



European Union Aviation Safety Agency

Comment-Response Document (CRD) CM–21. A-004

Comment-Response Document (CRD) to proposed Certification Memorandum ref. CM–21. A-004 Issue 01 issued 30 July 2024 - Acceptable approaches for the certification of Electric/Hybrid Propulsion Systems





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1. Summary of the outcome of the consultation

EASA thanks all the contributors who reviewed this CM-21. A-004, shared their comments and participated in its improvement.

185 comments were received during the consultation period (from 30 July to 20 September 2024), including 147 comments from the industry, 34 comments from National Aviation Authorities and 4 comments from universities.

All comments were reviewed and received an individual response, as presented in the table below.

Some comments have resulted in a change to the CM, which is indicated in the EASA response where applicable.

The most frequently discussed topics are the following:

- EHPS parallel architectures that were not addressed in the first version of the CM
- Integration aspects at Aircraft level to be highlighted
- The concept of an “active/passive” relation of a component with the Engine control system
- Propulsion batteries that cannot be certified as an E/TSO article



2. Individual comments and responses

In responding to comments, EASA states its position as follows:

- (a) **Accepted** — EASA agrees with the comment and any proposed change is incorporated into the text.
- (b) **Partially accepted** — EASA either partially agrees with the comment or agrees with it but the proposed change is partially incorporated into the text.
- (c) **Noted** — EASA acknowledges the comment, but no change to the text is considered necessary.
- (d) **Not accepted** — EASA does not agree with the comment or proposed change.

Note: Comments are listed by Sections of the CM

comment	<p>29 comment by: <i>Safran Helicopter Engines</i></p> <p>Safran would like to thank EASA for the document which provides very useful information and clarification about the certification approaches for EHPS. After review, Safran has no comment on the document.</p>
response	<p>Noted. Thank you for the comment.</p>
comment	<p>30 comment by: <i>DE-LBA</i></p> <p>LBA has no comments.</p>
response	<p>Noted. Thank you for the comment.</p>
comment	<p>31 comment by: <i>Airbus-Regulations-SRg</i></p> <p>Airbus Commercial Aircraft is pleased to participate in the review of this proposed Certification Memorandum.</p> <p>Our experts and matter specialists have carefully reviewed the proposed text.</p> <p>Our comments are provided at the dedicated place within this CRT document.</p> <p>In case an question may occur please contact >>regulations.policies@airbus.com<< for further Airbus internal coordination.</p> <p>Thank you.</p> <p>Administrative Note: Airbus Document Classification : not applicable Airbus Export Control classification: Not technical.</p>
response	<p>Noted. Thank you for the comment.</p>



comment	<p>32 comment by: <i>Airbus-Regulations-SRg</i></p> <p>AIRBUS COMMENT : Add a section describing ways of working between Authorities if there are different certification policies (i.e. how a validation of TC between Authorities would work if one Authority does not propose the same possible arrangements as the EASA)?</p> <p>RATIONALE: EASA is providing its position, and this is most welcome. However, other Authorities (the FAA for instance) have already declared in public forums that they would not necessarily have a regulatory framework that would provide similar flexibility. It would therefore be interesting to have some guidance/views on how to cope with this aspect.</p>
response	<p>Partially accepted: all authorities do not necessarily have the same level of maturity with regards to new technologies, however EASA is working with bilateral partners to foster harmonization to the maximum possible extent in the CMT, COB, etc. Moreover, some elements of the harmonisation process were presented at the 2023 webinars (https://www.easa.europa.eu/en/newsroom-and-events/events/electrichybrid-propulsion-system-ehps-progress-and-roadmap-means). This CM is Part 21 one and does not aim at providing additional elements on the validation process.</p>
comment	<p>37 comment by: <i>FOCA (Switzerland)</i></p> <p>Thank you for the opportunity to comment. As a general note, we would like to encourage EASA to consult with ICAO CAEP on the development of future emissions requirements for hybrid gas turbines for CS-23 aircraft projects, including EHPS. This is because in our opinion in the future, EHPS emissions regulation for large aircraft should be aligned with the level of Turbofan emissions regulation for large aircraft.</p>
response	<p>Noted. Thank you for the comment.</p>
comment	<p>56 comment by: <i>Rolls-Royce plc</i></p> <p>Page All, Section All</p> <p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p> <p>Formatting</p> <p><u>PROPOSED TEXT</u></p> <p>Make capitalization of headings consistent throughout the document. Inconsistencies such as "Log of issues", "Identification of Issue" etc.</p>
response	<p>Accepted. The document will be modified accordingly.</p>



comment	<p>57 comment by: <i>Rolls-Royce plc</i></p> <p>Page All, Section All</p> <p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p> <p>Typos</p> <p><u>PROPOSED TEXT</u></p> <p>Address inconsistent capitalization of nouns throughout. For example, "Aircraft Approach", "Engine Approach", "Engine TC" could be considered proper nouns, which require capitalization.</p>
response	<p>Accepted. Capitalization will be used in accordance with the Basic Regulation and CS-Definition.</p>
comment	<p>120 comment by: <i>European Powered Flying Union</i></p> <p>European Powered Flying Union (EPFU) thanks the Agency for preparing this document on which to comment is important for those active in the field of electrification/hybridisation of aviation. Within our community many electric-powered aircraft are operated, we closely follow, as well, the development of prototypes. Our comments are based on what we learned from aircraft operators and from aircraft developers.</p> <p>The author of the following comments was involved in the creation of CS-23, several years ago the function of an "independent external expert" was attributed to him, the identification number was/probably still is 785.</p> <p>As a really general comment, based on our discussions, we are of the opinion that this CM fits the purpose.</p>
response	<p>Noted. Thank you for the comment.</p>
comment	<p>126 comment by: <i>Pratt & Whitney Canada</i></p> <p>This comment is provided on behalf of Pratt & Whitney Canada (P&WC), Collins, and Pratt & Whitney (P&W), collectively referred to as "RTX".</p> <p>Regarding the title page:</p> <p>If this document is intended to focus on series hybrid systems, the title should be changed to "Acceptable approaches for the certification of electric or series hybrid propulsion system".</p> <p>As written this memorandum does not include sufficient considerations for parallel hybrid systems. If parallel was intended to be 'in scope' the document will need several modifications to avoid being too heavy in one direction.</p>
response	<p>Partially accepted. This CM is not limited to series hybrid propulsion system. An example will be added to cover parallel systems.</p>

comment	<p>135 comment by: Pratt & Whitney Canada</p> <p>This comment is provided on behalf of Pratt & Whitney Canada (P&WC), Collins, and Pratt & Whitney (P&W), collectively referred to as "RTX".</p> <p>The document uses the word "engine" for both electric and thermal drive.</p> <p>For the ease of reading, RTX recommends: Motor: for component converting electrical energy to mechanical Engine: for component converting thermal energy <i>directly</i> into mechanical.</p>
response	<p>Not accepted. The word "Engine" is used on purpose in this CM and in all EASA publications. It aims at differentiating electric Engines used to provide part or all of the propulsion power, from other electric motors used as equipment in the Aircraft (for flight controls for instance). As explained in the CM, this is consistent with CS-Definitions Amendment 2 which specifies that an Engine "means an Engine used or intended to be used for aircraft propulsion". This definition is harmonized with FAA, TCCA and ANAC.</p>

comment	<p>164 comment by: Kevin R Bruce - Aircraft Electronics Association</p> <p>This CM is not clear enough as to whether this is for the aircraft or engine TC. It is clear that EASA rules allow the engine and all associated elements to make up the powerplant can be certified as part of the aircraft. What is not clear is what are the standards needed to show compliance to whether I want to certify everything as part of the aircraft or I just want to certify an engine, or a battery system, or perhaps an inverter or other component. In the end this CM should apply to the engine TC applicant, and we should define what could be included in an electric/hybrid engine TC. Then the aircraft TC applicant can use the basis of it to apply to their certification plan if they chose to certify the engine with the aircraft.</p>
response	<p>Partially accepted. As explained in the CM: - An EHPS can be either completely certified as part of the Aircraft TC or as part of both the Aircraft and the Engine TC (see §3.2) - The parts of the EHPS which can be certified as part of the Engine TC are detailed in §3.3. - No matter which approach is used, the EHPS applicable requirements will remain the same between the Aircraft approach and the Engine approach (§3.2). - The applicable standards to be applied for an EHPS certification are summarized in §3.4.</p>

comment	58 comment by: Rolls-Royce plc
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Page 2 Table of ContentRATIONALE / REASON / JUSTIFICATION for the Comment

Typo

PROPOSED TEXT

Change heading from "Table of Content" to "Table of Contents"

response Accepted. The document will be modified accordingly.

1. Identification of Issue

p. 3

comment

4

comment by: H55

"An EHPS is energy source and power source agnostic except when the electrical power source is included in the type certificate (TC) definition. While a propulsion battery may be included within the engine TC boundary, other electrical power sources are so far excluded."

The paragraph does not seem to mandate the inclusion of propulsion battery in the TC boundary (and so is for the interconnection between propulsion battery and electrical generators or electrical engines). It seems to contradict with the previous discussion between the agency and H55. It could be just a question of wording but it is worth mentioning.

