U.S. Department
of Transportation
Federal Aviation
Administration

Advisory Circular

Subject: Laser Airworthiness Installation Guidance

Date: 12/15/14 **AC No: 20-183**
Initiated By: AIR-134

1 **PURPOSE.**

1.1 In this advisory circular (AC), we recommend one way to obtain Federal Aviation Administration (FAA) airworthiness approval for the installation of aircraft-mounted, nonrequired, invisible spectrum laser equipment such as infrared surveillance laser and light detection and ranging (LIDAR) equipment. This AC is not mandatory and does not constitute a regulation. This AC describes an acceptable means, but not the only means, to comply with the requirements found in Title 14 of the Code of Federal Regulations (14 CFR) 23.1301, 23.1309, 23.1529, 23.1581, 25.1301, 25.1309, 25.1529, 25.1581, 27.1301, 27.1309, 27.1529, 27.1581, 29.1301, 29.1309, 29.1529, and 29.1581 for the laser equipment aspects only. If you use the means described in this AC, you must follow it in its entirety.

1.2 This AC only addresses unique laser airworthiness installation requirements. It is not comprehensive installation guidance for airborne equipment with lasers because it does not address all the applicable installation airworthiness requirements such as those discussed in paragraph 7 below.

1.3 This AC is not intended for installations seeking airworthiness approval of required aircraft equipment that has a laser with radiation contained within a protective housing (for example, a ring laser gyro).

1.4 This AC is not intended for laser-based weapons and aircraft self-protection countermeasures equipment installations.

1.5 This AC is only intended for invisible lasers. This AC does not apply to visible lasers because they pose additional hazards (such as flash blindness) that are not addressed in this AC.

1.6 Additional airworthiness certification criteria beyond what is described in this AC would be required for installations intended for laser operation with head- or helmet-mounted vision devices such as night vision goggles (NVG). For NVG

1.7 guidance, refer to AC 27.1, *Certification of Normal Category Rotorcraft*, miscellaneous guidance (MG) 16, or AC 29.2, *Certification of Transport Category Rotorcraft*, MG 16.

2 AUDIENCE.

We wrote this AC for aircraft manufacturers, laser equipment manufacturers, installation shops, and other applicants seeking FAA airworthiness approval of invisible spectrum laser equipment installations on part 23, 25, 27, and 29 aircraft. The airworthiness approval can occur under a type certificate (TC), supplemental type certificate (STC), amended type certificate (ATC), amended supplemental type certificate (ASTC) or data approval for major alteration. This AC also provides guidance to FAA personnel involved in a TC, STC, ATC, ASTC, or data approval for major alterations that install invisible spectrum laser equipment.

3 BACKGROUND.

3.1 Laser Surveillance Equipment.

Local, State, and Federal law enforcement agencies use forward looking infrared (FLIR) equipment with laser illuminators, pointers, and range finders for nighttime, covert surveillance. Laser surveillance equipment may be used to support several kinds of tasks and missions, varying from target range-finding to illuminating small spots or large areas. Certification of such airborne surveillance equipment installations with lasers presents some unique challenges because lasers can pose a potential eye hazard to flight crew, passengers, other aircraft occupants, and the nonflying public. Laser surveillance equipment typically uses class IIIb or IV lasers. Before this guidance, many surveillance systems were installed using an STC for laser surveillance equipment that only included provisional wiring for the laser. For these installations, the STC type design would show that the laser was electrically disabled. These installations may have not completely addressed all the laser hazards.

3.2 LIDAR.

A LIDAR uses a laser to perform ranging by measuring the reflected return of a projected laser beam. LIDAR devices can be used in mapping terrain elevation, obstacles, and vegetation; or atmospheric measuring (for example, particulate tracking or turbulence monitoring). Some LIDARs use an internal class IIIb or IV laser, and through an internal mechanism, diffuse the external laser emissions to a class I level. LIDAR external laser emissions can range from class I to class IV.

3.3 Eye Hazard.

FLIR and LIDAR lasers can be especially hazardous because the beam is invisible and there is no blink reflex reaction to protect the eye, so eye exposure may initially go undetected. Exposure to lasers operating within the 750 to 1,400 nanometer (nm) near infrared spectrum can cause retinal eye damage. The 400 to 1,400 nm wave band is known as the retinal hazard region. Laser equipment that operates in the 315 to 400 nm ultraviolet or the 1,400 to 10,600 nm far infrared spectrums can damage the cornea,

lens, or both. Most FLIR and LIDAR lasers operate with a wavelength of 800 to 1570 nm. The extent of eye damage depends on the laser exposure dose.

4 ROLES AND RESPONSIBILITIES.

4.1 FAA Regulatory Authority Role.

The FAA is responsible for issuing a design approval (such as an STC) or other data approval for an aircraft laser installation when an applicant demonstrates the laser installation meets the applicable airworthiness requirements.

