

Certification Memorandum

Acceptable approaches for the certification of Electric/Hybrid Propulsion Systems

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Regulatory requirement(s): Part 21, 21.A.21(a)

EASA Certification Memoranda clarify the European Union Aviation Safety Agency's general position on specific initial airworthiness, validation, continuing airworthiness or organisational items. They are intended to provide guidance on a particular subject and may provide complementary information for compliance demonstration, similar to AMC/GM even if not formally adopted through an ED Decision. Certification Memoranda are not intended to introduce new certification requirements or to modify existing certification requirements.



Log of issues

Issue	Issue date	Change description
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1. Identification of issue

1.1. Purpose and scope

Electric/Hybrid Propulsion Systems (EHPS) are considered as means to reduce direct Aircraft emissions to contribute to a cleaner aviation system. Such systems use electrical propulsion technologies that are sometimes combined with traditional thermal propulsion Engines in various ways. For several years, design organisations have progressed in developing different concepts and architectures of Aircraft and Engines based on full electric or hybrid propulsion systems.

An EHPS may include, but is not limited to, electric Engines, turbine Engines, piston Engines, generators, electrical power generation, distribution, wirings, propulsion battery system, integrated fans, cooling systems, controllers and power management systems (see SC E-19 EHPS Issue 01, ref. [5]).

Notes:

- An EHPS can be energy source agnostic. For instance, a combustion Engine can run on several types of fuels, and an electric Engine can run on electricity coming from a propulsion battery system or from fuel cells.
- While a propulsion battery system may be part of an Engine TC, other electrical power sources (for instance fuel cell) are for the moment excluded.
- Interaction with hydrogen technologies is also not addressed in this Certification Memorandum (CM).

The highly integrated Aircraft systems, including powerplant, already present certification challenges to properly address the boundaries between Aircraft, Engine and Propeller. The new technologies introduced in EHPS make these challenges more complex and sometimes question the applicability of traditional methods as used for certification of legacy technologies.

The purpose of this CM is to provide guidance to applicants on type certification approaches which may be considered for an EHPS, including the perimeter of the “Engine” as a product.

2. Applicability

This CM is applicable to any EHPS used to provide or produce lift/thrust/power for flight in a manned or unmanned Aircraft, during both normal and emergency operations on all Aircraft applications. EHPS using hydrogen are for the moment excluded from the scope of the CM.

3. EASA certification policy

3.1. Background

EASA received applications to certify, or to provide advice¹ on the certification of, propulsion systems that range from single electric Engines to complete EHPS with or without energy storage system.

According to Regulation (EU) 2018/1139 (ref. [1]) Article 11, products shall be issued with a Type Certificate. The same regulation specifies in Article 3 that a product is “an aircraft, an engine or a propeller”.

CS-Definitions Amendment 2 (ref. [6]) further specifies that an Engine “means an engine used or intended to be used for aircraft propulsion”, and that “it consists of at least those components and equipment necessary for the functioning and control but excludes the propeller”. This definition is similar to the “engine” definition provided by ICAO Annex 8.

The different applications received by EASA for EHPS certification question the boundaries of the above “engine” definition, in particular on components which can be included in a single Engine type certificate.

Regulation (EU) 2018/1139 (ref. [1]) Article 11 states the following: “No separate type certificate shall be required for the design of engines and propellers that have been certified as part of the design of an aircraft [...]”. This provision is implemented in Regulation (EU) No 748/2012 (ref. [2]) point 21.A.21 and provides the possibility to certify the propulsion system as part of the Aircraft.

3.2. Acceptable approaches for the certification of EHPS

According to the existing regulatory framework, at least two possible approaches to certify an EHPS have been identified:

1. **Aircraft approach:** the EHPS is certified as part of an Aircraft.
2. **Engine approach:** the EHPS is certified as an Engine product, by determining *those components and equipment (of the EHPS) necessary for the functioning and control* in line with the “engine” definition of CS-Definitions Amendment 2 (ref. [6]).