Perhaps a link to figures later in this document is necessary to add clarity.

response

Not accepted. The CM content is consistent with all previous EASA presentations, including the first webinar in June 2021. As shown in Figure 1 of the CM, we also confirm that batteries do not necessarily have to be part of the electric Engine TC.

comment

12

comment by: Lilium

This note is a bit confusing:

Note: An EHPS is energy source and power source agnostic except when the electrical power source is included in the type certificate (TC) definition. While a propulsion battery may be included within the engine TC boundary, other electrical power sources are so far excluded. Interaction with hydrogen technology is not addressed in this Certification Memorandum (CM) at this stage.

may be better to simplify into the following:

Note: While propulsion batteries, as electrical power sources for propulsion, may be included in the EHPS scope, if it is part of type design definition of EHPS, the other electrical power sources, such as hydrogen technology, are not addressed in this Issue of Certification Memorandum (CM).



response	Partially accepted. The wording will be modified as follows : "While a propulsion battery may be included within the Engine TC boundary, other electrical power sources are so far excluded. In particular, hydrogen technology is not addressed in this Certification Memorandum (CM) at this stage."	
comment	13	comment by: <i>Lilium</i>
	"The novel boundaries" propose to replace by: "The difficulty to establish the boundaries"	
response	Not accepted. Boundaries are not necessarily difficult to establish.	
comment	127	comment by: <i>Pratt & Whitney Canada</i>
	This comment is provided on behalf of Pratt & Whitney Canada (P&WC), Collins, and Pratt & Whitney (P&W), collectively referred to as "RTX".	
	Suggest clarifying to state "Serial Electric/Hybrid propulsion systems (SEHPS) if that is the document intent. Suggest changing to "Such systems use novel electrical propulsion technologies that are combined with traditional thermal engines and / or batteries in various ways where electrical energy is sourced then used to directly create propulsion (Serial Hybrid).	
response	Partially accepted. This CM is not limited to series hybrid propulsion system. An example will be added to cover parallel systems.	

1.1. Purpose and scope

p. 3

comment	180	comment by: <i>Vasilis G. GKOUTZAMANIS</i>
	'to reduce direct aircraft gaseous and noise emissions'	
response	Accepted. The document will be modified accordingly.	
comment	141	comment by: <i>TCCA</i>
	After describing what EHPS is, the CM should identify the issue. Solving a complex issue requires a thorough description of its nuances. In this CM, actual difficulties of the existing situation are not presented. Therefore, it is not possible for the reader to clearly understand the reasons for and goals of the CM. Information that is essential includes: Why is this CM needed? Where does the current MOC approach fail? - Is it because the system could no longer be certified with existing standards? - Is it because the system itself is not clear?	



	<ul style="list-style-type: none"> - Is it because the aircraft and engine manufactures cannot agree on their responsibilities? - Is it because the certification authorities cannot understand the complexity that spans various manufactures and standards? - Is it the time or amount of effort it takes to certify the system that is too significant? <p>What is or are the issue(s) that this CM is trying to address?</p>
response	Partially accepted. The issue is presented in § 1.1.

comment	<p>143 comment by: TCCA</p> <p>Statement “The novel boundaries between aircraft, engine and propeller used for the certification of more conventional products.”</p> <p>Suggest editing to state:</p> <p>“High level of integration in the aircraft systems, including powerplant, already present challenges in defining boundaries between aircraft, engine and propeller/propeller control. The novel technology of EHPS, introducing new elements of powerplant systems, increase the complexities and presents an even bigger challenge”.</p> <p>Or similar, to avoid the notion that boundaries in engine/aircraft certification of today are not complex or are not presenting any challenges.</p>
response	Partially accepted. The document will be modified in this spirit.

comment	<p>144 comment by: TCCA</p> <p>Would "systems" be a better word to define energy storage systems instead of saying “energy storage solutions?”</p> <p>Suggest to revise text accordingly.</p> <p>Rationale: To avoid confusion with several other certification or industry documents that states energy storage system (ESS).</p>
response	Partially accepted. The related sentence will be removed for other reasons.

comment	<p>153 comment by: TCCA</p> <p>Last sentences, the scope of the CM is defined, as providing "guidance to applicants on type certification approaches for an EHPS." After going through the document, I found out that the document is to answer the question raised from applicants and it is more focused on the battery systems. I suggest adding more text in section 1.1 to make it more specific if necessary. This will make the scope clear and open the future discussions for other challenging systems when needed.</p>
response	Partially accepted. The text in §1.1 will be modified the following way: "The purpose of this CM is to provide guidance to applicants on type certification approaches for



an EHPS, especially regarding the perimeter of the 'Engine' from a certification perspective".

comment

165

comment by: *Kevin R Bruce*
Aircraft Electronics Association

In the note it states that the EHPS is agnostic to energy and power sources except when the electrical power source is included in the TC. What does this mean?

I agree with the first part of the statement as long as in the end you have an electric motor somewhere in the system.

When you have, say a traditional turboprop installed independent of the electric motors and electric energy source it should not be possible to combine these into one TC unless it is the aircraft TC.

If in this case the turboprop can also be used as a generator to charge the batteries this should need to meet a separate set of requirements at the aircraft level. There needs to be something that uniquely connects a standard piston or turbine engine with electric motors that allow it to be under one engine TC. Otherwise, things get complicated, and standards become difficult to manage to ensure all safety requirements are satisfied. There needs to be a criterion to allow one to obtain a TC for all the items identified in one package. Something that makes them inseparable. In many cases the distribution wiring, batteries, fans, cooling become aircraft level dependent and should be managed at the aircraft level. To try and lump this into the engine TC then complicates the TC of the engine and makes it limited to an installation. We are better served to define requirements for each unique element of the system and then define installation requirements. The fact you have applicants who wish to have a TC for everything should not drive what we establish as a rule. As an example, if some wished to design an integrated flight deck with the aircraft the TSO requirements are rolled into the TC process and become part of the means and methods of compliance.

response

Partially accepted.

The wording regarding the EHPS being energy source agnostic will be clarified.

Moreover, it is, or it will be, specified in §3.2 of the CM that:

- "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 also based on the level of systems integrations"

- "A combustion Engine and an electric Engine, if installed separately on an Aircraft and operating independently of each other, cannot be covered under the same Engine TC."

- "The final integration needs to be demonstrated at Aircraft TC level, including installation instructions addressing potentially complex interfaces and compliance to Aircraft level certification requirements not 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."

comment

166

comment by: *Kevin R Bruce*
Aircraft Electronics Association



To build on the comment about the criteria to include items or system that could be rolled into the engine TC - this criterion needs to be very clear. We have rules and guidance on piston and turbine engines already - what becomes unique about them being used in a hybrid aircraft. Verdego is a good example of what would be the criteria. You have piston engines in series with an electric motor which can run independently of the other or in series. The piston engine can also charge the batteries.

response Not accepted. The CM provides guidances and examples but cannot cover all possible cases. Specific projects have in any case to be discussed with EASA to establish a certification strategy on a case-by-case basis.

comment

167

comment by: *Kevin R Bruce*
Aircraft Electronics Association

I agree that there is a high level of integration and complexity in some EHPS installations, it is not all. We have managed the integration of highly complex systems into aircraft using TSO requirements and this has been successful - we need to consider that we use the same context for EHPS and allow for TSO elements, engine TC elements and aircraft elements. We manage it today and it can still be done.

response Not accepted. There are currently no existing mature industry standards and, as a consequence, no E/TSO standards for EHPS components that can be certified as part of the Engine.

comment

168

comment by: *Kevin R Bruce*
Aircraft Electronics Association

Another thing to consider here is the definition of powerplant. What is being suggested seems to imply that we redefine powerplant and make propulsion more like powerplant. We have always used propulsion as per the English definition.

I don't think this is appropriate to define propulsion nor redefine powerplant to mean engine. Many elements that are needed to make up the powerplant system are unique to the aircraft and to try and account for them at the engine level would be difficult and would potentially complicate things for the installer who then needs to retest (potentially in a significant way) because the engine TC holder did not think of a particular installation.

response Partially accepted. We agree and, as explained in the CM, "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 also based on the level of systems integrations". The relevant considerations you mention will therefore be taken into account when defining with the applicants the Engine perimeter.

comment

169

comment by: *Kevin R Bruce*
Aircraft Electronics Association

I have stated this in a few ways now but to be clear, how the engine is developed to take energy and convert it to power (work) – whether it is adapted to propel or lift or potentially provide flight control should not matter. Think of the helicopter. All

	that is happening here is taking the engine power and directing it to produce an end outcome. Lift, thrust or moving air in a 3D space to act like a flight control is all about redirecting air and is the same thing just in different vectors.
response	Partially accepted. As written in the document, "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 [...]" in accordance with CS-Definitions Amendment 2 specifying that an Engine "means an engine used or intended to be used for aircraft propulsion".
comment	<p>170 comment by: <i>Kevin R Bruce</i> <i>Aircraft Electronics Association</i></p> <p>Lets not re-invent things – lets focus on the right standards for each element of the new technology – then lets certify a few things and see if any change to what has worked to date needs adjustment. We are either assuming that the current method will be an issue, or the applicants in some cases are saying it is or we are over complicating the problem. The real focus should be on specific system technology requirements segmented into unique areas and then the installation requirements.</p>
response	Partially accepted. As written in the CM (§3.1), EASA has already received some applications challenging the boundaries of the ‘Engine’ definition, hence opening the question of what components can be included in a single Engine type certificate.
comment	<p>19 comment by: <i>European Powered Flying Union</i></p> <p>1.1 Purpose and scope Page 3/11 First text block, second last line Please replace "selected fuel/power supply" by "energy supply". Rationale: It fits better</p>
response	Partially accepted. The sentence will be removed for other reasons.
comment	<p>41 comment by: <i>Rolls-Royce plc</i></p> <p>Page 3 Section 1.1 Line 3</p> <p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p> <p>Electrical propulsion technologies are not only combined with traditional thermal propulsion engines.</p> <p><u>PROPOSED TEXT</u></p> <p>Change "...propulsion technologies that are combined with traditional thermal propulsion engines ..." to "...propulsion technologies that are sometimes combined with traditional thermal propulsion engines ..."</p>
response	Accepted. The document will be modified accordingly.

