

Certification Memorandum

Certification of airborne systems using Light Amplification by Stimulated Emission of Radiation (LASER) with high energy

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**Regulatory requirement(s): CS 23.1301, CS 23.1309, CS 25.1301, CS 25.1309, CS 27.1301, CS 27.1309,
CS 29.1301, CS 29.1309**

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Table of Content

Log of issues..... 2

Table of Content 2

1. Introduction..... 3

 1.1. Purpose and scope 3

 1.2. References 3

 1.3. Abbreviations..... 4

2. Background..... 5

3. EASA Certification Policy 6

 3.1. EASA Policy 6

 3.2. Airworthiness Certification..... 8

 3.3. Who this Certification Memorandum affects..... 11

4. Remarks 11



1. Introduction

1.1. Purpose and scope

The purpose of this Certification Memorandum (CM) is to provide specific guidance supporting the certification for installation of airborne systems based on Light Amplification by Stimulated Emission of Radiation (LASER or laser) with high energy while showing compliance with certification specifications CS XX.1301 and XX.1309. Other aspects of the installations such as aerodynamic effects of the external installations are not considered in the scope of the CM. Moreover, this CM intends to provide guidance for protection of ground personnel, third parties and other aircraft crew from hazards caused by the use of lasers in free airspace.

1.2. References

It is intended that the following reference materials be used in conjunction with this Certification Memorandum:

| Reference | Title | Code | Issue | Date |
|---|---|-------|-------|------|
| Regulation (EC) No 216/2008 | Regulation (EC) No 216/2008 of the European Parliament and of the Council on common rules in the field of civil aviation and establishing a European Aviation Safety Agency | --- | --- | --- |
| Annex Part 21 to Commission Regulation (EU) No 748/2012 21.A.31 21.A.91 | Commission Regulation (EU) No 748/2012 laying down implementing rules for the airworthiness and environmental certification of aircraft and related products, parts and appliances, as well as for the certification of design and production organisations Type design Classification of changes to a type-certificate | --- | --- | --- |
| CS 23.1301 CS 23.1309 CS 23.1529 CS 23.1581 | Certification Specifications for Normal, Utility, Aerobatic, and Commuter Category Aeroplanes | CS-23 | --- | --- |



| Reference | Title | Code | Issue | Date |
|--|---|---|-------|-------------------|
| CS 25.1301 CS 25.1309 CS 25.1529 CS 25.1581 | Certification Specifications and Acceptable Means of Compliance for Large Aeroplanes | CS-25 | --- | --- |
| CS 27.1301 CS 27.1309 CS 27.1529 CS 27.1581 | Certification Specifications for Small Rotorcrafts | CS-27 | --- | --- |
| CS 29.1301 CS 29.1309 CS 29.1529 CS 29.1581 | Certification Specifications for Large Rotorcrafts | CS-29 | --- | --- |
| 21 CFR § 1040.10 21 CFR § 1040.11 | Performance standards for light emitting products | US Code of Federal Regulations Title 21 - part 1040 | --- | --- |
| IEC 60825 | Safety of Laser Products | IEC 60825-1 | 3 | 15 May 2014 |
| ED-135/ ARP4761 | Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment | EUROCAE ED-135/ SAE ARP 4761 | --- | December 1996 |
| ED-79A/ ARP4754A | Guidelines for the development of civil aircraft and systems | EUROCAE ED-79A/ SAE ARP 4754A | A | December 2010 |
| ED-80/DO-254 | Design Assurance Guidance for Airborne Electronic Hardware. | EUROCAE ED-80/ RTCA DO-254 | --- | April 2000 |
| AMC 20-115C | Software Considerations for Certification of Airborne Systems and Equipment | AMC 20 Amendment 10 | C | 12 September 2013 |
| ICAO Doc 9815 | Manual on Laser Emitters and Flight Safety | Doc 9815 / AN-447 | 1 | 2003 |