4.2 Food and Drug Administration (FDA) Regulatory Authority Role.

The FDA has the authority to regulate light-emitting products and electronic product radiation (Title 21 of the United States Code section 360ii, Program of control). The FDA is also responsible for approval or disapproval of variance applications for a laser not meeting the laser performance standards found in Title 21 of the Code Federal Regulations (21 CFR) part 1040, Performance Standards for Light-Emitting Products.

4.3 Laser Manufacturer Equipment Certification Role.

The laser manufacturer is responsible for self-certifying that the laser meets the performance standards in § 1040.10, Laser products, and obtaining a variance from the FDA when laser equipment does not meet a laser performance standard.

4.4 Installation Applicant Role.

The applicant who applies for an installation design approval is responsible for meeting all applicable FAA airworthiness and FDA laser performance and variance requirements.

5 DEFINITIONS.

5.1 Accessible Emission Limit (AEL).

The maximum accessible emission level permitted by the FDA within a particular laser hazard class as stated in § 1040.10(c), (d), and (e).

5.2 Divergence.

The increase in diameter of the laser beam with distance from the exit aperture. Divergence is an angular measurement of the beam spread, expressed in milliradians (mrad) defined at the points where the irradiance is 37 percent of the peak irradiance.

5.3 Irradiance.

A means of expressing power of the beam per unit area, which is expressed in watts per centimeter squared (W/cm2).

5.4 **Maximum Permissible Exposure (MPE).**

The level of laser radiation to which an unprotected person may be exposed without hazardous effect or adverse biological change in the eye or skin, normally expressed in milliwatts per centimeter squared (mW/cm2) or millijoules per centimeter squared (mJ/cm2).

5.5 **Nominal Ocular Hazard Distance (NOHD).**

The distance from the laser beyond which the laser radiation does not exceed the MPE.

5.6 **Specular Reflection.**

A mirror-like deviation of radiation (light) following incidence on a surface.

6 **LASER CLASSES.**

The FDA recognizes four major hazard classes (I to IV) of lasers, including three subclasses (IIa, IIIa, and IIIb) as shown in the table below. International Electrotechnical Commission (IEC) equivalent laser classes are included in table 1 for products labeled under the classification system of the IEC.

Table 1. Laser Classes and Product Hazard

Class FDA	Class IEC	Laser Product Hazard
I	I, IM	Considered nonhazardous. Hazard increases if viewed with optical aids, including magnifiers, binoculars, or telescopes.
IIa, II	2, 2M	Hazard increases when viewed directly for long periods of time. Hazard increases if viewed with optical aids.
IIIa	3R	Depending on power and beam area, can be momentarily hazardous when directly viewed or when staring directly at the beam with an unaided eye. Risk of injury increases when viewed with optical aids.
IIIb	3B	Immediate skin hazard from direct beam and immediate eye hazard when viewed directly.
IV	4	Immediate skin hazard and eye hazard from exposure to either the direct or reflected beam; may also present a fire hazard.

7 **LASER EQUIPMENT INSTALLATION GUIDANCE.**

This section provides installation guidance for the laser aspects of equipment with invisible wavelength lasers. In addition to this specific laser installation guidance, the

installation must meet all other applicable airworthiness requirements such as those involving electrical system capacity, electrical circuit protection, lightning direct effects, ice protection, flammability, environmental qualification (such as radiated emissions, crash safety, vibration, and temperature), changes to flight and handling characteristics (such as drag, stall, max and min air speeds, and trim), vibration, structures, static and pitot systems, and electrical wiring interconnection systems. Laser equipment installations typically follow three basic steps: (1) laser equipment manufacturer certification of the laser equipment, (2) FDA review and approval of variance, and (3) FAA laser equipment installation approval. A fourth step to recertify the laser equipment may be required if the installer modifies the laser or deviates from an FDA variance. Step 2 would not be required for installations of FDA class I lasers or IEC class 1, 2, and 3R lasers.

7.1 **Laser Equipment Certification.**

Laser equipment installers must install the equipment according to the manufacturer's specifications as certified by the manufacturer to the FDA. Before installing the laser equipment, the installer must comply with all applicable FDA 21 CFR requirements (such as §§ 1002.10, 1010.2, 1010.3, 1040.10, and 1040.11) and have a label or tag permanently affixed to, or inscribed on, the laser equipment certifying the equipment complies with performance standards for laser products under part 1040. If this label or tag specifies an FDA variance, the type design for the installation must show that the variance's technical controls applicable to the installation (such as aircraft interface safety interlock) have been satisfied.

7.2 **FDA Variance.**

According to the FDA, surveillance lasers and LIDAR systems are considered "surveying, leveling, and alignment laser products," which are specific purpose laser products described in § 1040.11(b) and limited to class I AEL for the invisible laser wavelengths. However, most airborne surveillance lasers and some LIDARs exceed the allowable class I AELs for the invisible wavelengths and therefore require variances as described in § 1010.4. For products labeled under the classification system of the IEC, classes 1, 2, and 3R are acceptable class limits for an invisible emission and therefore do not require a variance. The FDA variance may require administrative controls (for example, the laser equipment purchasing organization is to maintain an active program of training for its employees in the safe use of the laser system) and technical controls (such as a range finder cutoff that disables the laser when the distance between the laser's aperture and the object being exposed is less than the NOHD).