comment	<p>42</p> <p>comment by: <i>Rolls-Royce plc</i></p> <p>Page 3 Section 1.1 line 13</p> <p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p> <p>Technical clarity</p> <p><u>PROPOSED TEXT</u></p> <p>What is meant by "An EHPS is energy source and power source agnostic"? This paragraph is overall somewhat unclear. Also, please provide definitions of "energy source" and "power source".</p>
response	Accepted. The wording will be clarified.
comment	<p>59</p> <p>comment by: <i>Rolls-Royce plc</i></p> <p>Page 3 Section 1.1 Line 4</p> <p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p> <p>Formatting</p> <p><u>PROPOSED TEXT</u></p> <p>Change "...design organisations started to develop different concepts..." to "...design organisations have been developing different concepts..."</p>
response	Accepted. The document will be modified accordingly.
comment	<p>60</p> <p>comment by: <i>Rolls-Royce plc</i></p> <p>Page 3 Section 1.1 Line 6</p> <p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p> <p>Formatting</p> <p><u>PROPOSED TEXT</u></p> <p>Change "...the selected fuel/power supply, suitable energy storage solutions..." to "...the selected fuel/power supplies, energy storage solutions..."</p>
response	Partially accepted. The sentence will be removed for other reasons.
comment	<p>61</p> <p>comment by: <i>Rolls-Royce plc</i></p> <p>Page 3 Section 1.1 Line 15</p> <p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p>



response	<p>Formatting</p> <p><u>PROPOSED TEXT</u></p> <p>Delete "interaction with" from "Interaction with hydrogen technology..."</p>
comment	<p>62 comment by: <i>Rolls-Royce plc</i></p> <p>Page 3 Section 1.1 Line 18</p> <p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p> <p>Formatting</p> <p><u>PROPOSED TEXT</u></p> <p>Change "high level" to "high-level"</p>
response	<p>Accepted. The document will be modified accordingly.</p>
comment	<p>63 comment by: <i>Rolls-Royce plc</i></p> <p>Page 3 Section 1.1 Line 19</p> <p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p> <p>Formatting</p> <p><u>PROPOSED TEXT</u></p> <p>Change "...presented by EHPS..." to "...presented by the EHPS..."</p>
response	<p>Accepted. The document will be modified accordingly.</p>
comment	<p>64 comment by: <i>Rolls-Royce plc</i></p> <p>Page 3 Section 1.1 Line 19/20</p> <p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p> <p>Formatting</p> <p><u>PROPOSED TEXT</u></p> <p>Change "...the typical methods used for the certification of more conventional products." to "...the methods used for certification."</p>
response	<p>Partially accepted. The document will be modified in this spirit.</p>

comment	<p>105 comment by: DGAC France</p> <p>DSAC France</p> <p>DSAC thanks you for this proposed Certification Memorandum.</p> <p>We would like first to raise a point regarding the definition of an EHPS system, and therefore the scope of the document.</p> <p>Indeed, some experts consider that an EHPS system is one that ensures a <u>propulsion</u> function, while it can potentially contribute to other functions (example including flight controls). And others understand that an EHPS system is exclusively dedicated to <u>propulsion</u> (full electrical or hybrid(including electrical) lift/thrust/power flight propulsion).</p> <p>Consequently, wouldn't it be preferable to specify the definition of an EHPS system by clearly indicating :</p> <ul style="list-style-type: none"> - whether it is a system dedicated exclusively to propulsion or if it can also contribute other functions including flight controls? - whether a full electrical <u>propulsion</u> system is in the scope of the document?
response	Partially accepted. As mentioned in the CM, please refer to SC E-19 for a more detailed definition of EHPS.

comment	<p>111 comment by: Voltaero</p> <p>In the words "...traditional thermal propulsion engines..." are you considering either aeronautical thermal engine (covered by TC) or other kind of TE to be certified (i.e. derivative from automotive engine)?</p>
response	Noted. It refers to piston and turbine engines as defined in CS-E.

2. Applicability

p. 3

comment	<p>181 comment by: Vasilis G. GKOUTZAMANIS</p> <p>Consider adding the conversion systems as well (not sure whether the comment applies on §1.1 or 2).</p>
response	Not accepted. The CM provides guidances and examples but cannot cover all types of equipment.
comment	<p>145 comment by: TCCA</p> <p>Even though the text of this section refers to "all aircraft operations", the text itself as well as references refer to CS-23 category whereas CS-25, CS-27 and/or CS-29 are not included in the same way. Suggest editing to state:</p> <p>" 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</p>



	<p>operations on all aircraft applications in CS-23 category. The mindset presented can be used for aircraft applications in CS-25, CS-29 and CS-27 applications as well, with adjustments appropriate for the category under review. “</p> <p>Or similar.</p>
response	Partially accepted. As stated in §2, the CM is applicable to all Aircraft categories.
comment	<p>25 comment by: <i>Samuel Mericq (Maeve Aerospace)</i></p> <p>[EHPS used to provide or produce lift/thrust/power for flight ... during both normal and emergency operations on all aircraft operations].</p> <p>For cases where hybridisation (batteries) is only providing some performance optimisation, and not part of any safety of flight consideration, could there be an adapted definition of the applicability? By reading the current memo, the full extent of SC e-19 would apply to the smallest of batteries as soon as they are participating to the aircraft thrust? In the past if I am not mistaken, batteries representing a mass of more than 25% of the aircraft mass would be considered as eligible for the full extent of the SC E-19, but what about cases of batteries being less than 5% of the aircraft weight? They would clearly not represent the same safety risk and could benefit from some relaxations of current SC E-19?</p>
response	Not accepted. The CM provides guidance to Part 21 and does not address technical requirements.
comment	<p>43 comment by: <i>Rolls-Royce plc</i></p> <p>Page 3 Section 2</p> <p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p> <p>Technical clarity and consistency with SC E-19</p> <p><u>PROPOSED TEXT</u></p> <p>This paragraph is inaccurate as hydrogen technologies are not addressed in this CM. Also, SC E-19 EHPS.10 states "... except for CS-22, CS-LSA, CS-23 Level 1 Day VFR and Light UAS". Do these exceptions not apply to this CM?</p>
response	Accepted. Hydrogen is not part of the scope, and the CM covers all certified A/C categories. The document will be modified accordingly.
comment	<p>102 comment by: <i>DGAC France</i></p> <p>DSAC France</p> <p>This CM would be applicable to unmanned aircraft. We are most likely referring to UAS in the certified category or in the specific category for which the anticipated SAIL of the operation requires a TC/RTC. But it is unclear whether this CM would or should be considered also for lower SAIL operations?</p>



response	Accepted: the CM covers all certified A/C categories, including SAIL operations requiring TC or RTC. Lower SAIL operations are not addressed by Part 21 and the CM is therefore not applicable. See Design verification report EASA
comment	<p>128 comment by: Pratt & Whitney Canada</p> <p>This comment is provided on behalf of Pratt & Whitney Canada (P&WC), Collins, and Pratt & Whitney (P&W), collectively referred to as "RTX".</p> <p>Clarify that this is applicable to any 'Series EHPS'.</p>
response	Partially accepted. This CM is not limited to series hybrid architecture. An example will be added to cover parallel architectures.

3.1. Background

p. 3

comment	<p>146 comment by: TCCA</p> <p>Referring to the statement “The different requests received by EASA challenge the boundaries of the above ‘engine’ definition... be included in a single engine type certificate as part of such product”</p> <p>The question of certification boundaries limited to selection of components poses challenges when the same components are involved in multiple functions, some of the functions being typical engine functions and some being aircraft level functions.</p> <p>Examples are:</p> <ul style="list-style-type: none"> · cockpit indication functions related to powerplant in which “engine components” are participating at the functional level. In EHSP technology in particular, not only by providing “raw” signals to Avionics system but actually generating indication parameters to be displayed, including fault detection and accommodation logic, necessitating verifiable at the aircraft level assumptions about crew actions, particular aircraft performance in failure scenarios and similar. · the aircraft specific threshold for Loss of Power Control/Loss of Thrust Control (LOPC/LOTC) · powerplant functions relating to Uncontrollable High Thrust, where both detection and accommodation for potentially Catastrophic condition must typically be implemented within engine control, during engine development. The actual architecture, system logic etc. with respect to this function is application/aircraft dependent for factors such as whether engines are positioned on fuselage or wings, what is the authority of rudder/nosewheel steering at aircraft speeds in question, what are the specific actual times for a particular aircraft’s systems reactions etc. · for aircrafts relying on propellers for thrust generation, the typically Catastrophic case of loss of engine power combined with inability to timely feather the propeller blades, requires fault detection and accommodation logic embedded in engine control. Parameters driving these very consequential engine control design aspects are all defined by the physical attributes of a particular aircraft, how much drag and for how long it can tolerate etc. <p>power distribution and power management are likely to require aircraft specific demands/requirements, both in terms of required functionality but also in</p>
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	addressing failure conditions potentially originating in other aircraft systems, for a specific aircraft in related systems, etc.
response	Accepted. All these aspects will have to be taken into account during the engine and aircraft certifications.
comment	<p>171 comment by: <i>Kevin R Bruce</i> <i>Aircraft Electronics Association</i></p>
	<p>I don't think it is appropriate to suggest that applicant have challenged the boundaries of engine to a point that needs redefinition. What is happening is that applicants are deciding to incorporate multiple elements into what they would like to offer and need a venue to meet the marketing goals. This does not mean that we should adjust a system that is not broken. Many of the elements traditionally not included in the engine where because of the fact that some elements where unique to the aircraft and not the engine. We should be careful we do not create a loosing of the boundaries such that we actually tighten them and restrict innovation. As said already it is easier to create unique requirements for each element and then combine them if you wish rather than trying to mesh everything together and then need to pull out certain parts if you only wish to create one part.</p>
response	<p>Partially accepted. As explained in the CM, all the components that are to be certified under an Engine TC 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.</p> <p>Moreover, "whatever certification approach is chosen by an applicant, it is essential to maintain the same level of safety of the end-product. This means that the EHPS certification requirements will be the same, independently from the selected certification approach, which is the prerequisite for offering the requested flexibility" and "The final integration needs to be demonstrated at Aircraft TC level, including installation instructions addressing potentially complex interfaces and compliance to Aircraft level certification requirements not 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".</p>
comment	<p>65 comment by: <i>Rolls-Royce plc</i></p> <p>Page 3 Section 3.1</p> <p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p> <p>Formatting</p> <p><u>PROPOSED TEXT</u></p> <p>Change "...to complete Electric/Hybrid Propulsion Systems (EHPS) with..." to "to complete EHPS with..." as the acronym has already been expanded earlier in the document.</p>
response	Accepted. The document will be modified accordingly.