1.3. Abbreviations

AFM

Aircraft Flight Manual



An agency of the European Union

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Page 4 of 11

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| AMC | Acceptable Means of Compliance |
| CM | Certification Memorandum |
| CS | Certification Specification |
| EASA | European Aviation Safety Agency |
| FAA | Federal Aviation Administration |
| FDA | Food and Drug Administration |
| FLIR | Forward Looking InfraRed |
| GM | Guidance Material |
| ICA | Instructions for Continued Airworthiness |
| IEC | International Electrotechnical Commission |
| LASER | Light Amplification by Stimulated Emission of Radiation |
| LIDAR | Light Detection and Ranging |
| NOHD | Nominal Ocular Hazard Distance |
| RFM | Rotorcraft Flight Manual |
| STC | Supplemental Type Certificate |
| TC | Type Certificate |
| TCDS | Type Certificate Data Sheet |

2. Background

There are many airborne laser systems that may be used for multiple missions and applications by different operators, including but not limited to:

- Laser pointers
- Laser range finders
- Laser illuminators
- Target designators
- LIDAR (Light Detection and Ranging) sensors

Laser systems can be used to point object or locations on the ground or to determine distance (range) to an object for different purposes of law enforcement, search and rescue, military, etc. The laser illuminators can light up large areas with near-infrared or invisible light and require the use of special viewing devices (e.g., night vision goggles or infrared cameras). Lasers may be also used to perform imaging by measuring the reflected return of a projected laser beam; these devices can be used for ground mapping, atmospheric measuring, surveillance, etc. and can emit visible or invisible laser energy.



Airborne lasers may present unique hazards to flight crews, passengers, and people on other aircraft, maintenance personnel and the non-flying public. Exposure to laser light can cause temporary blindness (only if visible) to the flight crew or crews of other aircraft, as well as significant and sometimes permanent injury to the eyes and skin, or damage to the aircraft structure, depending on the laser type, wavelength, power, pulsation, exposure time, distance, beam characteristics and other factors. The classification of laser radiation according to the different available standards is:

| IEC 60825-1 | | 21 CFR §1040.10 (US FDA/CDRH) | |
|--------------|---|-------------------------------|--|
| <i>Class</i> | <i>Description</i> | <i>Class</i> | <i>Description</i> |
| 1 | Not considered to be hazardous | I | Not considered to be hazardous for continuous viewing |
| 1M | No known hazards unless collecting optics are used | - | - |
| - | - | IIa | Considered a chronic hazard depending on the amount of time viewed |
| 2 | No known hazard within 0.25 seconds (aversion response time) | II | Laser radiation is a chronic viewing hazard |
| 2M | Not known to cause eye or skin damage within the aversion response time unless collecting optics are used | - | - |
| 3R | Direct exposure is potentially hazardous. Risk of injury is greater than for the lower classes but not as high as for class 3B. | IIIa | Laser radiation is hazardous to the eyes |
| 3B | Radiation is very likely to be dangerous and can be a hazard to the eye or skin. | IIIb | Acute hazard to skin and eyes from direct radiation |
| 4 | The laser is very dangerous for the eyes and dangerous for the skin. It can potentially cause fires and explosions. | IV | Considered an acute hazard to skin and eyes from direct or scattered radiation |

3. EASA Certification Policy

3.1. EASA Policy

The following policy provides guidelines for systems that contain lasers, while showing compliance with CS XX.1301 and CS XX.1309.

3.1.1 The installation of equipment that only emits Class 1, 1M, 2, 2M or 3R laser energy does not typically require major mitigation for the laser feature as a condition for the installation approval. Such a change shall be classified in accordance with Part 21.A.91.



3.1.2 Due to the hazardous effect of laser systems installations that emit effective¹ Class 3B and 4 lasers external to the equipment **should be classified as a major change** to a type certificate in accordance with Part 21.A.91. Therefore, the applicant should apply for a Major Change Approval or for a Supplemental Type Certificate, whichever is applicable.

Hazards from laser systems that may emit Class 3B or 4 laser energy should be identified and mitigation measures should be included in the installation.

3.1.3 The following hazards should be addressed (but are not necessarily limited to):

- Resulting local heating of material and/or human skin, inside and outside the aircraft
- Eye exposure to direct and indirect beam light inside and outside the aircraft including unintended events taking into consideration expected beam direction(s).