The above-mentioned “Engine approach” provides the flexibility to include in the scope of an Engine TC configuration some/all parts of the EHPS as long as they meet the “engine” definition.

As mentioned in the “engine” definition, a Propeller is not part of the Engine and must receive its own Type Certificate or be certified under the Aircraft Type Certificate.

Although flexibility on the certification approach is available to applicants, at the time of application/pre-application, EASA may advise on what it considers to be the most appropriate approach, depending on the complexity of interfaces between products and their elements, and based on the level of systems integration. This aims especially at mitigating the risk of dispute between the different design organisations regarding their respective responsibilities. For example, significant interactions between the propulsion battery system and other Aircraft systems or structure may lead to certify the batteries as part of the Aircraft to ensure compliance with crashworthiness requirements (as applicable as per the Certification basis of the intended Aircraft application).

¹ E.g., via Technical Advice Contract, Innovation Partnership Contract



No matter which approach is used, the applicable requirements will remain the same between the Aircraft approach and the Engine approach in order to ensure an equivalent level of safety.

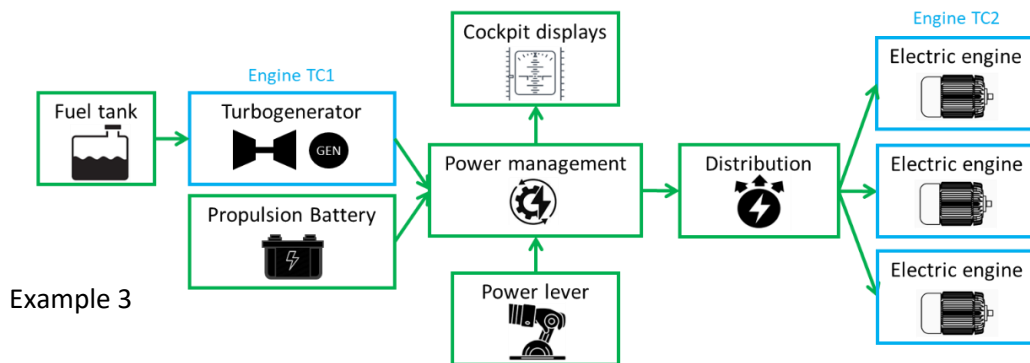
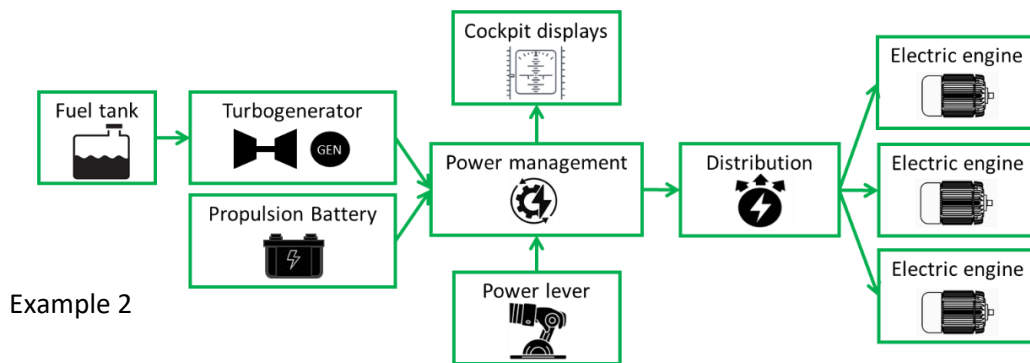
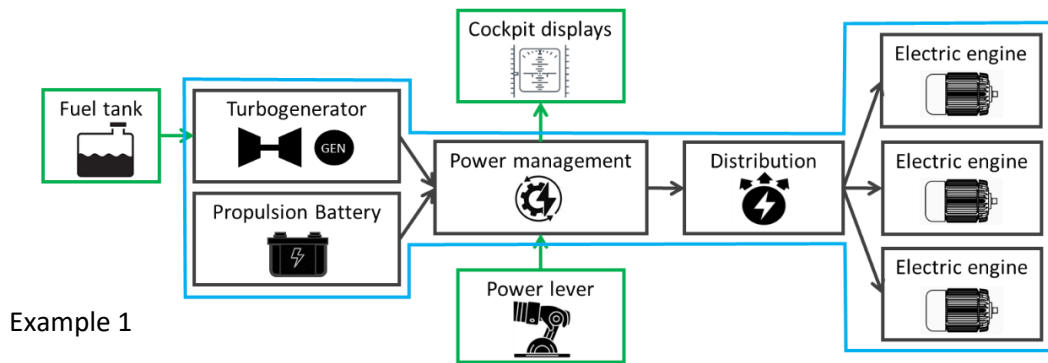
As a reminder, in accordance with Part 21 requirements, the scope of work of the applicant design organization shall be consistent with the selected approach used for type certification.