comment	66	comment by: <i>Rolls-Royce plc</i>
	<p>Page 3 Section 3.1</p> <p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p> <p>Formatting</p> <p><u>PROPOSED TEXT</u></p> <p>Change "...with or without energy storage system" to "...with and without energy storage system"</p>	
response	Not accepted.	

comment	67	comment by: <i>Rolls-Royce plc</i>
	<p>Page 3 Section 3.1</p> <p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p> <p>Formatting</p> <p><u>PROPOSED TEXT</u></p> <p>Add empty lines before and after the following sentence: "According to Regulation (EU) 2018/1139 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.'"</p>	
response	Accepted. The document will be modified accordingly.	

comment	68	comment by: <i>Rolls-Royce plc</i>
	<p>Page 4 Section 3.1</p> <p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p> <p>Formatting</p> <p><u>PROPOSED TEXT</u></p> <p>Change "The different requests received by EASA..." to "The different applications received by EASA..." to be consistent with the first paragraph of this section.</p>	
response	Accepted. The document will be modified accordingly.	

comment	69	comment by: <i>Rolls-Royce plc</i>
	<p>Page 4 Section 3.1</p> <p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p>	



	<p>Formatting</p> <p><u>PROPOSED TEXT</u></p> <p>Change "...as part of such product" to "...as part of such a product" or "...as part of such products"</p>
response	Accepted. The document will be modified accordingly.
comment	<p>70 comment by: <i>Rolls-Royce plc</i></p> <p>Page 4 Section 3.1</p> <p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p> <p>Formatting</p> <p><u>PROPOSED TEXT</u></p> <p>Change "...provides the possibility to certify the propulsion system as part of the aircraft" to "...provides the possibility to certify the EHPS as part of the aircraft"</p>
response	Not accepted. "EHPS" is a type of "propulsion system".

3.2. Acceptable approaches for the certification of EHPS

p. 4

comment	<p>1 comment by: <i>DAHER</i></p> <p>The examples are very valuable to understand the certification strategy. Would it be possible to insert a new figure with examples of parallel hybridizations in addition of distributed electric propulsion? In our opinion, the "engine-TC approach" could include the power management between the electric engine and the thermal engine in its scope. This is not crucial, only for better illustration of other possible hybridization concepts</p>
response	Partially accepted. This CM is not limited to series hybrid propulsion system. An example will be added to cover parallel architectures.
comment	<p>2 comment by: <i>CycloTech</i></p> <p>In our opinion the "Engine approach" of the CM goes in the right direction, but does not fully reflect the most novel designs of engines, which might integrate non-conventional rotors and propellers in a very tight manner, such that they are effectively an integral part of the EHPS. There are applications in large transport category, in particular, in the open fan technology, in which the open fan is considered part of the engine and its control system are part of the engine control system.</p> <p>It is also our opinion that in such cases of very integrated technology, the integration of the rotor/propeller with EHPS (or engine) actually helps in defining more clear</p>



	<p>interfaces for IAW and CAW and actually helps in lowering the risk of dispute between the DOAs regarding their responsibilities, as compared to the case when the propeller is certified on its own or at aircraft level.</p> <p>Incidentally, this would reduce also the effort of the Agency, having to deal with a single TC-project for the entire propulsion unit.</p>
response	<p>Partially accepted. The CM does not question the sharing between rotor, propeller and fan currently used in certification projects: the rotor is part of the Aircraft, the propeller is a product, and the fan is part of the Engine. This will be specified in the CM.</p>



comment	5	comment by: H55
	In Figure 1, the bottom schematic, the Power Management is not part of the Engine. This does not respect the definition under Paragraph 3.2 bullet point 2 (previous page): "those components and equipment (of the EHPS) necessary for the functioning and control".	
response	Not accepted. The control system of each engine is included in the Engine definition itself. Therefore, the Power management does not systematically include Engine control laws.	
comment	7	comment by: H55
	Figure 2. The flow of the arrow in some cases could be bidirectional (e.g. for regeneration)	
response	Noted. The CM only provides examples and cannot cover all possible cases.	
comment	14	comment by: Lilium
	"Maximum boundaries" - this terminology is not clear, probably it should be "Suggested/Proposed boundaries"	
response	Partially accepted. "Maximum" will be removed.	
comment	15	comment by: Lilium
	"In the case of a separate extended engine TC," - this terminology needs to be clarified, or eventually replaced by Engine TC, which will include: a..., b..., c..., and in the next row - EHPS TC, is it define the separate extended engine TC? "...for a multiplication of certificates (TCs)." may need to be changed to "...for a multiplication of type certificates (TCs)."	
response	Partially accepted. Sentence replaced by "As a reminder, in the case of a separate Engine TC, the Aircraft type certification will rely on the Engine TC while ensuring a safe installation on the Aircraft."	
comment	20	comment by: European Powered Flying Union
	3.2 Acceptable approaches for the certification of EHPS Page 4/11 Based on our experience we prefer the "engine approach" and we agree with the idea that a propeller may receive its own type certificate. Rationale: To draw the line at engine level eases further development of the propulsions, this being, at least to a certain degree, independent of the airframe. The flexibility offered by this solution enhances the search for optimum solutions and for possible new combinations based on progress achieved by developers and manufacturers.	
response	Noted. Thank you for your comment.	

comment	<p data-bbox="368 197 1394 241">21 comment by: <i>Pulkit Agrawal (Honeywell)</i></p> <p data-bbox="368 253 1394 331">Section 3.2, Figure 1 Illustration of certification approaches (example of a distributed Electric propulsion)</p> <p data-bbox="368 365 1394 689">Situation: Figure 1 consists of three images of a series hybrid architecture, presenting three different approaches to certification. Two utilize the Engine TC Approach (individual components, entire EPHS) and one is the Aircraft TC approach. This system architecture is identified as an “example” system to illustrate the three certification approaches. There is no mention in either the text or the figure that it is a series hybrid, nor is there any mention of the alternative parallel hybrid. There is no mention at all in the document of either of these two common and differing approaches to hybrid power systems.</p> <p data-bbox="368 723 1394 869">Issue: The lack of any mention of these two common and differing approaches to hybrid power systems may allow confusion for those seeking ho to certify parallel hybrid systems.</p> <p data-bbox="368 902 1394 1016">Recommendation: The example should be Identified as a series hybrid, and a parallel hybrid example should also be included for completeness.</p>
response	<p data-bbox="368 1016 1394 1115">Accepted. This CM is not limited to series hybrid propulsion system. An example will be added to cover parallel architectures.</p>
comment	<p data-bbox="368 1149 1394 1193">26 comment by: <i>Samuel Mericq (Maeve Aerospace)</i></p> <p data-bbox="368 1216 1394 1406">Case retained in this memo seems to be only the case detailed in previous EASA documents as "Serial hybrid", but many applications would still be parallel? Could the memo be more explicit about all retained cases ? It is key to give an exhaustive and detailed view about these cases, not only 1 example which could be retained as the only considered one?</p>
response	<p data-bbox="368 1406 1394 1505">Accepted. This CM is not limited to series hybrid propulsion system. An example will be added to cover parallel architectures.</p>
comment	<p data-bbox="368 1538 1394 1583">33 comment by: <i>Airbus-Regulations-SRg</i></p> <p data-bbox="368 1594 1394 1718">PDF page 4, para >>3.2. Acceptable approaches for the certification of EHPs<<, 3rd section quote:</p> <p data-bbox="368 1774 1394 2002">“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 also based on the level of systems integrations, to mitigate the risk of dispute</p>

between the different design organisations regarding their respective responsibilities.”

UNQUOTE

AIRBUS PROPOSED TEXT:

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 also based on the level of systems integrations. *A high level of integration*

within the aircraft systems (electrical generation and distribution system in particular) will warrant an aircraft approach or a

restricted engine approach with engine TC granted only for the electric engines and /or turbogenerator.

~~to mitigate the risk of dispute between the different design organisations regarding their respective responsibilities.~~

RATIONALE:

The question of the level of interaction with the aircraft system is key. The proposed ‘extended engine approach’ that this

memo is aiming at justifying and promoting is pertinent only if the electrical battery, electrical generators, power management

and power distribution systems are effectively only used for providing electrical power to electric engines. As soon as those

elements are also part of the aircraft electrical system in order to supply electrical power to the aircraft, they should be certified

as part of the aircraft. The objective should not be to mitigate risk of dispute between design organisations but rather to

select the approach that is the most adapted to the complexity and level of integration of the proposed architectures.

response

Not accepted. The aim of this paragraph is to highlight a potential concern regarding the identification of responsibilities in case of CAW issue. Moreover, the integration aspects are already covered in the CM ("complexity of interfaces between products and their elements, and also based on the level of systems integrations").

comment

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comment by: *Rolls-Royce plc*

Page 4 Section 3.2 Acceptable approached for the certification of EHPS

Comment summary

The proposed choices contain all the sub-systems needed to create a hybridised gas turbine as per previous RR R&T proposals (EFE, E2SG, NEST) or the current MTU / P&W SWITCH program but does not include such a diagram.

