does not constitute a regulation. It is issued for guidance purposes and to outline one method of compliance with airworthiness requirements. As such, the terms "shall" and " must" used in this advisory circular pertain to an applicant who chooses to follow the method presented.

2. RELATED FAR. Federal Aviation Regulations (FAR) Parts 23, 25, 43, and 91.

3. RELATED READING MATERIALS.

a. Federal Aviation Administration (FAA)/Technical Standard Order (TSO) C115, Area Navigation Equipment Using Multi-Sensor Inputs; TSO C60b, Area Navigation Equipment Using Loran-C Inputs; and TSO C120, Area Navigation Equipment Using Omega/VLF Inputs. Copies may be obtained from the Department of Transportation, FAA, Aircraft Certification Service, Aircraft Engineering Division (AIR-120), 800 Independence Avenue, SW., Washington, DC 20591.

b. Radio Technical Commission for Aeronautics (RTCA), Document No. RTCA/DO-160B, Environmental Conditions and Test Procedures for Airborne Equipment, Document No. RTCA/DO-178A, Software Considerations in Airborne Systems and Equipment Certification; RTCA/DO-187, Minimum Operational Performance Standards for Airborne Area Navigation Equipment Using Multi-Sensor Inputs; RTCA/DO-194, Minimum Operational Performance Standards for Airborne Area Navigation Equipment Using Loran-C Inputs; and RTCA/DO-190, Minimum Operational Performance Standards for Airborne Area Navigation Equipment Using Omega/VLF Inputs. Copies may be purchased from RTCA Secretariat, One McPherson Square, Suite 500, 1425 K Street, NW., Washington, DC 20005.

4. BACKGROUND.

a. System Description. Vertical navigation (VNAV) equipment provides vertical path guidance computed as deviation from a desired ascending or descending path to a specified altitude at a waypoint. Vertical guidance is generally provided as a linear deviation from the desired track defined by a line joining two waypoints with specified altitudes or as a vertical angle from a specified waypoint. Such systems may be enhanced by inclusion of secondary

inputs such as optimized climb or descent profiles, vertical acceleration and true airspeed. The desired vertical path may be pilot selectable or may be determined by the VNAV computer by computations based on the altitudes associated with successive waypoints.

b. General Operational Limitations. A vertical navigation system may be approved for en route, terminal and approach use within the conterminous United States and Alaska.

5. DEFINITIONS.

a. Approach Operations. Approach operations are those flight phases conducted on charted Instrument Approach Procedures (IAP's) commencing at the initial approach fix (IAF) and concluding at landing or the missed approach holding fix, as appropriate.

b. En Route Operations. En route operations are those flight phases conducted on charted Very High Frequency Omni Range (VOR) routes designated as high or low altitude routes (Jet or Victor), direct point-to-point operations between waypoints defined as part of these charted routes, or along great circle routes as described in Advisory Circular 90-82, Random Air Navigation Routes.

c. Flight Path Angle. The angle that the vertical flight path of the aircraft makes with the local horizontal.

d. Slant Range. The actual straight line distance between an aircraft in flight and a ground location. This distance is greater than the geographical surface range because of the aircraft altitude.

e. Slant Range Error. Slant range error is the difference between the distance of an aircraft to a Distance Measuring Equipment (DME) station on the surface and the distance from the station to a point directly beneath the aircraft on the surface. The error magnitude is a function of aircraft altitude above the station and the distance to the station.

f. Terminal Area Operations. Terminal area operations are those flight phases conducted on charted Standard Instrument Departures (SID), on charted Standard Terminal Arrivals (STAR), or other flight operations between the last en route fix/waypoint and an initial approach fix/waypoint.

g. Vertical Deviation. The deviation of the aircraft above or below the vertical profile as displayed on an indicator such that deflection is up when the aircraft is below the vertical profile.

h. Vertical Profile. A line or curve, or series of connected lines and/or curves in the vertical plane, defining an ascending or descending flight path either emanating from or terminating at a specified waypoint and altitude, or connecting two or more specified waypoints and altitudes. In this sense, a curve may be defined by performance of the airplane relative to the airmass.

i. Vertical Profile Angle Error. The difference in degrees that the current aircraft flight path angle makes with the vertical profile.

j. Vertical Profile Intercept Point. The point at which the current aircraft flight path angle intercepts the vertical profile.