In addition, the following should be taken into consideration:

- The scope (see section 3.3) and interfaces of the EHPS should be accurately identified.
- A combustion Engine and an electric Engine, if physically installed separately on an Aircraft and operating independently of each other, cannot be covered under the same Engine TC.
- Integration aspects have to be demonstrated at Aircraft TC level. This includes installation instructions addressing potentially complex interfaces and compliance to Aircraft level certification requirements which might not have been covered by the EHPS certification, such as Aircraft safety requirements or Aircraft requirements related to powerplant cockpit indication or controllability of the Aircraft for instance.

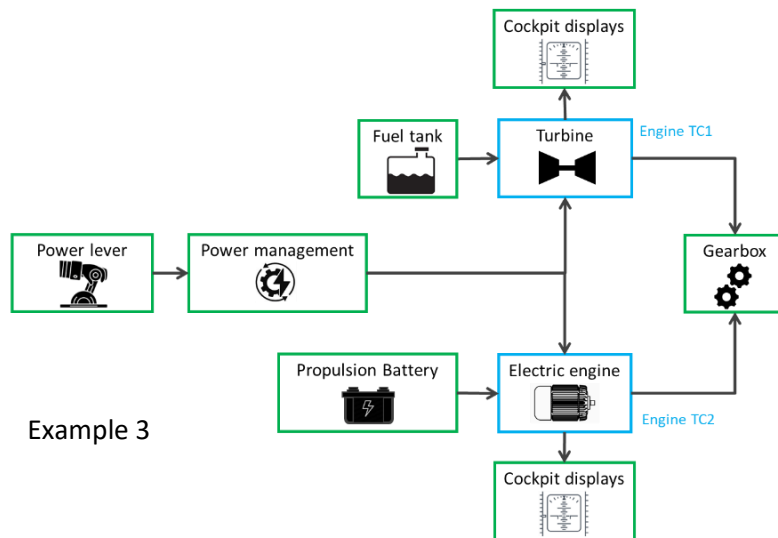
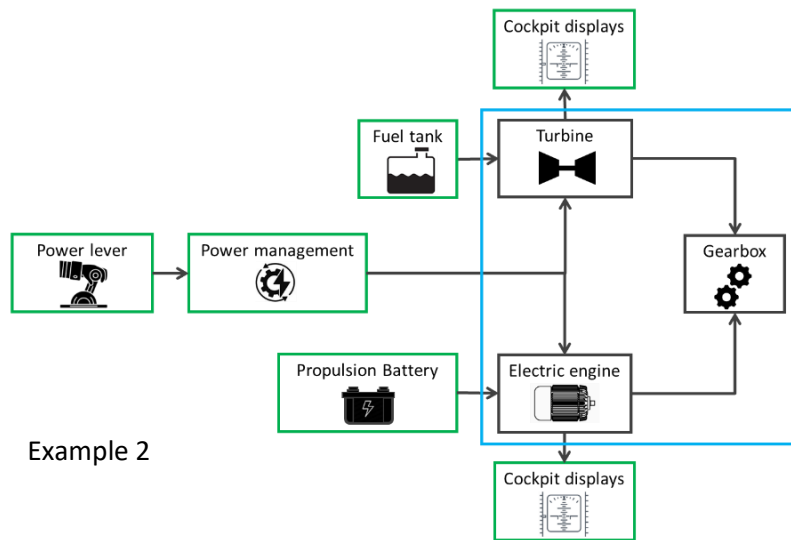
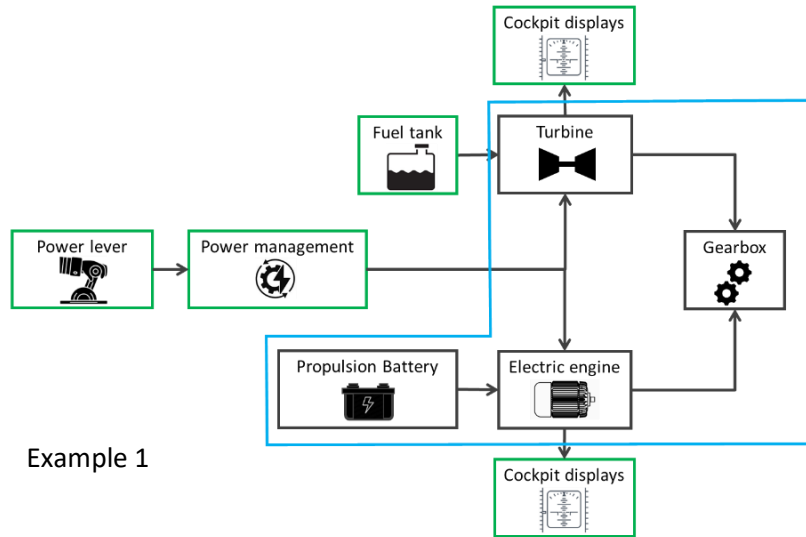
Figures 1, 2 and 3 below illustrate the flexibility that could be offered to an applicant willing to certify an EHPS. Note that these examples contain some, but not all, possible approaches.