Suggested resolution



	Propose the inclusion of a Hybridised GT diagram in the document under the "engine approach"
response	Accepted. An example will be added to cover Hybridised Gas Turbine.
comment	<p>44 comment by: <i>Rolls-Royce plc</i></p> <p>Page 4 Section 3.2</p> <p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p> <p>To be consistent with the following paragraph (which states states "except the propeller") and Figure 3.</p> <p><u>PROPOSED TEXT</u></p> <p>Under "2. Engine approach", change "A propeller may receive its own type certificate" to "A propeller must receive its own type certificate or be certified under the aircraft type certificate".</p>
response	Accepted. The document will be modified in this spirit.
comment	<p>45 comment by: <i>Rolls-Royce plc</i></p> <p>Page 4 Section 3.2</p> <p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p> <p>Technical clarity</p> <p><u>PROPOSED TEXT</u></p> <p>The above-mentioned "engine approach" provides the flexibility to include in the scope of an engine TC some/all parts of the EHPS, except the propeller. What about variable pitch propellers? Could there be an argument to be include them in the definition of 'engine' due to the influence they may have on the control of the EHPS?</p>
response	Not accepted. Variable pitch Propellers are Propellers.
comment	<p>46 comment by: <i>Rolls-Royce plc</i></p> <p>Page 4 Section 3.2</p> <p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p> <p>I assume that "to mitigate the risk of dispute" is not the only reason why EASA may advise on what it considers to be the most appropriate approach.</p> <p><u>PROPOSED TEXT</u></p>

	Change "...to mitigate the risk of dispute between the different design organisations..." to "...for example, to mitigate the risk of dispute between the different design organisations..."
response	Partially accepted. Wording modified in this spirit.
comment	<p>51 comment by: <i>Rolls-Royce plc</i></p> <p>Page 5 Fig. 3</p> <p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p> <p>No propeller gearbox is shown</p> <p><u>PROPOSED TEXT</u></p> <p>Especially in parallel hybrid architectures, but also potentially in some serial hybrid architectures featuring high speed electric motors, a propeller gearbox is required to ensure the optimal rotational speeds can be achieved by the thermal engine, electric engine and propeller. The propeller gearbox constitutes the primary interface between the "engine" and the propeller and should therefore be shown in the architectures or at least referenced in the text along with the certification possibilities for the gearbox.</p>
response	Accepted. An example of a parallel architecture with a gearbox will be added.
comment	<p>71 comment by: <i>Rolls-Royce plc</i></p> <p>Page 4 Section 3.2</p> <p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p> <p>Formatting</p> <p><u>PROPOSED TEXT</u></p> <p>Delete "Reminder:" from "Reminder: As required by Part 21, the scope of work of the applicant..."</p>
response	Not accepted.
comment	<p>72 comment by: <i>Rolls-Royce plc</i></p> <p>Page 4 Section 3.2</p> <p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p> <p>Formatting</p> <p><u>PROPOSED TEXT</u></p>

response	Change "paragraph" to "section" in "The scope and interfaces of the EHPS should be accurately identified (including maximum boundaries, refer to guidance in paragraph 3.3)."	Accepted. The document will be modified accordingly.
comment	73 Page 4 Section 3.2 <u>RATIONALE / REASON / JUSTIFICATION for the Comment</u> Formatting <u>PROPOSED TEXT</u> Change "The below example illustrates the flexibility that could be offered to an applicant willing to certify an EHPS" to "Figure 1 illustrates the flexibility that could be offered to an applicant who wishes to certify an EHPS."	comment by: <i>Rolls-Royce plc</i>
response	Partially accepted. The document will be modified in this spirit.	
comment	74 Page 5 Section 3.2 <u>RATIONALE / REASON / JUSTIFICATION for the Comment</u> Formatting <u>PROPOSED TEXT</u> Change "Figure 1-Illustration of certification approaches (example of a distributed Electric propulsion)" to "Figure 1-Illustration of EHPS certification approaches"	comment by: <i>Rolls-Royce plc</i>
response	Partially accepted. The document will be modified in this spirit.	
comment	75 Page 6 Section 3.2 <u>RATIONALE / REASON / JUSTIFICATION for the Comment</u> Formatting <u>PROPOSED TEXT</u> Label the examples in the Figure 1 as "Example 1", "Example 2", "Example 3" and change "In the example shown at the bottom of the picture above..." to "In Figure 1, Example 3..."	comment by: <i>Rolls-Royce plc</i>
response	Accepted. The document will be modified accordingly.	



comment	<p>99 comment by: <i>Diamond Aircraft Industries GmbH</i></p> <p>It is appreciated that EASA intends to provide the flexibility to adapt the certification approach to the individual projects.</p> <p>It is understood that the depicted certification approaches are not exhaustive and represent some extreme examples of the available paths.</p> <p>It is assumed that paths with individual component approvals (e.g. ETSO) are not depicted, because there is no path (e.g. ETSO) for these published yet. It would be important especially for the battery to have a component approval path available.</p>
response	<p>Noted. Thank you for your comment.</p>
comment	<p>103 comment by: <i>DGAC France</i></p> <p>DSAC France</p> <p>Reference: Figure 3 page 7 and §3.2 - "<i>The above-mentioned "engine approach" provides the flexibility to include in the scope of an engine TC some/all parts of the EHPS, <u>except the propeller.</u></i>"</p> <p>Comment: According to this sentence, it would mean that integrated fans will be part of the engine TC (also clarified in page 7). However, as the definition of a fan is not included in the CS-Definitions, the CM should clarify the definition of integrated fan and its distinction with the definition of a propeller.</p>
response	<p>Partially accepted. The CM does not question the sharing between rotor, propeller and fan currently used in certification projects: the rotor is part of the Aircraft, the propeller is a product and the fan is part of the Engine. This will be specified in the CM.</p>
comment	<p>106 comment by: <i>Chris Baczynski</i></p> <p>Article 11 of EU Regulation 2018/1139, being invoked as a basis for the possibility of certifying EHPS as part of the aircraft does not have an equivalent in the legal and regulatory framework of key non-EASA jurisdictions.</p> <p>In the interest of global mutual recognition of aeronautical products and to ensure a common level playing field, the decision to allow certification of EHPS as part of the aircraft should be coordinated at a global level. This could be accomplished via the Certification Management Team (CMT) with participation from EASA, FAA, TCCA, and ANAC, also considering the legal and regulatory changes required on part of the last three entities, and as an open CMT-industry consultative process.</p>
response	<p>Noted. This will be reported to CMT. Thank you for your comment.</p>
comment	<p>107 comment by: <i>Chris Baczynski</i></p>

	<p>While the CM is specific to EHPS, following the same logic, the legal basis quoted (Article 11) could easily be construed to apply equally to traditional combustion engines, thereby obviating the need for CS-E / Part 33 certification for reciprocating, turboshaft, or turbofan engines, even for Part 25 aircraft applications (per sec. 2 applicability of the CM is for "all aircraft applications").</p> <p>Hence, EASA would be welcome to clarify if certifying engines as part of the aircraft (without the need for CS-E/Part 33 cert) will be limited strictly and ONLY to EHPS due to their inherent nature, or could apply in the future for traditional combustion engines, should an applicant decide to propose such an approach.</p>
response	<p>Not accepted. As written in the CM, "the EHPS certification requirements will be the same, independently from the selected certification approach".</p> <p>Moreover, the CM only covers EHPS. Discussions concerning the integration of other type of engines in the A/C TC have to take place with EASA on a case-by-case basis. As of today, complex engines are required to have an Engine TC in the EASA context.</p>
comment	<p><i>108</i> comment by: <i>AURA AERO</i></p> <p>Is there any plan to update AMC 20-1 and AMC 20-3 (Amdt 23) regarding activity/responsibility sharing between the stakeholders? As the boundaries of an EHPS may be different compared to the legacy.</p>
response	<p>Noted. Revision of AMC 20-1 and AMC 20-3 is not planned at this stage.</p>
comment	<p><i>110</i> comment by: <i>Jorge Rodriguez ADSE</i></p> <p>Sentence "No matter which approach is used, the applicable requirements will remain consistent between the Aircraft approach and the engine approach."</p> <p>Word "consistent" could be misleading, since (at stated later) requirements will be the same. Suggest uses "will remain the same" instead</p>
response	<p>Accepted. The document will be modified accordingly.</p>
comment	<p><i>112</i> comment by: <i>Voltaero</i></p> <p>Regarding the first approach "1. Aircraft approach: the EHPS is certified as part of an aircraft.", with or without propeller(s)? Maybe good to specify it to avoid any confusion.</p>
response	<p>Accepted. The document will be modified in this spirit.</p>
comment	<p><i>113</i> comment by: <i>Voltaero</i></p> <p>Is it possible to have a fourth configuration based on the third one, but with the turbogenerator certified under the aircraft TC? (it means with turbogenerator in green box).</p>
response	<p>Partially accepted. In principle, yes, depending on the complexity of the turbogenerator. To be discussed on case-by-case basis with EASA.</p>

comment	<p>118 comment by: <i>Voltaero</i></p> <p>Could you provide some examples of a DOA Scope of Work for an a/c manufacturer (applicant) that intends to follow approach 1 with some of the EHPS unit not covered by a proper TC? (example: EE covered by TC and TE to be certified as part of the aircraft)</p>
response	<p>Not accepted. DOA scope of work has to be discussed for each project when an application has been made.</p>
comment	<p>122 comment by: <i>Airbus Helicopters</i></p> <p>Comment: §3.2 :The CM states "EASA may advise on what it considers to be the most appropriate approach" between an 'aircraft approach' and an 'engine approach'. Could EASA clarify the criteria that will be underlying the decision to advise negatively against the choice of the OEM. As an example can an OEM still choose an architecture that would integrate some engine related elements in the scope of the aircraft TC before engaging the discussion on certification with EASA?</p>
response	<p>Not accepted. For every project, discussions will have to take place with EASA to agree on a certification strategy. For complex products, as a gas turbine that may be subject to Hazardous events, an Engine TC will be requested.</p>
comment	<p>123 comment by: <i>Airbus Helicopters</i></p> <p>Comment: In all schematics, there is no mixed architecture where one type of engine would be engine TC and another type would be Aircraft TC. In the three examples, Engines are either both under engine TC, either both under aircraft TC. Could EASA confirm that such scope split is part of the flexibility offered ?</p>
response	<p>Partially accepted. In principle, yes, depending on the complexity of the Engine that is to be integrated in the A/C TC. To be discussed on case-by-case basis with EASA.</p>
comment	<p>129 comment by: <i>Pratt & Whitney Canada</i></p> <p>This comment is provided on behalf of Pratt & Whitney Canada (P&WC), Collins, and Pratt & Whitney (P&W), collectively referred to as "RTX".</p> <p>RTX interpretation of Figure 1 captures only three of many potential certifications approach for serial propulsion systems as many other combinations could be proposed to meet the same certification objectives and level of safety.</p> <ul style="list-style-type: none"> o The diagram is exemplary only, not intended to specifically exclude other series architectures → Accepted o The 'Distribution' block is drawn here is understood to be electrical distribution only to remain consistent with text below Figure 1 → Accepted o Flexibility delimitation is required for each application to allow optimization between airframer and engine manufacturer domain of expertise. → Accepted. This is the purpose of the CM. <p>Regarding Figure 1:</p>