7.3 **Aircraft Laser Equipment Installation.**

7.3.1 <u>System Safety Analysis.</u>

You must perform a system safety analysis to assess whether the installed laser equipment meets 14 CFR 23.1309, 25.1309, 27.1309, or 29.1309. Refer to AC 23.1309-1, *System Safety Analysis and Assessment for Part 23 Airplanes*. For part 25 airplanes, refer to AC 25.1309-1, *System Design and Analysis*. For part 27 rotorcraft, refer to AC 27.1309, *Equipment, Systems and Installations*. For part 29

rotorcraft, refer to AC 29.1309, *Equipment, Systems and Installations*. The systems safety assessment should address the following:

7.3.1.1 Laser Equipment Malfunction.

Laser equipment malfunction resulting in an aircraft crewmember's or passenger's eye or skin being exposed to invisible laser radiation exceeding the MPE is considered no less than a hazardous functional failure condition and could be catastrophic if continued safe flight is not possible because of the severity of the laser damage to a pilot's eye or skin. In your system safety assessment, you should document the rationale for a hazardous functional failure condition classification. If there is no direct or reflected path into the cockpit or cabin because of the location of the laser and physical shielding provided by the aircraft structure, this failure condition does not apply.

7.3.1.2 System Safety Considerations.

In assessing the failure conditions, you should consider direct and reflected radiation; the location of the laser, laser beam steering mechanism, and circuitry; the use of mechanical, software, or airborne electronic hardware (AEH) stops that prevent the laser from being steered in a direction that could result in the aircraft occupants' eyes being exposed to direct or reflected radiation; laser arming and firing circuitry; and other design features whose malfunction could contribute to an inadvertent exposure or an exposure that exceeds the MPE (such as failure of the internal laser diffuser used to reduce the AEL). If the laser's steering stops are implemented in software or AEH, their assurance level should be commensurate with the functional failure condition associated with the stops. Reflections off any part of the aircraft (such as the structure, blades, skids, or landing gear) should be considered specular.

7.3.1.3 Aircraft Structure.

Any malfunction resulting in damage to aircraft structure due to laser exposure should be assessed to determine the extent of aircraft damage and the associated functional failure condition classification.

7.3.1.4 Equipment Interfaces.

Any malfunction of the laser equipment's interfaces with other aircraft system will have to be assessed to determine the effect on the aircraft system and laser equipment as well as the associated functional failure condition classifications.

7.3.1.5 Other Functional Failure Condition.

Other malfunctions not described in paragraphs 7.3.1.1 through 7.3.1.4 of this AC should be identified and assessed to determine their functional failure conditions.

7.3.1.6 Loss of Function.

Because the laser is nonrequired equipment, the functional failure condition for loss of the laser function is "no effect."

7.3.2 NOHD and MPE Calculations.

You should provide a report that documents how the NOHD and MPE were calculated to include all equations, references for those equations, table references, equation parameters (such as wavelength, divergence, exposure time, and power), dimensions for the reflected and direct radiation paths into aircraft's windows, and justification for the exposure duration. For laser illuminators, spotters, range finders, and other nonscanning lasers, the NOHD exposure duration should be based on the maximum exposure duration expected, but not less than 10 seconds. AC 70-1, *Outdoor Laser Operations,* and American National Standards Institute document ANSI Z136.1, *American National Standard for Safe Use of Lasers*, provide acceptable means to calculate MPE and NOHD.

7.3.3 Installation Type Design.

The installation type design must include all the 21 CFR 1040 requirements that would be applicable to the installation (such as the key control, emissions indicator, labels, and remote interlock connector) and the technical controls (such as the aircraft interface safety interlock) from the FDA variance that affect the aircraft installation.

7.3.4 Software.

If the laser equipment includes software that can contribute to malfunctions described in paragraph 7.3.1 above, develop the software using the guidance in AC 20-115C, *Airborne Software Assurance*, to a software level commensurate with the functional failure condition classifications determined from paragraph 7.3.1.

7.3.5 AEH.

If the laser equipment includes custom AEH (such as an application-specific integrated circuit, field programmable logic device, or programmable logic device), which can contribute to the malfunctions described in paragraph 7.3.1 above, develop the AEH using RTCA, Inc., document RTCA/DO-254, *Design Assurance Guidance for Airborne Electronic Hardware*, to a design assurance level commensurate with the functional failure condition classifications determined from paragraph 7.3.1. For custom AEH classified as simple, paragraph 1.6 of RTCA/DO-254 applies.