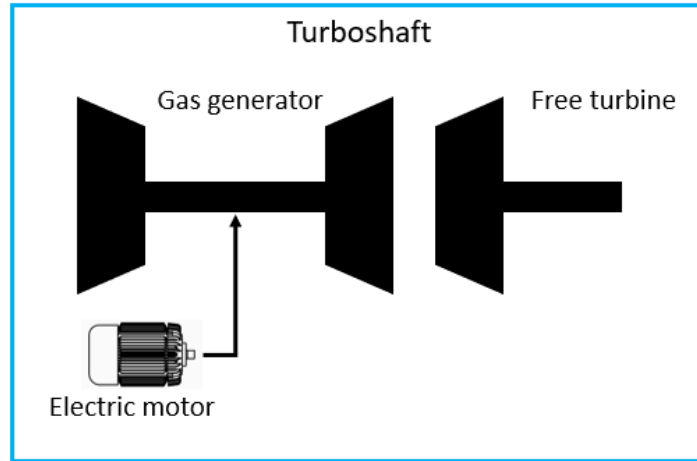
- Aircraft approach: parts and components certified under the Aircraft TC
- Engine approach: parts and components certified under the Engine TC

Figure 1 - Illustration of certification approaches - Series hybrid architecture



- Aircraft approach: parts and components certified under the Aircraft TC
- Engine approach: parts and components certified under the Engine TC

Figure 2 - Illustration of certification approaches - Parallel hybrid architecture



Engine approach: parts and components certified under the Engine TC

The electric motor does not directly provide power or thrust but helps the gas generator during transient phases. It is not an Engine as per say, and could be considered as an equipment according to CS-E.