	<p>o As noted in this guidance document batteries and other elements of the EHPS might be certified under an engine TC combined with airframe TC. It should be clarified that a turbo generator might have its thermal engine certified as part of it's own TC as implied by the TC1 vs TC2. → Partially accepted. May be possible but to be discussed on a case-by-case basis.</p> <p>o Guidelines should be proposed to justify the selection certification approach, and it should be linked to the SSHA. → Not accepted. Guidance is already provided as part of the CM and discussions will have to take place with EASA for every project to agree on a certification strategy. SSHA are usually provided later in the certification process.</p> <p>o If parallel Hybrid is in scope the figures should be generalized further, or at least one example should more closely represent a parallel system. → Accepted. The document will be modified accordingly.</p>
response	See EASA responses integrated in the Comment above (in bold type).

comment	<p>130 comment by: <i>Pratt & Whitney Canada</i></p> <p>This comment is provided on behalf of Pratt & Whitney Canada (P&WC), Collins, and Pratt & Whitney (P&W), collectively referred to as "RTX".</p> <p>Figure 1 illustrates three different approaches. While the objective of providing flexibility is understood, RTX considers that the third approach is high risk for missed systems requirements and potential hazards. RTX recommends removing this option</p> <p>a. A subsystem safety hazard analysis (SSHA) should set the limit of what is under the Engine TC vs setting the basis as a general context.</p> <p>b. The scope of the 'distribution' block should be defined as understood by the committee. It appears to include contactors & wiring and potentially motor controllers / electrical engine controllers as well. If the motor controllers are intended to always certify with the electrical engine that should be made clear.</p>
response	<p>Not accepted. As explained in the CM, "No matter which approach is used, the applicable requirements will remain the same between the Aircraft approach and the Engine approach."</p> <p>a. SSHA are usually provided too late in the certification process compared to the need of defining the certification strategy at TC application. However, we agree this type of safety analysis can be useful to define the certification strategy.</p> <p>b. The control system of each Engine is included in the Engine TC as per Engine definition. The "distribution" box therefore does not contain motor controllers / electrical engine controllers. Therefore, the last example of Figure 1 is valid.</p>

comment	<p>131 comment by: <i>Pratt & Whitney Canada</i></p> <p>This comment is provided on behalf of Pratt & Whitney Canada (P&WC), Collins, and Pratt & Whitney (P&W), collectively referred to as "RTX".</p> <p>If this document is intended to cover parallel systems, or becomes modified to better reflect parallel systems, the figure shown below and attached (or similar) is proposed to be added as an example.</p>
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	<p>If this document includes parallel systems RTX propose the electric portion can be in a separate TC from the thermal engine that it produces thrust with. In this case the power management should be part of the aircraft TC.</p>
response	<p>Accepted. Examples will be added to cover parallel architectures.</p>
comment	<p>136 comment by: <i>Pratt & Whitney Canada</i></p> <p>This comment is provided on behalf of Pratt & Whitney Canada (P&WC), Collins, and Pratt & Whitney (P&W), collectively referred to as "RTX".</p> <p>Figure 1 should also be expanded with other examples to show that it is still possible to obtain a Type Certificate for only the thermal engine part of a turbogenerator (i.e. Engine only, not including the generator), and that the generator might be part of the Aircraft TC or Electric Engine TC, since this scenario can be important to engine manufacturers who might wish to adapt their engine to one or more turbogenerator applications.</p>
response	<p>Partially accepted. In theory yes, this is possible. To be discussed with EASA on a case-by-case basis.</p>



comment	<p>137 comment by: <i>MTLS Aerostructure</i></p> <p>I suggest using letters or numbers to identify each approach and emphasizing that, in the first approach, the entire system outlined in blue should have its own TC. See figure below as suggestion:</p>
response	<p>Partially accepted. The document will be modified in this spirit.</p>
comment	<p>147 comment by: <i>TCCA</i></p> <p>It is unclear why is remark about propeller possibly having its own type certificate included against second option only. It is true for the first option as well, in practice and as shown in Figure 3 of this memo.</p> <p>In contemporary landscape, propeller itself is often certified under its own TC but its control system (modulating blade angles and providing protection from propeller overspeed) is certified as an aircraft system, under aircraft TC. This is typical arrangement even though propeller control could be, in theory, certified under propeller TC. This reality is, at least in part, driven by the fact that propeller manufacturers do not have required visibility over the aircraft characteristics allowing them to design and produce a propeller control system which will be adequate for a specific aircraft. The consequence of certifying (and designing) propeller alone is that it allows propeller manufacturers more flexibility when providing the same product (propeller itself only) for multiple aircraft applications.</p> <p>Engine manufacturers are not in the same position, they are very limited in this respect as there are no engines, especially lately and certainly will not be in EHSP landscape, which are separate from the engine control system. Engine control system cannot be segregated from aircraft level functions, as described in comment against Section 3.2 above.</p> <p>Furthermore, engine manufacturers are lately embarking upon providing integrated engine and propeller control, embedded in engine control unit. The propeller related functions in this arrangement cannot be certified under engine level certification, and are to be certified under aircraft level certification, even if the particular engine manufacturer has opted to go for option 2 listed in this Section.</p>
response	<p>Accepted. The document will be modified to cover the two approaches.</p>
comment	<p>148 comment by: <i>TCCA</i></p> <p>Referring to text “The above-mentioned “engine approach” provides the flexibility to include in the scope of an engine TC some/all parts of the EHPS, except the propeller.”</p> <p>Suggest adding text to the effect of the following:</p> <p>“It must be recognized that some of the EHSP parts in this arrangement will be involved in performing critical aircraft level functions and, consequently, contributing to aircraft level functional hazards. These functions and their relation to aircraft safety will remain within aircraft level certification scope. They are also, typically, aircraft specific in terms of means of compliance to aircraft certification requirements.”</p>

response	Partially accepted. An example has been added to illustrate the interaction between the EHPS components and critical Aircraft functions (crashworthiness).
comment	<p>149 comment by: TCCA</p> <p>Referring to the text “The final integration needs to be demonstrated at aircraft TC level (including installation instructions addressing potentially complex interfaces)” suggest adding text as follows: “.....(including installation instructions addressing potentially complex interfaces and compliance to aircraft level certification safety requirements which are not covered by EHSP level certification)</p>
response	Partially accepted. The document will be modified in this spirit.
comment	<p>150 comment by: TCCA</p> <p>Suggest to add yellow text to the following: “A propeller may receive its own type certificate or be certified as part of the aircraft”.</p> <p>Rationale: Several applications (eVTOL, LSA) have propellers certified as part of the aircraft</p>
response	Not accepted. In this case we would talk about "rotors", not "propellers". Generally speaking, the CM does not question the sharing between rotor, propeller and fan currently used in certification projects: the rotor is part of the aircraft, the propeller is a product, and the fan is part of the engine. This will be specified in the CM.
comment	<p>154 comment by: TCCA</p> <p>Figures 1 through 3 illustrates the different certification approaches that can be taken for different systems in EHSP. One of the systems that can be added to this example is cooling system. There are some crucial aspects of cooling system which are as challenging as battery system. For instance, the type of coolant whether it is flammable or not can have impact in defining the interfaces between AC system and EHPS regarding fire protection designs. Another aspect is the heat exchanger and the capacity of heat exchangers which may require complex installations on the aircraft including the location of the heat exchangers, their fairings, their control systems etc.</p>
response	Partially accepted. We agree with the comment however the CM provides guidances and examples and cannot cover all types of equipment. All specific projects will be discussed on a case-by-case basis with EASA. Note: oil cooling system of turbine Engines (e.g. oil tank, heat exchanger) may be part of the Engine or Aircraft TC.
comment	<p>163 comment by: TCCA</p> <p>As first time use of the term "extended engine TC" in the document, would EASA define the term here or refer to where it may be found?</p>

	Rationale: New term not typically used by other Airworthiness Authorities in engine certification programs
response	Accepted. The document will be modified accordingly. See also response to Comment #162.
comment	<p>172 comment by: <i>Kevin R Bruce</i> <i>Aircraft Electronics Association</i></p> <p>1/2 If you consider what is meant by powerplant of propulsion system, there are too many elements of this system that become unique to the aircraft and not the engine. It would be very difficult to bring all elements into the engine TC and be a viable product for multiple aircraft designs. What could be part of the electric engine system needs a better definition and criteria as to way it could be certified with the engine. We don't want to tie the engine manufacturer to an aircraft design – this limits innovation</p>
response	Not accepted. See previous responses (#165, #166, etc.).
comment	<p>173 comment by: <i>Kevin R Bruce</i> <i>Aircraft Electronics Association</i></p> <p>2/2 In the figure the top scenario poses significant issues to propose that this could be done under one TC. Just suggesting that the TC would approve a 3 engine or multi engine installation on the aircraft is not appropriate. There are so many factors that needed to be accounted for when installing multi engines, including independent energy sources and the potential need to have one energy source power to engines in emergencies. These are aircraft level requirements and far to complex to try and resolve at the engine level. The same could be said for the batteries and distribution. You may need to have to energy sources for one motor in a dual channel motor. Distribution is unique to the aircraft installation and the intended purpose of the use of the propulsion. If one intends to use the aircraft approach – well it no longer falls under an engine TC. We still need to have rules, standards and guidance for each element represented in the figure. The statement in bold emphasizes the need for clear rules, standards and guidance for each element of the powerplant system (propulsion could be used in place of powerplant it is the same).</p>
response	Partially accepted. The Engine TC would cover the Engines only, not their installation on the A/C. The Engine installation instructions only contain some requirements, but the Engine installation is A/C responsibility and is part of the A/C certification. Coordination between the engine manufacturer and the airframer is of course necessary, even beyond certification aspects.
comment	<p>184 comment by: <i>GE Aerospace team</i></p> <p>Page 4 Currently reads "The below example illustrates the flexibility that could be offered to an applicant willing to certify an EHPS."</p>