6. AIRWORTHINESS CONSIDERATIONS. Vertical navigation equipment has been certificated for VFR and IFR use as a vertical flight path guidance system for en route, terminal and approach navigation in the National Airspace System (NAS). This paragraph establishes acceptable criteria for VNAV systems.

a. VNAV Equipment Installations Used for Operations Under Visual Flight Rules (VFR) Only. Operators wishing to use VNAV equipment that is not coupled to an autopilot or flight director (except as noted in 6a(5) below) for operations limited to VFR may obtain approval of the installation by Type Certificate (TC), Supplemental Type Certificate (STC), data field approved by the FAA on an FAA Form 337, Major Repair and Alteration, or by the use of previously approved data. The approval for return to service should be signed by one of the entities noted in FAR 43; i.e., repair station, manufacturer, holder of an inspection authorization, etc. The installation verification should ensure, but is not limited to, the following:

(1) The VNAV Equipment Installation does not interfere with the normal operation of other equipment installed in the aircraft. This is accomplished by a ground test and flight test to check that the VNAV equipment is not a source of objectional electromagnetic interference (EMI), is functioning properly and safely, and operates in accordance with the manufacturer's specifications.

(2) The Structural Mounting of the VNAV Equipment is sufficient to ensure the restraint of the equipment when subjected to the emergency landing loads appropriate to the aircraft category.

(3) A Vertical Navigation Source Annunciator is Provided on or adjacent to the display if the VNAV equipment installation supplies any information to displays such as a horizontal situation indicator (HSI) or course deviation indicator (CDI) which can also display information from other systems normally used for aircraft navigation.

(4) The VNAV Equipment Controls and Displays are Installed with a placard(s) which states "VNAV Equipment Not Approved for IFR."

(5) The VNAV Equipment May Not Be Coupled to an autopilot or flight director unless the same installation has previously been made using the same VNAV equipment, autopilot, and/or flight director in the same aircraft under either TC or STC approval.

b. VNAV Equipment Installations Used for Operations Under IFR. Acceptable criteria for approval of VNAV equipment to be used under IFR are contained in this advisory circular. The initial certification of a VNAV system requires an engineering evaluation because of the need to verify performance, failure indications, environmental qualifications, etc. Subsequent installations of the same VNAV equipment system in other aircraft may require additional engineering

evaluation, depending upon the degree of integration of the system with other aircraft systems, in particular autopilot and flight director systems. VNAV systems for use under IFR should provide the following:

(1) Flightcrew Inputs of:

(i) Altitude associated with the active waypoint in terms of feet at least to the nearest 100 feet for en route and terminal flight phases and 10 feet for the approach phase. If provided, waypoint horizontal position in increments not greater than 0.1 nautical miles (nmi) or 0.2 degrees bearing from the waypoint.

(ii) Ascent or descent angle in terms of degrees at least to the nearest 0.1 degree, for equipment which specifies gradient angles.

(iii) Station elevation, if necessary for equipment employing slant range error correction, in terms of feet, at least to the nearest 1,000 feet for en route and terminal flight phases and 100 feet for the approach phase.

(iv) For terminal and approach operations, the ability to enter the altitude associated with at least eight (for to-from equipment) or nine (for to-to equipment) successive waypoints.

(v) A means to confirm correctness of input data prior to utilization of the new data by the system.

(2) The system displays should give no operationally misleading information and should provide:

(i) A continuous display of vertical path deviation with

	En Route/Terminal (feet)	Approach (feet)
Minimum Full-Scale Deflection	≥500	* ≥150
Readability	≤100	≤ 30
Minimum Discernable Movement	≤ 10	≤ 5

* NOTE: Smaller values of minimum full-scale deflection for approach may be acceptable provided the proposed value is found satisfactory by an engineering evaluation.

(ii) Entry of waypoint altitude in terms of feet to at least the nearest 100 feet for en route and terminal flight phases and 10 feet for the approach phase.

(iii) A vertical guidance presentation compatible with the aircraft's flight instrumentation such that the pilot is continuously furnished vertical deviation of the aircraft with respect to the preprogrammed ascent/descent or level flight profile.

(iv) An annunciation of impending vertical waypoint crossing.

(3) Caution Indication(s) for the System Should Be Located on or near the indicator specified in paragraph 6b(2)(i) and should provide a readily discernible caution indication(s) to the pilot(s) for any of the following:

(i) Inadequate or invalid navigation signals or sources.

(ii) The absence of primary power.

(iii) Inadequate or invalid navigation displays or output sources.

(iv) Equipment failures.

NOTE: These failure/status indications shall occur independently of any operator action. Power or navigation equipment failures may be indicated in a common manner. In the approach mode, the lack of adequate navigation signals or sources shall be annunciated by means of a flag displayed on the primary vertical navigation display. In other modes, an appropriately located annunciator may be used.

(4) The System Shall Be Capable of Providing Navigation Guidance to the accuracy specified in paragraph 8 within 20 seconds after input of the desired vertical track information (assuming sensor outputs are available).

(5) The System Shall Correct DME Range for Slant Range error unless it is demonstrated that the accuracies specified in paragraph 8 can be achieved without slant range error correction.