Figure 3 - Illustration of certification approaches – Hybridised turboshaft architecture

Special attention should be given to the following points:

- The EHPS certification approach selected by an applicant shall not affect the expected level of safety of the end flying product. This means that the EHPS certification requirements will be the same, independently from the selected certification approach (i.e. independently of whether the EHPS is certified within the Engine TC or within the Aircraft TC), which is the prerequisite for offering flexibility. To be noted that the applicable requirements for the EHPS certification depend on the on the intended Aircraft application (see section 3.4).
- Compliance demonstration should not be duplicated between the Aircraft and Engine TC holders. In the case of a separate extended Engine TC (see section 3.3 below), the Aircraft type certification will rely on the Engine TC while ensuring a safe installation on the Aircraft.
- In the examples shown above, the potential exists for a multiplication of type certificates (TCs). It is therefore paramount that responsibilities for continued airworthiness of the EHPS are clearly defined in working procedures and managed through arrangements between TC holders (see GM2 21.A.239(d)(3)). In this regard, point 21.A.3A of ref.[2] contains continued airworthiness responsibilities for each of the design approval holders and covers the interfaces amongst them. AMC 20-8A (ref. [7]) contains additional guidance regarding occurrence reporting.

3.3. Elements that may be certified within an Engine Type Certificate

The “Engine approach”, which would allow a complete EHPS to be certified under one Engine TC, requires the scope of the “Engine TC” as it is known today to be reconsidered in the form of an extended Engine TC. In addition to the Engine itself, the extended Engine TC could include components such as generators, power management, power distribution and propulsion battery systems. All these components, despite being part of the same propulsion system and potentially physically installed at different locations, should be shown to be “*components and equipment necessary for the functioning and control of the engine*”, thus fulfilling the applicable “engine” definition of CS-Definition Amendment 2 (ref. [6]).

When looking at Figure 1, one could state that the elements providing the power or the thrust for the Aircraft propulsion are the electric Engines only. However, turbogenerators (or piston engine generators) also fall under the “engine” definition when used for Aircraft propulsion. It can also be noted that these systems may be derived from existing type certified Engines according to CS-E (CS-APU may be used under conditions to be agreed with EASA). Therefore, integrating turbogenerators or piston engine generators in the extended Engine definition of an EHPS is possible.

Moreover, certifying the thermal Engine of the turbogenerator or of the piston engine generator under an Engine TC, and the electric generator as part of the Aircraft, is also part of the proposed flexibilities.

In addition, as the power management and the distribution make the link between the electric Engines and the turbogenerator or piston engine generator, they are considered necessary for the functioning and control of the Engine and may therefore belong to the extended Engine definition as well, as shown in Example 1 of Figure 1 above.

Regarding the propulsion battery system, from an integration point of view, it can be considered as an “active” element in the EHPS for the following reasons:

- The electric Engine efficiency is dependent (but not only) on the voltage level of the propulsion battery system (related to the energy quantity).
- When the propulsion battery system discharges, the voltage level decreases accordingly. This may force the Engine designer to adapt the Engine control laws (field weakening function) to reach the higher declared speeds. This has implications as regards the Engine control system software development and the certification tests performed during the electric Engine certification process.
- The electric Engine controller also has an influence on the current drawn from the propulsion battery system.

This “active” relation between the propulsion battery system and electric Engines, in particular with regards to the Engine control system, demonstrates that the propulsion battery system could be considered as part of the *components and equipment necessary for the functioning and control of the Engine* as stated in the “engine” definition of the CS-Definitions (ref. [6]).



The various components of an EHPS that may be included under the Engine TC are illustrated by the schematic below:

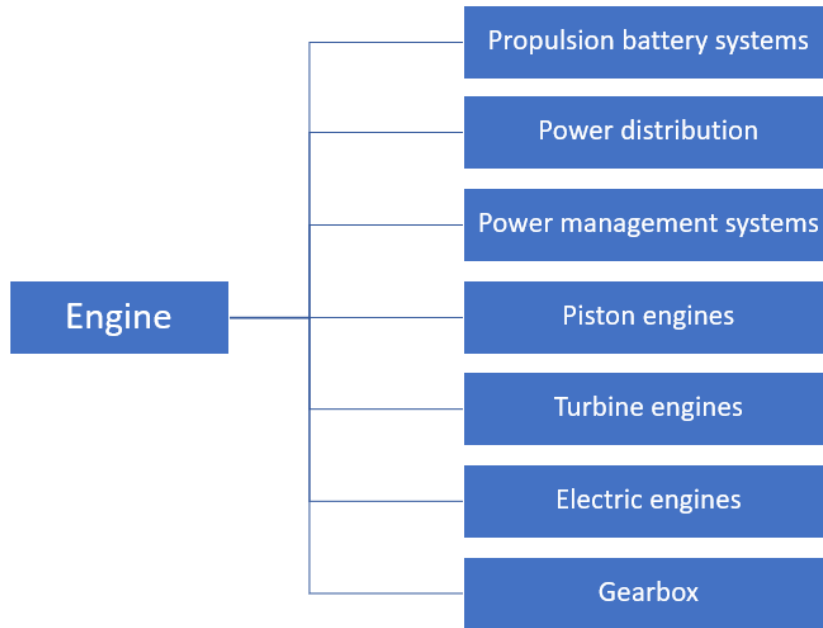


Figure 4 - Components of an EHPS that can be included under Engine TC

Note: turbogenerators and piston engine generators previously mentioned in the document can be seen as a combination of a turbine or piston Engine with an electric Engine. They are therefore covered by Figure 4 above.

This extended Engine definition excludes Aircraft cockpit displays, power levers (or any other type of Aircraft control input), fuel tanks and their fuel distribution systems certified within the Aircraft TC.

When electric Engines are designed with fans, the associated fans shall be certified as part of the Engine definition, similarly to turbine Engines.

More generally, this CM does not question the existing definitions and certification approaches for rotor, Propeller and fan as currently used in certification projects, i.e. the rotor is part of the Aircraft, the Propeller is a product, and the fan is part of the Engine.

The Engine TC must always include the Engine(s) used or intended to be used for Aircraft propulsion. For example, an Engine TC cannot be limited to a propulsion battery system only.

Moreover, for some systems being certified as part of the Engine TC, compliance with applicable Aircraft requirements must still be demonstrated for Aircraft certification (crashworthiness or the impact on the centre of gravity for batteries for instance).

3.4. Certification basis for the EHPS

This chapter proposes a set of guidance to support applications for the certification of EHPS powered by a propulsion battery system and/ or fuel.

When defining the certification basis, EASA uses a performance-based approach considering a level of proportionality that depends on the intended Aircraft application, ranging from light UAS or powered sailplanes up to CS-25 large aeroplanes. Figure 5 below lists the available guidance and their applicability:

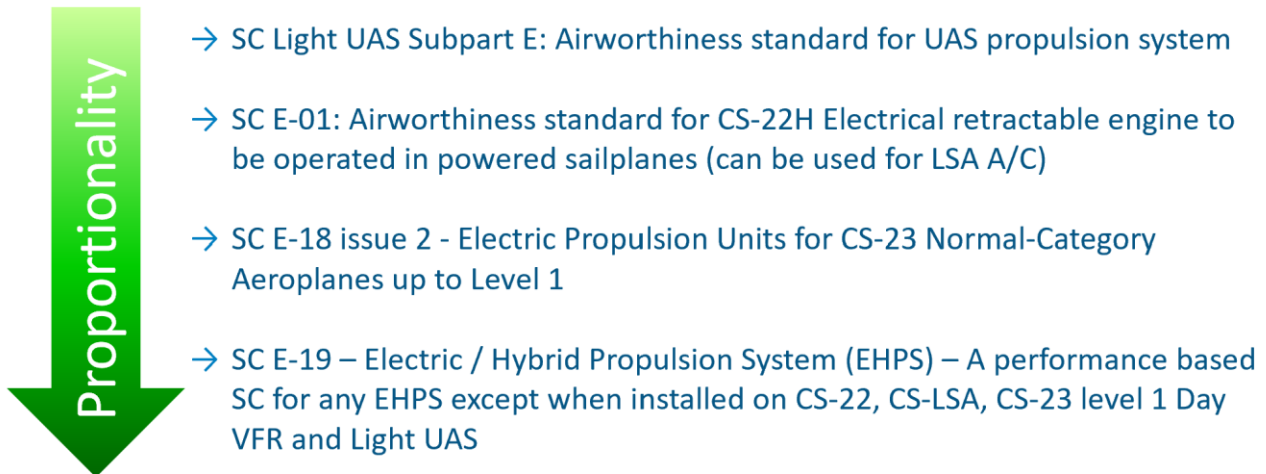


Figure 5 - Performance-based guidance for EHPS certification, including proportionality linked to Aircraft application