Note: We encourage the use of industry-recognized system safety standards (such as SAE International ARP 4761 and IEC 61508) and development assurance standards (such as RTCA/DO-178C, RTCA/DO-254, and IEC 61508) for the laser equipment when its malfunction could result in an exposure that could exceed the MPE for people outside the laser-equipped aircraft.

7.3.6 Configuration Control.

Unapproved changes to the laser equipment or the installation should not be made because they could affect the airworthiness (for example, electromagnetic and

environmental compatibility or new failure modes) of the equipment installation and invalidate the laser equipment certification and FDA-approved variances. The applicant should provide a plan for maintaining configuration throughout the product life cycle. If the installation results in a modification to the laser equipment as certified by the laser equipment manufacturer, the laser equipment must be recertified as described in § 1040.10(i).

7.3.7 Aircraft Flight Manual Supplement (AFMS).

An approved AFMS is required for laser equipment installation where airframe limitations, operational procedures, or the flight characteristics of the basic aircraft change because of the proposed modification. It should include any special procedures required for safe operation of the laser system. It must also include any changes to the limitations of the aircraft caused by the installation, particularly for externally mounted systems. AC 70-1 should be consulted for additional requirements and permits.

7.3.7.1 For the laser equipment installation, the AFMS must include the following limitations:

7.3.7.1.1 The laser must not be used to intentionally radiate other flying aircraft.

7.3.7.1.2 The laser must not be used on the ground or during taxi, takeoff, or landing. For FDA class IIIb and IV lasers and IEC class 3B and 4 lasers, the key control must be in the off position on the ground and during taxi, takeoff, and landing.

7.3.7.1.3 The laser must not be used to radiate people when the distance between the laser and the people is less than the NOHD. The NOHD should be specified in the AFMS or on a placard.

7.3.7.1.4 The atmospheric conditions when the laser must not be used (such as rain or snow).

7.3.7.1.5 The flight conditions when the laser must not be used (such as angle of bank, flying in close proximity to terrain, or hoist operations).

7.3.7.1.6 The laser must not be used if any of the laser safety interlocks that require an interface to an aircraft system are inoperable. The AFMS should identify the aircraft interface safety interlocks. An FDA variance could require an aircraft interface safety interlock (such as an interface with a radar altimeter that disables the laser when the aircraft height above the terrain is less than a specified altitude).

7.3.7.1.7 The aircraft configurations when the laser must not be used (such as when cargo mirrors are installed since they may provide a reflected path into the cockpit).

7.3.7.2 The AFMS must also contain the following user information identified in § 1040.10(h)(1):

7.3.7.2.1 Adequate instruction for operation, including warnings and cautions concerning precautions to avoid possible exposure to laser and collateral radiation above accessible limits.

7.3.7.2.2 Legible reproductions of all labels and hazard warnings required by §§ 1040.10(g) and 1040.11 to be affixed to the laser product.

7.3.7.2.3 A listing of all controls, adjustments, and normal, abnormal, and emergency procedures for operation including the following statement: "Caution—use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure."

7.3.8 Laser Safety Program.

We recommend that the aircraft operator establish a laser safety program in accordance with ANSI Z136.1, paragraph 1.3.

7.3.9 Instructions for Continued Airworthiness (ICA).

In addition to what is required by the airworthiness regulations, the ICA should contain the following laser service information:

7.3.9.1 Procedures for service with appropriate warnings and precautions to avoid exposure to laser and collateral radiation above the accessible emission limits,

7.3.9.2 A schedule of maintenance to maintain the product in compliance,

7.3.9.3 A listing of controls and procedures that could increase the level of accessible radiation,

7.3.9.4 Identification of removable portions of protective housings allowing human access to laser or collateral radiation above the accessible emission limits,

7.3.9.5 Procedures to avoid exposure to levels of laser and collateral radiation known to be hazardous for each procedure or sequence of maintenance procedures to be accomplished,

7.3.9.6 Reproductions of required labels (color optional) and warnings, and

7.3.9.7 Equipment location of the required labels and warnings.

7.3.10 STC Limitations.

The STC limitations must contain the FDA variance's administrative controls that would limit the applicability of the STC (for example, government agencies only).

7.3.11 LIDAR Installations

Appendix B identifies the section 7.3 paragraphs that should be applied to one example LIDAR installation configuration, provides recommendations for installations with multiple LIDAR equipment configurations, and provides the criteria for a LIDAR equipment change to be considered a minor change in type design or a minor alteration.

8 PUBLIC USE.

8.1 Most surveillance lasers were developed for public use operations and were not developed using FAA-recognized software assurance, system assurance, airborne electronic hardware assurance, and safety analysis process. As a result, they will most likely not meet the applicable airworthiness requirements. We recognize public aircraft, as defined in Title 49 of the United States Code sections 40102(a)(41) and 40125, are not required to meet FAA airworthiness requirements. However, if the public aircraft operator wishes to remain FAA compliant, the applicant must either (1) satisfy the guidance materials in paragraph 7 of this AC, or some acceptable alternative, or (2) the type design for the installation must show the laser feature is disabled. The following are the installation certification, maintenance, and flight manual requirements for a disabled laser:

8.1.1 The type design data must show the laser feature is disabled (for example, the arming and firing wiring harness connector is capped and stowed). The nonlaser features (such as FLIR) can be electrically enabled and operational.