(6) Navigation Guidance Should Be Available within five seconds of waypoint data input.

(7) The Equipment Should Have the Capability to meet the criteria outlined in paragraph 6b(1) through 6b(6) throughout the range of environmental conditions which will be encountered in actual service. Exposure of the equipment to the environmental test conditions of TSO's C60b, C115, or C120 may be used to demonstrate this capability. For VNAV systems certified independent of an area navigation system, the environmental test conditions contained in RTCA Document No. DO-160B may be used to demonstrate this ability.

(8) The Equipment Should Provide a Means for the Flightcrew to determine system status prior to flight.

(9) The Equipment Should Provide the Navigation Accuracy specified in paragraph 8 for all groundspeeds up to a maximum value to be set by the manufacturer and for all ascent and descent rates up to a maximum value to be set by the manufacturer.

(10) The Equipment Should Provide Means to Alert the Flightcrew prior to arrival at a waypoint to permit anticipation of necessary vertical maneuvering. This indicator should be located on or near the indicator specified in paragraph 6b(2)(i). For VNAV equipment that is not coupled to a flight director or autopilot, a procedural means based on a continuous and properly located distance to waypoint display may be used for vertical maneuver

anticipation. Systems which provide steering signals for flight directors or autopilots should provide automatic vertical maneuver anticipation and a waypoint alert which occurs prior to the initiation of the vertical maneuver. Systems that are coupled to the automatic guidance/control system(s) should not cause the aircraft to depart an assigned altitude until the impending altitude change is indicated to the crew within the pilot's primary field of view, then acknowledged by timely crew action. If this acknowledgment is stored by the equipment, acceptance of the acknowledgment should not precede the indication. The timing of acknowledgment of an impending vertical path change is dependent on operational procedures and aircraft/equipment design; however, past practice has shown that this acknowledgment should not occur more than five minutes prior to the impending vertical path change.

(11) If a Capability for Parallel Offset Tracks is Provided, waypoint alerting and vertical maneuver anticipation should be provided prior to arrival at the point where the offset track intersects the angle bisector of the parent track. These functions should operate as described in paragraph 6b(10).

(12) The Equipment Should Be Capable of Providing correct vertical path guidance when interfaced with lateral navigation equipment providing turn anticipation. The VNAV equipment should recognize the angle bisector of the lateral track change as the "zero distance to waypoint" location.

c. Software Changes. The provisions of this paragraph apply to VNAV equipment which utilizes a digital computer to provide navigation information for system monitoring. The computer program (software) operates the computer and provides the basic functions of these systems. The software for navigation functions of VNAV equipment described in paragraph 6b (for VNAV equipment used for IFR operations) should be verified and validated to at least the level 2 requirements as defined by RTCA/DO-178A. Any changes to software which affects navigation functions are considered to be major changes to the equipment. Unless software partitioning has been previously established, any change to Level 1 or Level 2 software of VNAV equipment should be verified and validated to the appropriate level and should be demonstrated as not having inadvertently affected the remaining navigation functions. Changes to software used for VNAV equipment limited to VFR use or equipment having established partitioning from software which provides navigational functions in IFR systems are considered to be minor and do not require prior approval by the FAA, providing the manufacturer of the VNAV equipment has a software configuration management and quality assurance plan approved by the FAA. All software changes must be identified on the outside of the associated line replaceable unit in accordance with the criteria of RTCA/DO-178A. Software changes in TSO approved equipment must be reported to the cognizant Aircraft Certification Office. If the equipment displays a software identifier to the flightcrew, the airplane or rotorcraft flight manual (or appropriate placard) should indicate the approved identifier. Software changes incorporated in equipment already installed in an aircraft may require additional evaluation and possible flight manual revision prior to returning the aircraft to service, depending upon the scope of the change.

7. EQUIPMENT INSTALLATION CONSIDERATIONS FOR USE UNDER IFR.

a. Location of the VNAV System Display. Each display element, used as a primary flight instrument in the guidance and control of the aircraft, should be located where it is clearly visible to the pilot with the least practicable deviation from the pilot's normal position and line of vision when looking forward along the flight path.

b. Failure Protection. Any probable failure of the airborne VNAV system should not degrade the normal operation of other required equipment or create a flight hazard. Normal operation of the VNAV equipment installation should not adversely affect the performance of other aircraft equipment.

c. Environmental Conditions. The aircraft environment in which the VNAV system is installed should be found to be compatible with the environmental categories to which the equipment was tested.

d. Electromagnetic Interference. The VNAV system should not be the source of objectionable electromagnetic interference, nor be adversely affected by electromagnetic interference from other equipment in the aircraft.