	<p>We propose to change this to “The below example illustrates the flexibility that could be offered to an applicant willing to certify an EHPS. Note that Figure 1 contains some but not all possible approaches.”</p> <p>We feel this is necessary to provide better consistency with Figure 3 and also simply to be clear that Figure 1 is not all encompassing.</p>
response	Accepted. The document will be modified in this spirit.

comment	<p>185 comment by: FAA</p> <p>Section 3.2, Paragraph/Sentence 1</p> <p>The FAA is still evaluating the possible certification approaches and may or may not be possible to do some under our current regulatory framework, e.g. distributed propulsion.</p>
response	Noted.

comment	<p>186 comment by: FAA</p> <p>Section 3.2, Figure 1 “Illustration of certification approaches”</p> <p>FAA is in the process of evaluating the certification approaches, including what makes technical sense and meets our regulatory framework. Recall we have an action from the September 17-19, 2024 COB Hydrogen work group meeting to develop similar illustrations. It will likely be a few months before we have a concrete FAA position. Some of the areas we are discussing are:</p> <ul style="list-style-type: none"> • Whether we can or should certify the propulsion battery with the engine, including which aircraft may make sense, e.g. single engine part 23 aircraft vs transport. • Whether the engine can or should be certified under the aircraft TC beyond what is currently allowed under FAA regulations, e.g. part 25 transport airplanes. • Whether a “device” that only generates electrical power can or should be granted an engine TC, e.g. turbogenerator and/or hydrogen fuel cells. • Distributed propulsion as noted in previous comment.
response	Noted. Thank you for your comment.



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

p. 6

comment

3

comment by: *CycloTech*

We agree with the 'active' relation that the CM defines between the engine and the "upstream component" that is the propulsion battery system.

We would like to highlight how this is also true for "downstream components" such as non-conventional rotor / propeller, for the cases when they are highly integrated with the EHPS.

The engine control laws are in this case also tightly connected with the non-conventional propeller/rotor control laws, or example when modulating (or even vectoring, as in CycloTech's case) the thrust.

The controlling of the propeller has immediate influence on the engine directly coupled with the propeller, so that the engine designer needs to take this into account when designing the engine control law (i.e. constant RPM by thrust modulating and vectoring).

There are already cases that include part of the propeller system into the engine system (see SC-E21 "Propeller control system components as part of engine type design").

We propose to extend the scope of such approach to the propeller system. Not for all cases, but for cases where the integration between EHPS and non-conventional propeller/rotor is very tight.

response

Not accepted. The CM does not question the sharing between rotor, propeller and fan currently used in certification projects: the rotor is part of the Aircraft, the propeller is a product, and the fan is part of the Engine. This will be specified in the CM.

comment

6

comment by: *H55*

Figure 2. While this schematic does offer guidance of the high level, H55 suspect many applicants will seek to understand the scope of each one of these boxes. Perhaps further guidance on the 'scope' of some of the less obvious elements would be beneficial.

E.g. The Energy Flow Counter could be incorporated in the Propulsion Battery, Power Management or in the Distribution system.

response

Not accepted. The CM aims at providing general guidances and examples and cannot cover all possible parts and pieces of equipment.

comment

8

comment by: *H55*

Figure 3 implies that other energy generation means (e.g. Fuel cells) are out of the scope of the EHPS. Is this correct?

response

Accepted. As mentioned in the CM, hydrogen is for the moment not in the scope.



comment	<p data-bbox="368 230 1394 271">9 comment by: <i>Salvatore Demelas</i></p> <p data-bbox="368 293 1394 472">Understanding that the intention of the memorandum is to provide a generic certification approach extending the boundaries of the typical “engine” definition driven by the new EHPS architectures, in section 3.3 a comparison between the Fuel tank and the propulsion battery is used to justify the more “active” characteristics of the latter one.</p> <p data-bbox="368 506 1394 685">While I do not technically disagree with the listed justifications (they are actually fully valid points), I would like to point out that the supporting arguments might be too specific (e.g. battery effect on engine efficiency, voltage level...) and therefore only applicable to a subset of EHPS architectures, affecting the generic applicability of the memorandum.</p> <p data-bbox="368 689 1394 902">For example, should the applicant architecture feature a DCDC converter downstream the batteries (used for instance when different power sources feed the same propulsion HVDC network) the arguments to justify the propulsion battery as an “active” elements might no longer be valid as the battery voltage level is now decoupled from the electric engine controller input and the electric engine efficiency and speed are now not directly affected by the battery operating point.</p> <p data-bbox="368 936 1394 1227">A potential workaround, fully coherent with the certification approaches depicted in figure 1, could be to generically highlight the strong power and control interactions between the power source (battery), power management (which I understand also includes eventual propulsion power converters e.g. DCDCs), power distribution and engines that need to be jointly accounted in a common design effort making them intrinsically necessary “for the functioning and control” (and protection I might add) of the “engine” as a system. The existing low level technical justification might be still included as a supporting specific example of such interactions.</p>
response	<p data-bbox="368 1238 1394 1435">Noted. The CM provides guidances and examples and cannot cover all architectures. All specific projects will be discussed on a case-by-case basis with EASA. Moreover, no architecture including a DCDC converter has been seen so far. It can also be noted that the comparison with the fuel tank has been removed, while only keeping the analysis on the battery system.</p>
comment	<p data-bbox="368 1469 1394 1509">16 comment by: <i>Lilium</i></p> <p data-bbox="368 1536 1394 1603">"However, turbogenerators (possibly reciprocating engine-generators) also fall under the ‘engine’ definition when used for aircraft propulsion."</p> <p data-bbox="368 1608 1394 1727">Would it make sense to amend the document by certain criteria in order to identify which regulations are applicable CS-E or CS-APU? If this is in general possible to summarized without going on case-by-case basis.</p>
response	<p data-bbox="368 1738 1394 1823">Not accepted. The Certification Basis is always discussed as part of the project. As explained in the CM, this has to be discussed with EASA on a case-by-case basis.</p>
comment	<p data-bbox="368 1856 1394 1897">17 comment by: <i>Lilium</i></p> <p data-bbox="368 1924 1394 2036">Page 7: "When electric engines are designed with fans, the associated fans are certified as part of the engine definition, similarly to turbine engines."</p>

	<p>May be usefull to add the following sentence: "When electric engines are designed for propeller installation, the associated propellers are certified under CS-P and receive their own TC, similarly to conventional aviation."</p>
response	<p>Partially accepted. It will be clarified in the CM that "A Propeller is not part of the EHPS and must receive its own Type Certificate or be certified under the Aircraft Type Certificate."</p>
comment	<p>22 comment by: <i>Pulkit Agrawal (Honeywell)</i></p> <p>3.3. Elements that may be certified within an engine Type Certificate</p> <p>Situation: It is made clear that a propulsion battery is not considered equivalent to a fuel tank, as "From a functional point of view, the propulsion battery is equivalent to the combination of fuel tank and turbogenerator(s) as they both provide electrical power."</p> <p>The engine TC must always include the engine(s) used or intended to be used for aircraft propulsion. For example, an engine TC can not be granted for a propulsion battery only.</p> <p>Issue: This comparison of the fuel tank and the battery is flawed as from a functional standpoint the fuel tank and the battery both provide stored energy for the system to use, though in different forms. In both cases an 'engine' is used to convert this stored energy to mechanical power used by the propulsors (propeller, fan or rotor).</p> <ul style="list-style-type: none"> • For a conventional powerplant, an internal combustion engine converts the fuel to mechanical power. • For an all-electric system, an electric engine converts the stored electric energy to mechanical power. • In a series-hybrid electric system with a turbo generator, an internal combustion engine converts the fuel to mechanical power that is immediately used in a generator that converts it back to electric energy, that later uses an electric engine to convert. If the TWO turbogenerator conversions are ignored then this device could be considered only a means to convert fuel to electric energy as does a fuel cell. <p>The combination of fuel and turbogenerator are functionally equivalent to a battery as an 'active' source of electric energy, and can be certified under and Engine TC approach. A battery, though, cannot be certified independently and so any use in other applications requires that it be re-certified with the associated electric engine(s). This dramatically complicates the ability to develop and certify propulsion batteries for use in multipole applications.</p> <p>Recommendation:</p>

response	<p>A propulsion battery should be eligible for certification under the same provisions as a turbogenerator (and fuel tank), the Engine TC approach, as they are functionally equivalent providing stored electric energy (voltage) to an aircraft propulsion system.</p> <p>Not accepted. Even if this reasoning makes sense, propulsion battery is not defined as a product by the basic regulation. Moreover, it can be noted that the comparison with the fuel tank has been removed, while only keeping the analysis on the battery system.</p>
comment	<p>27 comment by: <i>Samuel Mericq (Maeve Aerospace)</i></p> <p>[This 'active' relation between the propulsion battery and electric engines demonstrate that the propulsion battery could be considered as part of the components and equipment necessary for the functioning and control of the engine]</p> <p>Even if schematics from §3.2 are indicating that batteries could be part of the "aircraft approach", Memo recommendation in 3.3 seems to be mainly advocating for the "engine approach". However, for cases were the batteries are not only for propulsive power use but also powering aircraft systems as well, the engine approach would be highly impractical or even impossible to develop. Could this case of multi purpose batteries be more clearly detailed?</p>
response	<p>Not accepted. This criterion ("multi-purpose batteries") may not trigger the need to certify the battery as part of the Aircraft. To be discussed on a case-by-case basis for each project.</p>
comment	<p>28 comment by: <i>Samuel Mericq (Maeve Aerospace)</i></p> <p>[Therefore, it makes sense to integrate the turbogenerator in the extended engine definition for EHPS. Following this reasoning, as the power management and the distribution make the link between the electric engines and the turbogenerator, they are necessary for the functioning and control and therefore belong to the extended engine definition.]</p> <p>While this may be true for a 'Serial hybrid' architecture, for other architectures such as 'Parallel hybrid' the main thrust is provided by a conventional turbine which includes a motor/generator. The power management and distribution are complementary to the engine control (FADEC or otherwise) but not strictly necessary for its functioning, since failures on electric motor and/or batteries only result in a partial loss of thrust/power. Similarly, failures in the gas turbine (with the exception of the common shaft in a parallel architecture) do not necessarily result in failures in the motor/generator and batteries. Therefore, it does not follow that these should be included in the extended engine definition. Could the logic in this paragraph be extended to additional hybrid architectures?</p>
response	<p>Partially accepted. The text will be modified to bring nuance and to add clear reference to Example 1 of Figure 1 (series architecture). As a reminder, certifying the Power management and Distribution system as part of the Engine TC is not an obligation, it is a possibility. Moreover, examples will be added to cover parallel architectures.</p>