8.1.2 Before operating the aircraft in operations other than public use, the laser features must be disabled through some maintenance action (such as removing a dongle or disconnecting, capping, and stowing a wiring harness).

8.1.3 The installed laser equipment should comply with all applicable 21 CFR requirements (such as §§ 1002.10, 1010.2, 1010.3, 1010.4, 1040.10, and 1040.11).

8.1.4 The ICA must include inspection instructions to verify the laser's feature is disabled. The procedures to transition from the FAA-approved civil use configuration to the modified public use configuration and back to the civil use configuration should be included in the ICA.

8.1.5 The ICA should contain maintenance procedures to protect the maintainers from laser hazards.

8.1.6 For TC or ATC installations, the limitation in the type certificate data sheet (TCDS) must state: "Laser operation is not FAA approved for civil aircraft operations. The laser is disabled."

8.1.7 For STC or ASTC installations, the limitation in the "Limitations and Conditions" section must state: "Laser operation is not FAA approved for civil aircraft operations. The laser is disabled."

8.1.8 The flight manual supplement must include a limitation stating: “Laser features are not FAA approved for civil aircraft operations. These features are disabled.”

8.1.9 The following caution must be added to the flight manual supplement: “The FAA has not assessed all hazards associated with the laser feature(s) and the FAA has not validated the manufacturer’s laser safety or hazard assessments.”

8.1.10 A placard must be installed near the laser controls stating: “Laser operation is not FAA approved.”

9 APPLICABLE 14 CFR SECTIONS.

Refer to 14 CFR 23.1301, 23.1309, 23.1529, 23.1581, 25.1301, 25.1309, 25.1529, 25.1581, 27.1301, 27.1309, 27.1529, 27.1581, 29.1301, 29.1309, 29.1529, and 29.1581. For part 23 aircraft, § 23.1301 may not be applicable.

10 APPLICABLE 21 CFR SECTIONS.

Refer to 21 CFR 1002.10, 1002.13, 1002.20, 1010.2, 1010.3, 1010.4 1040.10, and 1040.11.

If you have any suggestions for improvements or changes, you may use the template provided at the end of this AC.

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Appendix A. Related Documents

A.1 FEDERAL AVIATION ADMINISTRATION (FAA) ADVISORY CIRCULARS (AC).

A.1.1 AC 27-1B, *Certification of Normal Category Rotorcraft.*

A.1.2 AC 29-2C, *Certification of Transport Category Rotorcraft.*

A.1.3 AC 20-115C, *Airborne Software Assurance.*

A.1.4 AC 20-152, *RTCA, Inc., Document RTCA/DO-254, Design Assurance Guidance for Airborne Electronic Hardware.*

A.1.5 AC 20-168, *Certification Guidance for Installation of Non-Essential, Non-Required Aircraft Cabin Systems & Equipment (CS&E).*

A.1.6 AC 20-171, *Alternatives to RTCA/DO-178B for Software in Airborne Systems and Equipment.*

A.1.7 AC 23.1309-1, *System Safety Analysis and Assessment for Part 23 Airplanes.*

A.1.8 AC 25.1309-1, *System Design and Analysis*.

A.1.9 AC 27.1309, *Equipment, Systems, and Installations* (included in AC 27-1B).

A.1.10 AC 29.1309, *Equipment, Systems, and Installations* (included in AC 29-2C).*sure*

A.1.11 AC 70-1, *Outdoor Laser Operations.*

A.2 INDUSTRY STANDARDS.

A.2.1 SAE International (SAE) ARP4761, *Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment.*

A.2.2 RTCA, Inc., document RTCA/DO-160G, *Environmental Conditions and Test Procedures for Airborne Equipment.*

A.2.3 RTCA/DO-178C, *Software Considerations in Airborne Systems and Equipment Certification.*

A.2.4 RTCA/DO-254, *Design Assurance Guidance for Airborne Electronic Hardware.*

A.2.5 RTCA/DO-313, *Certification Guidance For Installation Of Non-Essential, Non-Required Aircraft Cabin Systems And Equipment.*

A.2.6 American National Standards Institute document ANSI Z136.1, *American National Standard for Safe Use of Lasers*.

A.2.7 SAE ARP5572, *Control Measures for Laser Safety in the Navigable Airspace*.

A.2.8 SAE ARP5293, *Safety Considerations for Lasers Projected in the Navigable Airspace.*

A.2.9 SAE ARP5674, *Safety Considerations for Aircraft-Mounted Lasers Projected Into the Navigable Airspace.*

A.2.10 International Electrotechnical Commission document IEC 61508, *Functional safety of electrical/electronic/programmable electronic safety-related systems.*

A.2.11 International Electrotechnical Commission document IEC 60825-1, *Safety of laser products - Part 1: Equipment classification and requirements.*

A.3 OTHER DOCUMENTS.