3.1.4 Mitigation strategies may consist of, but are not limited to, the following measures:

- Design related:
 - Automatic deactivation
 - Diffusion of the beam
 - Divergence of the beam
 - Scanning safeguard
 - Usage of protection covers
 - Limitation of the beam angle envelope
- Operational:
 - Operational restrictions
 - Ensuring safe distance

It may be useful to use automatic deactivation at distances less than the Nominal Ocular Hazard Distance (NOHD). When viewing through optical aids, this is termed “extended NOHD (ENOH)””. Some systems may be able to calculate the distance to a target.

The use of “height above the terrain” sensors as the only mean may not be considered optimal as it is not addressing terrain variations and not taking into account the aircraft orientation. Certification guidance for these systems are presented in para 3.2.1.

The fully enclosed Class 3B or 4 laser device that does not emit or transmit laser energy external to the system, or a system that includes such a laser (Class 3B or 4) that through some internal mechanism diffuses the laser energy down to a Class 1, 1M, 2, 2M or 3R laser at emission, is a specific case and may be acceptable for installation and use without requiring disabling capability as a condition of the installation approval. Certification guidance for these types of systems can be found in 3.2.2.

If the Class 3B or 4 laser system is to be used for carrying out operations which are excluded from the remit of Regulation (EC) No 216/2008 (refer to Art. 1.2) (military, customs, police, search and rescue, firefighting, coastguard or similar activities), it is acknowledged that the installation may not be compliant with EASA airworthiness requirements. However, if the applicant wishes the aircraft to remain compliant with an EASA type certification basis, it should satisfy either the guidance materials laid down in para 3.2.1 and 3.2.2 of this

¹ Classification of laser products is normally done by the manufacturer of the laser product, but where this is not the case (e.g. laser components, experimental or prototype systems), then the user should ensure that the effective class of the laser is determined based on the level of its accessible emission in accordance with IEC 60825.



CM respectively or the design of the installation must show that the laser feature is disabled. The same applies to modifications that set the aircraft in the Annex II of the Regulation (EC) No 216/2008.

For disabled laser installations, certification guidance can be found in para 3.2.3 below. In these cases, EASA should not assess all hazards associated with laser operations. Nevertheless, although the laser is to be operated in an EASA unapproved configuration, it should be demonstrated that its use is not causing any damage to aircraft systems so that airworthiness is compromised, when the aircraft is reverted to the EASA approved configuration.

3.2. Airworthiness Certification

3.2.1 Certification provisions for effective Class 3B and 4 lasers on board aircraft to be used during operations under the remit of the Regulation (EC) No 216/2008.

These specific policy guidelines help applicants to comply with all relevant requirements pertaining to installation of such systems by the appropriate Certification Specification (CS).

- a) The development assurance levels for software and airborne electronic hardware should be commensurate with the failure condition category associated with the intentional and inadvertent emission of the laser beam external to the system. Guidance provided in the ED-79A could be used. The applicant can incorporate design installation mitigations intended to address the assessed hazards (e.g., altitude interlocks).

There should be no direct or reflected path (e.g. off the skids, cargo mirror, spinner, landing gear) from the laser into the cockpit or cabin exceeding the relevant exposure limits (MPE, AEL, or the visual interference levels in case of visible laser). Mechanical stops or shielding may be used to ensure the laser emissions cannot be unintentionally aimed or reflected into the cockpit or cabin, thus exposing the occupants to the emissions. A systems safety analysis should be conducted to identify hazards and determine the development assurance levels to mitigate unintentional exposure of crew and passengers to laser energy. If using electronic stops instead of mechanical stops or shielding, the associated Development Assurance Level (DAL) should be equal to or greater than the failure condition category associated with the hazard of unintentionally exposing the pilot, crew or passengers to laser emissions.

Note: Commercial off the shelf systems typically have no Development Assurance qualification and may be used for applications having No Safety Effects (NSE) only. **The direct exposure of occupants, pilot, crew or passengers to laser emissions Class 3B and 4 is considered a hazardous failure condition** and could be catastrophic if continued safe flight is not possible because of the severity of the laser damage to the pilot's eye or skin in the sense of CS XX.1309. Risk to the non-flying public should be operationally treated in a similar way to basic regulation (EC) 216/2008, ANNEX I, item 2 "Airworthiness aspects of product operation".

