

Notification of a Proposal to issue a Certification Memorandum

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

EASA Proposed CM No.: Proposed CM-AS-006 Issue 01 issued 20 July 2015

**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**

In accordance with the EASA Certification Memorandum procedural guideline, the European Aviation Safety Agency proposes to issue an EASA Certification Memorandum (CM) on the subject identified above. All interested persons may send their comments, referencing the EASA Proposed CM Number above, to the e-mail address specified in the "Remarks" section, prior to the indicated closing date for consultation.

EASA Certification Memoranda clarify the European Aviation Safety Agency's general course of action on specific certification items. They are intended to provide guidance on a particular subject and, as non-binding material, may provide complementary information and guidance for compliance demonstration with current standards. Certification Memoranda are provided for information purposes only and must not be misconstrued as formally adopted Acceptable Means of Compliance (AMC) or as Guidance Material (GM). Certification Memoranda are not intended to introduce new certification requirements or to modify existing certification requirements and do not constitute any legal obligation.

EASA Certification Memoranda are living documents into which either additional criteria or additional issues can be incorporated as soon as a need is identified by EASA.

Log of issues

Issue	Issue date	Change description
01	20.07.2015	First issue.

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1. Introduction

1.1. Purpose and scope

The purpose of this Certification Memorandum (CM) is to provide specific guidance for 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 requirements 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	---	---	20 February 2008
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 in type design	---	---	3 August 2012
CS 23.1301 CS 23.1309	Certification Specifications for Normal, Utility, Aerobatic, and Commuter Category Aeroplanes	CS-23	Amd. 3	13 July 2012
CS 25.1301 CS 25.1309	Certification Specifications and Acceptable Means of Compliance for Large Aeroplanes	CS-25	Amd. 16	12 March 2015



Reference	Title	Code	Issue	Date
CS 27.1301 CS 27.1309	Certification Specifications for Small Rotorcrafts	CS-27	Amd. 3	11 December 2012
CS 29.1301 CS 29.1309	Certification Specifications for Large Rotorcrafts	CS-29	Amd. 3	11 December 2012
1040.10, 1040.11	Performance standards for light emitting products	Title 21 CFR part 1040	---	---
SAE ARP 5674	Safety Considerations for Aircraft-mounted lasers projected into the navigable airspace	SAE ARP 5674	---	17 August 2012
IEC 60825	Safety of Laser Products	IEC 60825-1	3	15 May 2014
ED-135	Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment	SAE ARP 4761/ EUROCAE ED-135	---	December 1996
ED-79A	Guidelines for the development of civil aircraft and systems	EUROCAE ED-79A/ SAE ARP 4754A	A	December 2010
ED-80	Design Assurance Guidance for Airborne Electronic Hardware.	RTCA DO-254/ EUROCAE ED-80	---	April 2000
AMC 20.115C	Software Considerations for Certification of Airborne Systems and Equipment	---	C	September 2013

1.3. Abbreviations

AFM	Aircraft Flight Manual
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	Laser Imaging 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 (Laser Imaging 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)	
Class	Description	Class	Description
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 contains a Class 1, 1M, 2 or 2M laser and only emits Class 1, 1M, 2 or 2M laser energy does not typically require major mitigation for the laser feature as a condition of the installation approval. The complexity and scope of the equipment integration and installation will determine the classification of the change in accordance with Part 21.A.91.

3.1.2 Due to the hazardous effect of laser systems installations that contain Class 3R, 3B and 4 lasers (with or without an internal diffuser feature) **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 3R, 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
 - 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). 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 3R, 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 3R, 3B or 4) that through some internal mechanism diffuses the laser energy down to a Class 1, 1M, 2 or 2M 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 3R, 3B or 4 laser system is to be used during operations not under remit of the Regulation (EC) No 216/2008 (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 the airworthiness requirements. However, if the applicant wishes the aircraft to remain compliant with EASA type certification basis, it should satisfy either the guidance materials laid down in para 3.2.1 and 3.2.2 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 Class 3R, 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. 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 level 'E' software stops, which is not suitable for such hazards.

The direct exposure of occupants, pilot, crew, passengers or the non-flying public to laser emissions Class 3R, 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.

- 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.
- 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). The interlock system design should optimally control power to the laser emitter.
- 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. The installation may be either an intrinsically flight-safe laser system or a design-mitigated flight-safe laser system as defined in SARP 5674 "Safety Considerations for Aircraft-Mounted Lasers Projected Into the Navigable Airspace".
- 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. 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.

- 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 is deactivated 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 3R, 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 3R, 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 or 2M laser at emission. This specific guidance helps applicants to comply with all relevant requirements pertaining to installation of such systems.

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



- b) 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. Placards, operation manuals, flight manuals and maintenance manuals should define safe operational practices and procedures, identify hazards and provide appropriate limitations.

3.2.3 Certification provisions for Class 3R, 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 3R, 3B and 4 laser system onboard civil registered aircraft to be used during operations not under the remit of the 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 (e.g., harness connector is capped and stowed). Wiring for the non-laser features of the installation (e.g. Forward Looking InfraRed (FLIR)) can be electrically enabled and operational. Transition between both configurations needs a maintenance action.
- 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) For installations with a disabled laser, the Instructions for Continued Airworthiness (ICA) should include inspection instructions to verify that the laser features are electrically disabled. Procedures to transition from the EASA approved configuration to an unapproved configuration and back to the EASA approved configuration should be included in the ICA. It is highly recommended that the manufacturers establish procedures with the pertinent warnings and precautions to protect persons while operating the laser on ground..
- e) 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. This EASA Proposed Certification Memorandum will be closed for public consultation on the **31st of August 2015**. Comments received after the indicated closing date for consultation might not be taken into account.
2. Comments regarding this EASA Proposed Certification Memorandum should be referred to the Certification Policy and Safety Information Department, Certification Directorate, EASA. E-mail CM@easa.europa.eu or fax +49 (0)221 89990 4459.
3. For any question concerning the technical content of this EASA Proposed Certification Memorandum, please contact:

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