A.3.1.1 Food and Drug Administration document FDA 86-8260, *Compliance Guide for Laser Products.*

A.3.1.2 Food and Drug Administration document Laser Notice No. 50, *Laser Products – Conformance with IEC 60825-1 and IEC 60601-2-22; Guidance for Industry and FDA Staff.*

A.4 HOW TO GET RELATED DOCUMENTS.

A.4.1 Order SAE documents from SAE World Headquarters, 400 Commonwealth Drive, Warrendale, PA, 15096-0001; telephone (724) 776-4970, fax (724) 776-0790. You can also order copies through the SAE website at: www.sae.org.

A.4.2 Order copies of RTCA documents from RTCA, Inc., 1150 18th Street NW., Suite 910, Washington, DC, 20036; telephone (202) 833-9339, fax (202) 833-9434. You can also order copies on the RTCA website at: www.rtca.org.

A.4.3 Order copies of 14 CFR parts from the Superintendent of Documents, Government Printing Office, P.O. Box 37154, Pittsburgh, PA, 15250-7954. You can order copies through the Government Printing Office website at: http://bookstore.gpo.gov/catalog/laws-regulations/code-federal-regulations-cfrs-print/cfr-title-14-aeronautics-space.

A.4.4 You can find copies of ACs on the FAA website at: http://www.faa.gov/regulations_policies/advisory_circulars/.

A.4.5 You can find copies of 21 CFR sections on the FDA website at: http://www.fda.gov/MedicalDevices/DeviceRegulationandGuidance/Databases/default.htm/.

A.4.6 You can find copies of the FDA Compliance Guide at: http://www.fda.gov/downloads/MedicalDevices/DeviceRegulationandGuidance/GuidanceDocuments/UCM095304.pdf.

A.4.7 You can find copies of the FDA Laser Notice No. 50 at: http://www.fda.gov/MedicalDevices/DeviceRegulationandGuidance/GuidanceDocuments/ucm094361.htm

A.4.8 Order copies of ANSI standards from the ANSI standards store at: http://webstore.ansi.org/.

A.4.9 Order copies of IEC documents from the IEC web store at: http://webstore.iec.ch/.

Appendix B. LIDAR Equipment Installations

B.1 CLASS 3R LIDAR EXAMPLE

B.1.1 The table below identifies the section 7 paragraphs that would apply for an internally mounted LIDAR with an opening in the bottom of the fuselage for the LIDAR's laser aperture. For this example, there is no direct path or reflected path into the cabin or cockpit windows from the laser at all scan angles. The LIDAR is an IEC class 3R laser. The only aircraft electrical interface is for electrical power. There is a laser emissions indicator, laser safety switch and a LIDAR flight guidance display in the cockpit.

Table 2. Applicable Section 7 Paragraphs

Para	Title	Does it Apply?	Comment
7	Laser Equipment Installation	Yes	The equipment installation must be shown to meet all the applicable airworthiness requirements such as electrical load capacity, circuit protection, wiring, bonding, and grounding; flammability; environmental qualification; ICA; AFMS; and structural and stress aspects. Since the laser equipment is nonrequired aircraft cabin-mounted equipment, the guidance in AC 20-168 could be used for the airworthiness requirements not specifically addressed in Section 7.3 herein.
7.1	Laser Equipment Certification	Yes	The laser equipment must comply with all applicable FDA 21 CFR standards. Since the laser equipment complies with IEC standard 60825-1, the FDA's Laser Notice No. 50 may be used to determine what IEC 60825-1 guidance can be substituted for the FDA's 21 CFR standards.
7.2	FDA Variance	No	Since the LIDAR is a class 3R laser, a variance is not required
7.3.1	System Safety Analysis	Yes	The results of the systems safety analysis for paragraphs 7.3.1.1, 7.3.1.2, 7.3.1.3, 7.3.1.4, and 7.3.1.5 should be documented. For this example, the system safety analysis would document the rationale why the functional failure conditions in paragraphs 7.3.1.1, 7.3.1.2,