- b) The laser installation should include safety interlock, remote interlock connector, key control and an emissions indicator. In addition, the laser installation should comply with the laser labelling requirements. The International Standard IEC 60825 is hereby referred for 3.2.1 b) requirements.
- c) To prevent unintentional ground emission and to minimise any hazards to non-flying public, the installation should include a safety 'firing' interlock, such as altitude and direction limiters. The 'firing' interlock can use a radio altimeter or other means to prevent laser emission while on the ground or below a prescribed height above the terrain (e.g., 1,000ft above ground level). If a radio altimeter safety interlock is used, an analysis should be provided that demonstrates the safety interlock will protect the non-flying public for all terrain types to include cities with tall buildings. The interlock system design should optimally control power to the laser emitter. The applicant may propose other interlock means.



- d) Detailed type design and engineering data should be provided for those aspects of the laser system where malfunctions could create hazards in order to ensure adequate manufacturing quality and configuration design control measures to mitigate laser hazards of subsequent installations.
- e) Provisions should be implemented for safety of operation and continued airworthiness and there should be operational and maintenance procedures to protect the flight crew, the flying and non-flying public, and maintenance and ground personnel from the laser hazard. This hazard shall include potential laser exposure such as irradiance at anticipated exposure distances, expected reflection characteristics and other physical considerations, e. g., window transmittance at operational laser wavelength(s). Placards, operation manuals, flight manuals and maintenance manuals should define safe operational practices and procedures, identify hazards and provide appropriate limitations. As a further mean to minimise the risk for the non-flying public, a limitation could be set so, that power to the system and its operation is prohibited when flying over densely populated areas.
- f) The following laser characteristics should be provided by the applicant, (more data may be required):
 - (1) Maximum permissible exposure (MPE),
 - (2) Nominal ocular hazard distance (NOHD),
 - (3) Accessible Emission Limit (AEL)
 - (4) Parameters : wavelength, divergence, emission duration, exposure time, and power

In addition for the characteristics 1 to 3 the rationale and evidence how those characteristics have been established should be provided as well.

The International Standard IEC 60825-1 “Safety of laser products” and the associated parts of IEC 60825 are hereby referred as a guide for these calculations.

For visible lasers, distances where beams are bright enough to distract aircrews or create after-effects on persons are of concern. Laser-beam Sensitive, Laser-beam Critical and Laser-beam Free Flight Zones should be calculated. Those distances and the associated emission level shall be complied.

If the calculated visual effect distance is less (shorter distance) than the NOHD, it shall be warned “Less than NOHD”.

The ICAO Doc 9815 “Manual on Laser Emitters and Flight Safety” is hereby referred as a guide for visible lasers.

- g) The following mitigating factors should be provided as well:
 - (1) Control measure operation and reliability: Control measure reliability, conditions under which control measures might fail or be defeated, any operation when the control measures are defeated for service or maintenance and how the control measures mitigate laser hazards.
 - (2) Aircraft orientations: Orientations of the aircraft such as banking angles and the safety ramifications of flying below surrounding terrain as these factors may have a direct implication that the radar altitude is not a measure for the shortest distance to the non-flying public on the ground.
 - (3) Flight conditions: A list of acceptable flight conditions for use of the laser system and a description of how the system will remain safe in those conditions (e.g., turbulence and rain).
 - (4) Effects on other aircraft: This includes possible effects on other aircraft and the personnel aboard those aircraft.



- (5) Service and maintenance: a description of effects of service and maintenance on safety and how these effects are mitigated. This may include test procedure, calibration certification, etc.
- h) The AFM/RFM (Aircraft Flight Manual/Rotorcraft Flight Manual) or the corresponding supplement should include information, limitations, procedures, as well as cautions and warnings, deriving from manufacturer's safety or hazard assessments in order to warn the operator about the safety risk of the laser, as well as to ensure a safe operation, both in normal and failure condition, as well as protection of the flight crew, the flying and non-flying public and ground personnel from laser hazards.
- Limitations should be included so that the laser emission is deactivated or the laser beam blocked during taxi, take-off and landing.
- i) Manufacturers should establish procedures with the pertinent warnings and precautions to protect persons while operating the laser on ground.

3.2.2 Certification guidance for fully enclosed Class 3B and 4 lasers or lasers with internal diffusion mechanisms onboard civil registered aircraft to be used during operations under the remit of the Regulation (EC) No 216/2008.