An applicant intending to provide the same EHPS for installation on different Aircraft applications should consider, at an early stage of the design, the most demanding certification specifications, and corresponding Special Conditions (SC). For example, one company that develops a propulsion system for a CS-LSA aeroplane as first application may consider the requirements contained in SC E-19 (ref. [5]) if the final intent is to propose the propulsion system for a CS-23 Level 2 aeroplane.

An EHPS also has to comply with some specific Aircraft requirements which may be different depending on the intended Aircraft application even on Aircraft from the same category (Level).

Dedicated SCs complement SC E-18 (ref. [4]) and SC E-19 (ref. [5]) on the integration tailored to the Aircraft application and with appropriate emissions requirements that are yet to be defined for EHPS.

EASA is currently working on developing Means of Compliances (MoC) to the above performance-based SCs to support applicants' demonstration of compliance. The MoC development will strongly rely on industry standards and close coordination with industry. Harmonisation with EASA bilateral partners will be ensured to the maximum extent.

4. Supporting data

4.1. References

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

N°	Reference	Title	Code	Issue	Date
[1]	Regulation (EU) 2018/1139 of the European Parliament and of the Council	Regulation on common rules in the field of civil aviation and establishing a European Union Aviation Safety Agency (the 'Basic Regulation')	Art. 3 Art.11	-	4.07.2018
[2]	Commission Regulation (EU) No 748/2012	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	Art.2 21.A.21(a) 21.A.3A	-	3.08.2012
[3]	SC E-01	Airworthiness standard for CS-22H Electrical retractable Engine to be operated in powered sailplanes.	-	01	15.04.2006
[4]	SC E-18	Electric Propulsion Units for CS-23 Normal-Category Aeroplanes up to Level 1 (aim to make use of ASTM F3338-18 to have a joined approach with the FAA)	-	02	22.10.2020
[5]	SC E-19	Final Special Condition SC E-19 – Electric/Hybrid Propulsion System	-	01	13.04.2021
[6]	CS-Definitions	Definitions and abbreviations used in Certification Specifications for products, parts, and appliances	-	Amdt 2	23.12.2010
[7]	AMC 20-8A	Occurrence Reporting	-	23	21.01.2022



4.2. Abbreviations

AMC	Acceptable Means of Compliance
APU	Auxiliary Power Unit
ASTM	American Society for Testing and Materials
CM	Certification Memorandum
CS	Certification specification
EASA	European Union Aviation Safety Agency
ED	Executive Director
EHPS	Electric/Hybrid Propulsion System
EU	European Union
FAA	Federal Aviation Administration
GM	Guidance Material
ICAO	International Civil Aviation Organization
LSA	Light Sport Aircraft
MoC	Means of Compliance
SC	Special Condition
TC	Type Certificate
UAS	Unmanned Aircraft System

4.3. Definitions

EHPS	Electric/Hybrid Propulsion System (EHPS) may include, but is not limited to, electric Engines, turbine Engines, piston Engines, generators, electrical power generation, distribution, wirings, propulsion battery system, integrated fans, cooling systems, controllers and power management systems. (see SC E-19 EHPS Issue 01, ref. [5]).
Electrical power generation	Process of converting different forms of power into electrical power.
Energy source	Term that refers to any substance or phenomenon that can produce useful energy.
Power source	Device or machine that supplies electric power to a system.



Propulsion battery system	Means a battery system used primarily for electric and hybrid propulsion applications. The propulsion battery system may supply power to other systems as well. (Note: definition agreed with the FAA)
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5. Remarks

For any question concerning the technical content of this EASA Certification Memorandum, please contact:

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