			7.3.1.3, 7.3.1.4, and 7.3.1.5 are not applicable.
7.3.1.1	Laser Equipment Malfunction	No	Since there is no direct or reflected path into the cockpit or cabin, the malfunction described in 7.3.1.1 is not applicable.
7.3.1.2	System Safety Considerations	No	Since there is no direct or reflected path into the cockpit or cabin, the malfunction described in 7.3.1.2 is not applicable.
7.3.1.3	Aircraft Structure	No	A class 3R laser is not capable of burning or melting the aircraft structure or paint.
7.3.1.4	Equipment Interfaces	No	The laser equipment does not interface with any other are aircraft systems (e.g. attitude heading reference system) other than electrical power. The electrical power wiring is protected with an appropriately sized circuit breaker.
7.3.1.5	Other Functional Failure Condition	No	Other functional failure conditions should be assessed for each equipment installation. This specific equipment installation does not have other functional failure conditions (such as the laser sensor fails to retract posing a hazard during landing).
7.3.2	NOHD and MPE Calculations	Yes	Since this is not a class I laser, the NOHD and MPE should be calculated and documented in a report.
7.3.3	Installation Type Design	Yes	The type design for the installation should include all the applicable 21 CFR 1040 requirements (such as laser emissions indicator in the cockpit, labels)
7.3.4	Software	No	Based on the system safety analysis, the laser equipment installation has no functional failure conditions that would affect the aircraft or its' occupants. Therefore, the laser equipment software would not have to be developed using AC 20-115C.
7.3.5	AEH	No	Based on the system safety analysis, the laser equipment installation has no functional failure conditions that would affect the aircraft or its' occupants. Therefore, the laser equipment AEH would not have to be developed using AC 20-152.
7.3.6	Configuration Control	Yes	Changes to the laser equipment could affect the laser equipment installation

			airworthiness and the laser equipment certification.
7.3.7	Aircraft Flight Manual Supplement	Yes	An approved AFMS is required for laser equipment installation.
7.3.7.1	Limitations	Yes	The following AFMS limitations would apply: 7.3.7.1.1 Laser must not be used to radiate other flying aircraft. 7.3.7.1.2 Laser must not be used on the ground or during taxi, takeoff, or landing. 7.3.7.1.3 Laser must not be used to radiate people when the distance between the laser and the people is less than NOHD. The NOHD should be specified. 7.3.7.1.4 Atmospheric conditions when the laser must not be used. 7.3.7.1.5 Flight conditions when the laser must not be used (such as angle of bank, flying in close proximity to terrain, or hoist operations). 7.3.7.1.7 Aircraft configurations when the laser must not be used (such as cargo mirrors).
7.3.7.2	User Information	Yes	The following AFMS laser user information would apply: 7.3.7.2.1 Adequate instructions for operation, including warnings and cautions. 7.3.7.2.2 Legible reproductions of all labels and hazard warnings. 7.3.7.2.3 A listing of all controls, adjustments, and normal, abnormal, and emergency procedures for operation including the following statement: "Caution –use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure."
7.3.8	Laser Safety Program	Yes	A laser safety program is recommended.
7.3.9	Instructions for Continued Airworthiness	Yes	In addition to what is required by the airworthiness requirements for an ICA, the ICA should contain the following laser service information: 7.3.9.1 Procedures for service with appropriate warnings and precautions to avoid exposure to laser and collateral

			radiation above the accessible emission limits. 7.3.9.2 A schedule of maintenance to maintain the product in compliance. 7.3.9.3 A listing of controls and procedures that could increase the level of accessible radiation. 7.3.9.4 Identification of removable portions of protective housings allowing human access to laser or collateral radiation above the accessible emission limits. 7.3.9.5 Procedures to avoid exposure to levels of laser and collateral radiation known to be hazardous for each procedure or sequence of maintenance procedures to be accomplished. 7.3.9.6 Reproductions of required labels (color optional) and warnings. 7.3.9.7 Equipment location of the required labels and warnings.
7.3.10	STC Limitations	No	An FDA variance is not required.

B.2 INSTALLATIONS WITH MULTIPLE LIDAR CONFIGURATIONS

Some LIDAR operators have a need to frequently change LIDAR equipment. To support these equipment changes, we recommend that the initial approval (such as an STC, data approval for major alteration) include descriptive data for all the LIDAR configurations that have been demonstrated to comply with the applicable airworthiness standards. The AFMS and ICA should also contain all required data for each LIDAR configuration. For the initial approval, all of the LIDAR configurations would be evaluated for installation airworthiness. The installation approval would list the approved LIDAR configurations.

B.3 APPROVAL OF A NEW LIDAR CONFIGURATION

Installation approval of a new LIDAR configuration may require an ASTC, STC, ATC or data approval for a major alteration and revisions to the ICA and AFMS. The new LIDAR configuration should be evaluated for installation airworthiness such as electrical system capacity, system safety, electrical circuit protection, lightning direct effects, ice protection, flammability, environmental qualification (such as radiated emissions, crash safety, vibration, and temperature), changes to flight and handling characteristics (such as drag, stall, max and min air speeds, and trim), vibration, structures, static and pitot systems, and electrical wiring interconnection systems).

B.4 LIDAR MINOR CHANGE IN TYPE DESIGN OR MINOR ALTERATION

B.4.1 New LIDAR equipment configurations may be approved as a minor change to type design when criteria such as the following are satisfied and the change process is approved by the FAA Aircraft Certification Office serving your geographic area. The following criteria could also be used to classify an alteration as minor.