e. Dynamic Responses. The system should indicate aircraft vertical position to the accuracy specified in paragraph 8 within five seconds after any maneuvering or changes in attitude encountered in normal operations.

f. System Controls. The system controls should be arranged to provide adequate protection against inadvertent system turnoff. The controls for system operation should be readily accessible to, and useable by, the flightcrew and be visible under all expected lighting conditions, including night and direct sunlight.

g. System Tests. The initial approval of a VNAV system for IFR use involves extensive testing to demonstrate operational performance, environmental qualifications, etc. When no autopilot/flight director interface is provided, subsequent installations of the same VNAV system in other aircraft need only be tested to the extent necessary to demonstrate proper operation of interfacing navigation and display equipment, satisfactory clearance of electromagnetic interference (EMI), and functional check of the VNAV equipment. For those systems interfaced with an autopilot/flight director system, each VNAV/aircraft combination should be carefully evaluated using the guidelines presented in this advisory circular.

h. Manufacturer's Instructions. VNAV equipment should be installed in accordance with instructions and limitations provided by the manufacturer of the equipment.

8. SYSTEM ACCURACY.

a. En Route, Terminal and Approach IFR Operation in the NAS. The error of the airborne VNAV equipment, excluding altimetry, should be less than that shown below on a 99.7 percent probability basis:

Altitude Region	Level Flight Segments and Climb/Descent Intercept of Specified Altitudes (ft)	Climb/Descent Along Specified Vertical Profile (angle) (ft)
At or below 5,000 ft	50	100
5,000 ft to 10,000 ft	50	150
Above 10,000 ft	50	220

NOTES:

1. Maximum operating altitudes to be predicated on compliance with total accuracy tolerance.

2. VNAV guidance may be used in level flight en route as in the case of altitude hold control laws, which are integrated with speed control laws to provide an energy trade. The incremental error component contributed by the VNAV equipment must be offset by a corresponding reduction in other error components, such as flight technical error, to ensure that the total error budget is not exceeded.

3. Altimetry Error. Refers to the electrical output and includes all errors attributable to the aircraft altimetry installation including position effects resulting from normal aircraft flight attitudes. In high performance aircraft, it is expected that altimetry correction will be provided. Such correction should be done automatically. In lower performance aircraft, upgrading of the altimetry system may be necessary.

4. VNAV Equipment Error. Includes all errors resulting from the vertical guidance equipment installation. Does not include errors of the altimeter system but does include any additional errors resulting from the addition of the VNAV equipment. This error component may be zero in level en route flight if the operation is limited to guidance by means of the altimeter only. It should not be disregarded in terminal and approach operations where the pilot is expected to follow the VNAV indications.

b. Flight Technical (Pilotage) Errors. With satisfactory displays of vertical guidance information, consensus estimates based upon experience and some limited testing indicate that flight technical errors can be expected to be less than the values shown below on a three-sigma basis.

Altitude Region	Level Flight Segments and Climb/Descent Intercept of Specified Altitudes (ft)	Climb/Descent Along Specified Vertical Profile (angle) (ft)
At or below 5,000 ft	150	200
5,000 ft to 10,000 ft	240	300
Above 10,000 ft	240	300

Sufficient flight tests of the installation should be conducted to verify that these values can be maintained. Smaller values for flight technical errors should not be expected, unless the VNAV system is to be used only when coupled to an autopilot; however, at least the total system vertical accuracy shown below should be maintained.

If an installation results in larger flight technical errors, the total vertical error of the system (excluding altimetry) should be determined by combining equipment and flight technical errors using the root sum square (RSS) method. The result should be less than the values listed below.

Altitude Region	Level Flight Segments and Climb/Descent Intercept of Specified Altitudes (ft)	Climb/Descent Along Specified Vertical Profile (angle) (ft)
At or below 5,000 ft	158	224
5,000 ft to 10,000 ft	245	335
Above 10,000 ft	245	372

9. IFR AIRWORTHINESS APPROVAL. There are two types of approval which differ greatly as to test requirements and data analysis.

a. First-Time Airworthiness Approval. This type of approval refers to the very first time an applicant presents a particular model VNAV equipment for FAA airworthiness installation approval and certification for an IFR navigation system. Any new models of VNAV equipment by the same manufacturer should undergo the same approval process as the original equipment unless it can be shown by analysis and tests that the new model will function as well or better than the approved equipment. A first-time approval is conducted in three phases:

(1) Lab/Bench Tests and Equipment Data Evaluation. This phase consists of the following:

(i) Analysis of the manufacturer's procedures for verification and validation of software and review of supporting documentation in accordance with the guidelines of RTCA/DO-178A.

(ii) Verification of compliance with appropriate environmental qualification standards such as RTCA/DO-160B.