This section identifies specific certification guidance for installation of a fully enclosed Class 3B or 4 laser feature that does not emit or transmit laser energy external to the system; or a system that includes such a laser, but through some internal mechanism, diffuses the laser energy down to a Class 1, 1M, 2, 2M or 3R laser at emission. Classification of the change shall be done in accordance with Part 21.A.91. In any case, a system safety analysis should be conducted to identify failure effects. The effect of mechanical failures such as breaking of lens, prism, mirror, optical fiber, etc. should be included. Where the failure effect is classified catastrophic or hazardous, the change should be classified major and provisions in 3.2.1 apply. Where the failure effect is classified Major the criteria set in the Appendix A to GM 21.A.91 paragraph 4(ii) applies.

3.2.3 Certification provisions for effective Class 3B and 4 lasers onboard civil registered aircraft to be used during operations **not under** the remit of Regulation (EC) No 216/2008

This section identifies several provisions for the installation of Class 3B and 4 laser system onboard civil registered aircraft to be used for carrying out operations which are excluded from the remit of Regulation (EC) No 216/2008. The AFM/RFM (supplement) and placard provisions are intended to alert owners and operators that the laser has been deliberately disabled in the EASA approved configuration. These specific policy guidelines help applicants to comply with relevant regulations pertaining to installation of such systems.

- a) Wiring and switch provisions to disable the laser should be part of the approved type design. For the laser feature, the type design data should show that the laser features are disabled. The installation should be designed in a way that during an operation under the remit of Regulation (EC) No 216/2008:
- The crew cannot activate the laser
 - The disabling status of the laser can be checked before starting the operation

Wiring for the non-laser features of the installation (e.g. Forward Looking InfraRed (FLIR)) can be electrically enabled and operational..

- b) For installations with a disabled laser feature, a limitation should be included in the Type Certificate Data Sheet (TCDS), or in the "Limitations and Conditions" section of the Major Change Approval or of the Supplemental Type certificate, whichever is applicable, stating as follows: "Laser operation is not EASA approved. The laser is disabled".



- c) For installations with a disabled laser feature, the AFM/RFM (supplement) should include a limitation that states: “Laser operation is not EASA approved. The laser is disabled.”
- d) EASA does not assess the consequences of a laser operated in a non EASA certified configuration unless it causes permanent harm that may affect the safe operation of the aircraft in an EASA certified configuration.

3.2.4 Aspects linked to the use of laser equipment provided by third parties

Detailed type design data should be provided for those aspects of the laser system where malfunctions could create hazards. This would ensure adequate manufacturing quality (as per Part 21.A.31(a)2) and configuration design control (as per Part 21.A.31(a)1) of subsequent installations performed under the TC/STC approval.

- a) If detailed type design data is not available for those aspects of the laser system where malfunctions could create hazards, the applicant should propose a process by which configuration design control can be maintained. This process should ensure that system design features of integrated vendor supplied parts are sufficiently documented so that subsequent changes to those parts are identified and evaluated against any impact on continued safe operation of the system. This may be accomplished through the application of a source control drawing or specification, or other acceptable method to maintain configuration control. This process should ensure that system design features of integrated vendor supplied parts are sufficiently documented so that subsequent changes to those parts are identified and evaluated against any impact on continued safe operation of the system.
- b) The source control drawing or specification provides a means by which the applicant can assure that changes in design or non-compliances introduced during manufacturing that could cause a hazard if the equipment is installed with these changes will be detected. To determine the required information in a source control drawing or specification, the applicant should first identify the critical characteristics of the equipment that could create safety hazards if changes or problems with these critical characteristics are not detected and managed through a change control process. Critical characteristics for these systems may include the laser emission power, dimensions, weight, electrical power, software, and hardware parts.

3.3. Who this Certification Memorandum affects

This Certification Memorandum affects applicants who apply to install and operate laser equipment in CS-27 or CS-29 rotorcrafts or CS-23 or CS-25 aircraft.

4. Remarks

1. Suggestions for amendment(s) to this EASA Certification Memorandum should be referred to the Certification Policy and Safety Information Department, Certification Directorate, EASA. E-mail CM@easa.europa.eu.
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