B.4.1.1 The initial LIDAR equipment installation was approved under a TC, STC, ATC, ASTC, or data approval for major alteration and included LIDAR laser equipment. The previous approval was not just for provisions (such as mounting and electrical power).

B.4.1.2 The new LIDAR equipment installation does not have a direct or reflected path into the cockpit or cabin windows for the laser radiation.

B.4.1.3 The new laser equipment must comply with all applicable FDA 21 CFR requirements (such as §§ 1002.10, 1010.2, 1010.3, 1040.10, and 1040.11) and have a label or tag permanently affixed to, or inscribed on, the laser equipment certifying the equipment complies with performance standards for laser products under part 1040.

B.4.1.4 The new LIDAR equipment laser class must be the same or less than the class of the laser equipment which was previously approved.

B.4.1.5 The new LIDAR equipment does not interface with any aircraft systems (such as air data) with the exception of aircraft electrical power.

B.4.1.6 If the initial LIDAR installation approval required an FDA variance, the new LIDAR equipment requires the same variance.

B.4.1.7 If the original LIDAR installation approval did not require an FDA variance, the new LIDAR equipment does not require a variance.

B.4.1.8 With the exception of a global positioning system puck antenna, all equipment is internally mounted within the aircraft or within a protective housing that is carried outside the aircraft. If it installed in a protective housing, the protective housing must have been approved during the initial installation approval and must not have any modifications.

B.4.1.9 The LIDAR equipment AFMS limitations and user information required by 7.3.7 that were approved during the initial installation approval must apply to the new LIDAR equipment configuration without changes needed. A cockpit placard could be used to identify the new LIDAR model and NOHD in lieu of a revision to the AFMS.

B.4.1.10 For LIDAR equipment that is mounted in the cabin or within a protective housing outside the aircraft, the weight, center of gravity, and envelope of the new equipment must fall within the ranges specified in the initial installation approval. The mounting attachment points and method for the new LIDAR equipment must have been approved during the initial installation approval.

B.4.1.11 Electrical power for all the LIDAR equipment is no greater than the maximum power specified in the initial approval. The new laser equipment should be protected with a circuit breaker or fuse with an amperage rating recommended by the laser equipment manufacturer.

B.4.1.12 All new LIDAR equipment must pass the RTCA/DO-160, Section 21 emissions of radio frequency energy, category M or H.

B.4.1.13 For cabin mounted equipment, the new equipment must pass the RTCA/DO-160, Section 7, crash safety tests.

B.4.1.14 With all the new equipment installed and operating, an aircraft electromagnetic compatibility test is conducted and recorded using an FAA accepted procedure (such as the procedure that was originally used during the initial STC).

B.4.1.15 No additional equipment is installed beyond what was approved during the initial approval.

B.4.1.16 The new equipment must not introduce any new function failure conditions that would affect the airworthiness.

B.4.1.17 Depending on the LIDAR equipment configuration new or revised minor change criteria may be required.

B.4.1.18 Minor changes to an STC are added to the STC descriptive data to include identification of the new LIDAR equipment, results of RTCA testing, NOHD calculations, results of on aircraft electromagnetic testing, circuit breaker size and any data supporting the change.

B.4.1.19 Minor alterations are recorded in the maintenance records.

B.5 TYPE DESIGN AND DATA APPROVAL FOR MAJOR ALTERATION RECOMMENDATIONS

B.5.1 To facilitate the approval of new LIDAR configurations, recommend that the initial installation type design or initial data approval for the major alteration include descriptive data specifying the following:

B.5.1.1 The class of the laser.

B.5.1.2 The allowable weight range, center of gravity range, and maximum envelope for the equipment that is mounted to the aircraft.

B.5.1.3 The mounting attachment points and method for the LIDAR equipment.

B.5.1.4 Maximum electrical power for the LIDAR equipment that the LIDAR equipment circuit breaker and electrical power wiring can support.

B.5.1.5 The LIDAR equipment RTCA/DO-160 tests and categories.

B.5.1.6 The technical and administrative controls for applicable FDA variances.

Appendix C. Advisory Circular Feedback Information

If you have comments or recommendations for improving this advisory circular (AC), or suggestions for new items or subjects to be added, or if you find an error, you may let us know by using this page as a template and 1) emailing it to 9-AWA-AVS-AIR500-Coord@faa.gov or 2) faxing it to the attention of the AIR Directives Management Officer at 202-267-3983.

Subject: (insert AC number and title) Date: (insert date)

Comment/Recommendation/Error: (Please fill out all that apply)

An error has been noted:

Paragraph _____

Page _____

Type of error (check all that apply): Editorial:----- Procedural-----

Conceptual____

Description/Comments:_____
_____
_____

Recommend paragraph _____ on page _____ be changed as follows:
(attach separate sheets if necessary)

_____

In a future change to this advisory circular, please include coverage on the following subject:
(briefly describe what you want added attaching separate sheets if necessary)

_____

Name: _____