(iii) Examination of the equipment's display capabilities with emphasis on warning, caution, and advisory annunciations.

(iv) Analysis of failure modes.

(v) Review of reliability data to establish that all probable failures are detected.

(vi) Evaluation of the ease of use of the controls and of the viewing ease of the displays and annunciations from a human factors point of view.

(vii) Review of installation and maintenance manuals.

(viii) Evaluation of operator's manual (pilot's guide).

(2) Aircraft Installation Data Evaluation. Normally the manufacturer of the VNAV equipment will provide an aircraft as a test bed for a first-time installation approval. The first-time installation approval will serve as a basis for subsequent installation approvals on the same type of aircraft incorporating the same autopilot/flight director system and for other aircraft installations not incorporating autopilot/flight director interface with the VNAV equipment. The following assessments are to be made:

(i) Review of installation drawings, wiring diagrams, and descriptive wiring routing.

(ii) Examination of a cockpit layout of the installed equipment with emphasis on equipment controls, applicable circuit breakers (labels and accessibility), switching arrangement and related indicators, displays, annunciators, etc.

(iii) Analysis of a data flow diagram in order to review which equipment transmits what data to which other equipment.

(iv) Review of a structural analysis of the equipment installation in order to ascertain whether all system components are satisfactorily attached to the basic aircraft structure.

(v) Examination of an electrical load analysis in order to verify that the added electrical power requirements of the system installation will not cause overloading of the aircraft's electrical generating capacity.

(vi) Evaluation of the integration with the associated lateral navigation equipment.

(3) Flight Test Evaluations. Flight tests are conducted in two stages:

(i) Functional Flight Tests consist of:

A Evaluation of all operating modes of the VNAV equipment.

B Examination of the interface (function) of other equipment connected to the VNAV system.

C Review of various failure modes and associated annunciations such as loss of electrical power, loss of lateral navigation signals, VNAV equipment failures, etc.

D Evaluation of steering response while autopilot is coupled to the VNAV equipment during a variety of lateral and vertical track changes including selection of VNAV modes while operating at the maximum and minimum speeds approved for VNAV use.

E Evaluation of displayed VNAV navigation parameters on interfaced flight deck instruments such as HSI, CDI, etc.

F Assessment of all switching and transfer functions pertaining to the VNAV equipment including high-power electrical loads and electrical bus switching.

G Evaluation to determine whether there exists any electromagnetic or radio frequency interference between the VNAV equipment installation and other onboard equipment, or vice versa.

H Evaluation of the accessibility of all controls pertaining to the VNAV system installation.

I Evaluation of the visibility of the displays and annunciators pertaining to the VNAV system installation during day and night lighting conditions. No distracting cockpit glare or reflections may be introduced.

J Analysis of crew workload when operating the VNAV equipment.

(ii) Determination of Navigation Error Flight Test. The initial certification of each VNAV system to be used for IFR operations should be based on a demonstration of system performance by recording the VNAV equipment vertical guidance and comparing it to the actual position of the aircraft along a pre-established vertical flight path. This evaluation can be made by use of theodolite observation, comparison against Instrument Landing System (or microwave landing system (MLS)) glide path signals, or by equivalent measuring techniques. Data should be gathered using a variety of descent/ascent rates, angles, and lateral navigation source inputs available to the VNAV system. The data should demonstrate that the appropriate accuracy criteria of paragraph 8 are met on a 99.7 percent probability basis. Flights into known poor performance areas, outside system angle and/or rate limits, using large (greater than 100 degrees) lateral track changes, etc. should be evaluated to verify proper operation of caution indications and lateral navigation interface. Normal flight maneuvers should not cause loss of system sensor inputs and the system dynamic response should be confirmed. Any unusual flight technical errors or errors resulting from use of the autopilot and flight director should be evaluated and examined.

b. Follow-On Airworthiness Installation Approvals. This type of approval refers to installation approvals of the system in the same type of aircraft with the same autopilot/flight director integration and for other aircraft installations not incorporating autopilot/flight director interface with the VNAV equipment. Installation of VNAV systems in different types of aircraft where autopilot/flight director interface is provided or where a different autopilot/flight director is interfaced with the VNAV equipment require

engineering approval. Follow-on approvals may use the first time airworthiness approval, which was either a TC or an STC, as a basis for installation approval. Follow-on installation approvals may be accomplished by TC or STC, or may be in the form of a field approval on an FAA Form 337. The applicant or installing agency requesting a follow-on VNAV system installation utilizing this method of data approval should:

(1) Contact either the manufacturer or organization responsible for obtaining the first-time airworthiness approval in order to:

(i) Obtain a sample airplane flight manual (AFM) or rotorcraft flight manual (RFM) supplement (or supplemental flight manual, as appropriate).

(ii) Obtain verification of the equipment approval status, including the software program identification and lateral navigation equipment that may be interfaced with the system.

(iii) Discuss any problem areas and seek assistance in their solution.

(2) Conduct a similar data evaluation as outlined in paragraph 9a(2).

(3) Conduct flight evaluations similar to the flight tests outlined in paragraph 9a(3)(i).

(4) Verify that the maximum expected groundspeed of the aircraft is less than the maximum operating speed for which the VNAV equipment is qualified.

(5) Spot check VNAV performance by conducting an evaluation flight incorporating at least three ILS approaches (or MLS comparing VNAV vertical guidance to that provided by the ILS glideslope) and three nonprecision approaches to a specified minimum descent altitude (not a descent angle). Accuracy should be verified by comparison to the ILS (MLS) glideslope indication and altimeter reading. The purpose of this test flight is not to validate VNAV navigation error values, but rather to verify that in the course of this installation nothing was done to compromise the accuracy of the system as determined by the first-time approval. Significant differences between the vertical path data provided by the ILS (MLS) glideslope and/or altimeter and VNAV equipment should be evaluated to determine possible causes. If a logical explanation is not available, additional flight test data points should be collected. If such error(s) persists, approval of the installation should be withheld.

10. OPERATIONAL CONSIDERATIONS.

a. Operation in the NAS. VNAV equipment may be used to provide supplemental vertical path guidance to aid in more efficient and precise operation of the aircraft. The altimeter shall always be the primary altitude reference for all flight operations.

b. Operational Procedures. Operators and their flightcrews should consult the approved flight manual supplement for their aircraft to determine approved operational procedures that may apply to particular systems installed in various aircraft. Flightcrews must be aware that these procedures may vary for different equipment and in different aircraft, and the appropriate procedures for a particular system installation can only be determined by reference to the approved flight manual or other FAA approved documents.

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APPENDIX 1. PROCEDURES FOR OBTAINING FAA APPROVAL FOR IFR/VFR OPERATIONS BY SUPPLEMENTAL TYPE CERTIFICATE OR FAA FORM 337 (FIELD APPROVAL) FOR FOLLOW-ON INSTALLATIONS.

1. APPROVAL OF TECHNICAL DATA BY SUPPLEMENTAL TYPE CERTIFICATE (STC).

a. The STC Applicant:

(1) Makes an application for an STC at the nearest FAA aircraft certification office. Early contact is wise, since scheduling may be critical. FAA evaluates the data submitted by the applicant, issues a Type Inspection Authorization (TIA), and participates in ground/flight tests outlined in paragraph 9. An STC is issued when all airworthiness requirements are met. If the submitted data is adequate, the STC authorizes identical installations in the same aircraft type with the same autopilot/flight director interface.

(2) Designs and installs the VNAV system to the criteria set forth in applicable paragraphs of this advisory circular, or consistent with other data acceptable to the Administrator.

(3) Obtains an authorization from the equipment manufacturer to reference the original data for equipment accuracy (per paragraph 8), or conducts the necessary tests.

(4) Makes an aircraft available (with the VNAV system installed) for ground inspection and flight test. The applicant is responsible for furnishing a qualified flightcrew for the required flight tests.

(5) Should Submit the following kinds of data for FAA airworthiness evaluation:

(i) Equipment data such as:

A Equipment schematics and system wiring diagrams.

B Equipment manufacturer's operating instructions and installation instructions.

C Equipment manufacturer's quality control procedures (not required if manufacturer's quality control is FAA approved).

D Environmental test data.

NOTE: Equipment data need not be submitted if the equipment has been manufactured under a TSO authorization.

(ii) Fault analysis covering installation.

(iii) Installation information and/or photographs.

(iv) Structural substantiation as necessary.

(v) Installation wiring diagrams.

(vi) Flight manual revision or supplement, or placard drawings as required (see paragraph 2c of this appendix).

(vii) Evidence of previously approved data.

(viii) Electrical load analysis.

c. The Equipment Manufacturer Can Certify (to the applicant and FAA) that the performance criteria in paragraph 8 by reference to the original STC are satisfied, a TSO has been obtained, and that the appropriate environmental tests have been conducted.

2. APPROVAL OF TECHNICAL DATA/INSTALLATION FOR IFR OPERATIONS BY FAA FORM 337 (FIELD APPROVAL).

a. Data Submitted by the Applicant. Alteration data for the equipment in installation will be submitted with a properly executed FAA Form 337 and a certification from the manufacturer to confirm that the system accuracy requirements of paragraph 8 have been met.

b. Additional Data Which May Be Required. If required for FAA airworthiness evaluation by the FAA district office approving the technical data/installation, the applicant may also be required to furnish a copy of the equipment data (for equipment not produced under a TSO authorization), manufacturer's operating and installation instructions, fault analysis for installation, installation details and/or photographs, substantiation of structural changes, and system wiring diagrams.

c. Airplane Flight Manual (AFM) or Rotorcraft Flight Manual (RFM) Supplement. An AFM/RFM supplement (or supplemental flight manual) prepared by the applicant and containing the following information must be presented for FAA approval.

(1) Equipment operating limitations.

(2) Emergency/abnormal operating procedures (if applicable).

(3) Normal procedures for operating the VNAV system and any interfaced equipment.

(4) Procedures for verifying proper operation after power outages.

d. The Applicant Makes an Aircraft Available (with the VNAV system installed for ground and flight tests, and is responsible for furnishing a qualified flightcrew for the required flight test. The results of the flight test should be made a part of the data submited. The FAA approving inspector will request to observe the flight test.

NOTE: The FAA inspector will evaluate and sign the airplane flight manual supplement or rotorcraft flight manual supplement (or supplemental flight manual) presented by the applicant as part of a field approval. Generally, FAA inspectors should have sufficient understanding of the AFM or the RFM to approve

a supplement for the VNAV system installation without the need for engineering assistance. However, if engineering assistance is needed then the inspector should request it early in the program.

e. Field approvals of VNAV system installations should be limited to follow-on installations where the original approval was through the TC or STC process and where the system installation is either of the stand-alone kind or where it is interfaced with the same autopilot, flight director, and aircraft instruments. Field approvals without engineering assistance should not be made when:

(1) The VNAV equipment transfers or accepts data from navigation systems, sensors, or computers other than those for which it has previously been approved.

(2) The VNAV equipment is coupled to an autopilot/flight director and the particular installation (aircraft type and VNAV system) has not previously been approved by the TC or STC process.

(3) The aircraft has numerous sources of lateral navigation information installed and available to the VNAV system through a complex switching system.

(4) The VNAV equipment incorporates a software configuration that has not been FAA approved.

3. APPROVAL OF INSTALLATION FOR VFR OPERATIONS. Approval of VNAV system installations for operations under VFR may be obtained by TC, STC, or data field approved by the FAA on an FAA Form 337. If previously approved data is available or the installation can be accomplished by utilizing provisions provided by the airframe manufacturer for standard avionics equipment installations, the installation can then be approved for return to service signed by one of the entities noted in FAR 43; i.e., repair station, manufacturer, holder of an inspection authorization, etc., provided the installation:

a. Conforms to the acceptable methods, techniques, and practices contained in AC 43.13-1A, Acceptable Methods, Techniques and Practices--Aircraft Inspection and Repair, and AC 43.13-2A, Acceptable Methods, Techniques, and Practices--Aircraft Alterations.

b. Does not interfere with the normal operation of other equipment installed in the aircraft. This is accomplished by a ground test and flight test to check that the VNAV equipment is not a source of objectional electromagnetic interference (EMI), is functioning properly and safely, and operates in accordance with the manufacturer's specifications.

c. Does not involve complex switching for integration with other aircraft systems; e.g., electronic flight instrument system (EFIS) displays, various lateral navigation systems, etc. The VNAV system should not be coupled to the vertical navigation function of an autopilot or flight director unless the specific VNAV system, autopilot, and aircraft type have previously been approved under the TC or STC process.

d. Provides a navigation source annunciator if the VNAV installation supplies any information to displays such as an HSI or CDI which can also display data from other equipment normally used for aircraft navigation.

e. Except for items c and d of this paragraph, is completely isolated from all IFR systems.

f. Has an approval recordation contained in an FAA Form 337 and that a placard is in clear view of the pilot which indicates "VNAV System Not Approved For IFR."

APPENDIX 2. SAMPLE AIRPLANE FLIGHT MANUAL SUPPLEMENT.

INSTALLATION CENTER/FAA REPAIR STATION #_____
123 Fourth Street Anytown, USA

FAA APPROVED AIRPLANE FLIGHT MANUAL SUPPLEMENT
VNAV SYSTEM

AIRPLANE MAKE:

AIRPLANE MODEL:

AIRPLANE SERIAL NUMBER:

AIRPLANE REGISTRATION NUMBER:

This document must be carried in the airplane at all times. It describes the operating procedures for the _____ VNAV System when it has been installed in accordance with (manufacturer's installation manual) and FAA Form 337 dated _____.

For airplanes with a Pilot's Operating Handbook and/or FAA approved Airplane Flight Manual, this document serves as the FAA approved _____ VNAV System Flight Manual Supplement. When the _____ VNAV System is installed in an airplane that does not have an FAA approved Airplane Flight Manual, this document serves as the FAA approved Supplemental Flight Manual.

The information contained herein supplements or supersedes the basic Airplane Flight Manual only in those areas listed herein. For limitations, procedures, and performance information not contained in this document, consult the basic Airplane Flight Manual (if applicable).

FAA APPROVED: _____
(Inspector's Name)
Aviation Safety Inspector (Avionics)
ACE-GADO/ACDO/FSDO #_____
Federal Aviation Administration

FAA APPROVED
DATE: _____

INSTALLATION CENTER/FAA REPAIR STATION #_____
123 Fourth Street
Anytown, USA

FAA APPROVED AIRPLANE FLIGHT MANUAL SUPPLEMENT
VNAV SYSTEM

SECTION 1

INTRODUCTION

A. EQUIPMENT DESCRIPTION

Provide a general description of the VNAV equipment installed in the aircraft.

B. GENERAL

Provided the _____ VNAV system is receiving adequate usable signals, it has been demonstrated capable of and has been shown to meet the accuracy requirements of:

VFR/IFR en route, terminal, and approach (if applicable) VNAV operation within the conterminous United States and Alaska in accordance with the criteria of AC 20-129.

FAA APPROVED
DATE: _____

INSTALLATION CENTER/FAA REPAIR STATION #_____
123 Fourth Street
Anytown, USA

FAA APPROVED AIRPLANE FLIGHT MANUAL SUPPLEMENT
VNAV SYSTEM

SECTION II

LIMITATIONS

A. The _____ VNAV System Pilot's Guide, P/N _____, dated _____, (or later revision) must be immediately available to the flight crew whenever navigation is predicated on the use of the system.

B. When using the _____ VNAV system, the altimeter must be used as the primary altitude reference for all operations.

C. Minimum altitude for autopilot coupled VNAV operation is _____ feet (AGL).

FAA APPROVED
DATE: _____

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123 Fourth Street
Anytown, USA

FAA APPROVED AIRPLANE FLIGHT MANUAL SUPPLEMENT
VNAV SYSTEM

SECTION III

EMERGENCY PROCEDURES

A. If VNAV information is intermittent or lost, disengage VNAV and utilize the altimeter for vertical guidance.

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DATE: _____

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Anytown, USA

FAA APPROVED AIRPLANE FLIGHT MANUAL SUPPLEMENT
VNAV SYSTEM

SECTION IV

NORMAL PROCEDURES

A. OPERATION

Normal operating procedures are outlined in the Pilot's Guide, P/N _____ dated _____, (or later revision).

B. SYSTEM ANNUNCIATORS

Describe each remote annunciator, such as:

1. Waypoint (WPT)

2. Message (MSG)

C. SYSTEM SWITCHES

Describe the function and operation of the various switches used with the system.

D. PILOT'S DISPLAY

Describe the pilot's display (i.e., CDI, HSI, RMI, OBS).

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123 Fourth Street
Anytown, USA

FAA APPROVED AIRPLANE FLIGHT MANUAL SUPPLEMENT
VNAV SYSTEM

E. COPILOT'S DISPLAY

Describe the copilot's display (i.e., CDI, HSI, RMI, OBS).

F. AUTOPILOT OPERATION

Describe the coupling of VNAV System steering information to the autopilot.

G. FLIGHT DIRECTOR

Describe the coupling of VNAV System steering information to the flight director.

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DATE: _____

INSTALLATION CENTER/FAA REPAIR STATION #_____
123 Fourth Street
Anytown, USA

FAA APPROVED AIRPLANE FLIGHT MANUAL SUPPLEMENT
VNAV SYSTEM

SECTION V

ABNORMAL PROCEDURES

No change.

SECTION VI

PERFORMANCE

No Change

FAA APPROVED
DATE: _____

APPENDIX 3. SAMPLE DATA SHEET TO ATTACH TO FAA FORM 337.

ATTACH TO FAA FORM 337
AIRPLANE MAKE:

AIRPLANE MODEL:

AIRPLANE SERIAL NUMBER:

AIRPLANE REGISTRATION NUMBER:

DATE WORK COMPLETED:

_____ Vertical Navigation System, consisting of the following components, was installed per _____ Installation Manual Number _____, Revision _____, dated _____. The installation conforms to AC 43.13-1A and AC 43.13-2A.

Equipment	Part Number	Serial Number	Software Version
____ VNAV Computer	xxx-xx-xxxx	yyyy-zz	ww
____ Control/Display	xxx-xx-xxxx	yyyy-zz	ww
etc.			

Proper ground operation of the _____ system was confirmed through completion of the system checkout, Section ____, of the Installation Manual. The system was found to meet or exceed all specifications of this section.

A flight check was made to insure that the accuracy requirements of AC 20-129 were met during flight.( ) YES ( ) NOT APPLICABLE