comment	<p>34 comment by: Airbus-Regulations-SRg</p> <p>PDF page 6, para. >>3.3 Elements that may be certified within an engine Type Certificate<<, second section</p> <p>AIRBUS PROPOSED TEXT: We propose the following changes in the 2nd section to read: The ‘engine approach’, which would allow to certify a complete EHPS under one engine TC, requires to reconsider the scope of the ‘engine TC’ as it is known today, in the form of an extended engine TC including additional components such as generators, power management, power distribution and propulsion batteries, <i>if these components are only used for providing electrical power to the electric engines. At this condition</i>, all these components, despite being part of the system and even if physically installed at different locations, could 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.</p> <p>RATIONALE: The reasoning developed in this section in order to justify the “extended engine TC approach” is heavily dependent on the level of integration of the components to be included in this extended engine TC in the aircraft systems. The extended engine TC approach should be considered only when the EHPS architecture and integration with the aircraft system is limited and the components that are described as ‘necessary for the functioning and control of the engine’ in this certification memorandum have limited use as part of the aircraft systems</p>
response	<p>Partially accepted. While it is acknowledged and mentioned in the CM that the extended Engine TC may not be appropriate for specific A/C configuration (to be discussed on a case-by-case basis with EASA), it should be noted that the electrical power supply certified under the Engine TC must be used for propulsion but may also be used for other Aircraft systems.</p>
comment	<p>35 comment by: Airbus-Regulations-SRg</p> <p>PDF page 6, para >>3.3 Elements that may be certified within an engine Type Certificate<<, second section, quote</p> <p>“When looking at the schematic above, one could state that the elements providing the power or the thrust for the aircraft propulsion, are only the electric engines. However, turbogenerators (possibly reciprocating engine-generators)</p>

also fall under the ‘engine’ definition when used for aircraft propulsion. *They are often derivatives of type certified engines according to CS-E (CS-APU may be used under conditions to be agreed with EASA). Therefore, it makes sense to integrate the turbogenerator in the extended engine definition for EHPS. Following this reasoning, as the power management and the distribution make the link between the electric engines and the turbogenerator, they are necessary for the functioning and control and therefore belong to the extended engine definition.”*
UNQUOTE

AIRBUS COMMENT:

The comment is about a reasoning developed in this section.

The underlined sentence which gives the justification for considering the turbogenerator as an element of the “extended engine definition” appears to be weak. It is not because a turbomachine was previously certified with an engine TC that it necessarily meets the intent of the engine definition in an EHPS architecture. In addition, there may be proposed designs for which the turbo generator will not be a derivative of a previously certified engine. In such a case, what would be justification for considering it as part of an extended engine definition?

RATIONALE:

See paragraph above

response Noted. As explained in the CM, if a turbogenerator is part of the Aircraft propulsion, it will fall under the Engine definition, even if the turbogenerator is not a derivative of a previously certified Engine.

comment 36 comment by: Airbus-Regulations-SRg

PDF page 6, para. >>3.3 Elements that may be certified within an engine Type Certificate<<,
3rd section, quote:

Fuel tank and propulsion battery:

The fuel tank and the propulsion battery are not considered equivalent in view of an ‘extended engine TC’,
although both systems influence the center of gravity and surrounding systems of the aircraft and shall be compliant with crashworthiness requirements defined at aircraft level.

They differ as regards two aspects:

[...]

UNQUOTE

PROPOSED TEXT:

Delete the second part of the first sentence to read:

The fuel tank and the propulsion battery are not considered equivalent in view of an ‘extended engine TC’.



~~although both systems influence the center of gravity and surrounding systems of the aircraft and shall be compliant with crashworthiness requirements defined at aircraft level.~~

They differ as regards two aspects:

[...]

RATIONAL:

It is not bringing any value to the argumentation in the certification memorandum and is either incorrect or incomplete in terms of interactions of fuel tank and batteries with the other aircraft systems as well as aircraft level certification requirements that those elements would need to satisfy (why citing only crashworthiness requirements?) → **Accepted. The comparison with the fuel tank has been removed, while only keeping the analysis on the battery system.**

The rest of the paragraph is providing a reasoning to justify the integration of an energy storage system, the electrical battery, as part of the 'extended engine TC'. This argumentation is essentially based on a more 'active' relationship between the battery and the electric engine than between a typical kerosene fed engine and the fuel tank. Although there may be a level of truth

in this reasoning, it is clear that this 'more active' relationship can be managed even if the battery and the rest of the electrical system elements are certified as part of the aircraft. It should therefore not be the only element taken into consideration in order to accept an 'extended engine TC' definition. As stated in the previous comment, the other key criteria to take into account (and which is absent from this certification memorandum) is the complexity and level of integration within the aircraft of a proposed EHPS design architecture.

The extended engine TC definition proposed in this certification memorandum may be appropriate for proposed designs where the electrical components of the EHPS are used solely for powering the electric engines with very limited interface/interactions with the aircraft electrical system. → **Partially accepted. Certifying the battery system as part of the Engine TC is only a possibility (not an obligation), based on conditions. It is already explained in the CM that "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 also based on the level of systems integrations". An example has also been added to illustrate the potential complexity of interfaces ("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").**

response See EASA responses integrated in the Comment above (in bold type).

comment 38 comment by: FOCA (Switzerland)

In this regard, we would be very grateful to EASA if the question could be answered as to whether this CM also takes into account EHPS that are only intended for emergency situations, i.e. autorotation?



response Noted. As written in the document, "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 [...]".

comment 47 comment by: *Rolls-Royce plc*

Page 7 Section 3.3

RATIONALE / REASON / JUSTIFICATION for the Comment

Technical clarity

PROPOSED TEXT

Regarding "...turbine efficiency is not dependent on the fuel flow or fuel quantity", voltage is analogous to fluid pressure not fluid flow.

response Accepted. The document will be modified accordingly.

comment 48 comment by: *Rolls-Royce plc*

Page 7 Section 3.3

RATIONALE / REASON / JUSTIFICATION for the Comment

Technical clarity

PROPOSED TEXT

Regarding "The engine controller also has an influence on the energy drawn from the propulsion battery", change "energy" to "current" or delete the sentence completely.

response Accepted. The wording will be modified accordingly.

comment 52 comment by: *Rolls-Royce plc*

Page 7 Second bullet point on page 7

RATIONALE / REASON / JUSTIFICATION for the Comment

Technical clarity

PROPOSED TEXT

This bullet point refers to voltage drop of the battery when it discharges. Is this intended to refer to battery voltage output profile during one mission, or is intended to highlight that the battery output voltage will reduce with battery life?

response Noted. This refers to battery voltage output profile during one mission.



comment	<p>76 comment by: <i>Rolls-Royce plc</i></p> <p>Page 6 Section 3.3</p> <p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p> <p>Formatting</p> <p><u>PROPOSED TEXT</u></p> <p>Change "A typical EHPS aircraft installation is described in the here figure 2" to "A typical EHPS aircraft installation is described in Figure 2."</p>
response	<p>Partially accepted. The text and associated Figure have been removed for other reasons.</p>
comment	<p>77 comment by: <i>Rolls-Royce plc</i></p> <p>Page 6 Section 3.3</p> <p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p> <p>Formatting</p> <p><u>PROPOSED TEXT</u></p> <p>Change "Figure 2-Schematic view of EHPS installation and interaction" to "Figure 2-Schematic view of EHPS primary interactions and aircraft installation". I used the word primary as certain use cases (such recharging of the propulsion battery) are not reflected in Figure 1 or Figure 2. Alternatively, you could use double-headed arrows.</p>
response	<p>Partially accepted. The text and associated Figure have been removed for other reasons.</p>
comment	<p>78 comment by: <i>Rolls-Royce plc</i></p> <p>Page 6 Section 3.3</p> <p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p> <p>Formatting</p> <p><u>PROPOSED TEXT</u></p> <p>Change "The 'engine approach', which would allow to certify a complete EHPS under one engine TC, requires to reconsider the scope of the 'engine TC' as it is known today..." to "The 'engine approach', which would allow a complete EHPS to be certified under one engine TC, requires to the scope of the engine TC as it is known today to be reconsidered."</p>
response	<p>Accepted. The wording will be modified accordingly.</p>

comment	79	comment by: <i>Rolls-Royce plc</i>
	<p>Page 6 Section 3.3</p> <p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p> <p>Formatting</p> <p><u>PROPOSED TEXT</u></p> <p>Change "When looking at the schematic above..." to "When looking at Figure 2..."</p>	
response	Accepted. The wording will be modified accordingly.	
comment	80	comment by: <i>Rolls-Royce plc</i>
	<p>Page 6 Section 3.3</p> <p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p> <p>Formatting</p> <p><u>PROPOSED TEXT</u></p> <p>Insert empty line before "However, turbogenerators..."</p>	
response	Not accepted. This paragraph is related to the one above.	
comment	81	comment by: <i>Rolls-Royce plc</i>
	<p>Page 6 Section 3.3</p> <p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p> <p>Formatting</p> <p><u>PROPOSED TEXT</u></p> <p>Change "However, turbogenerators (possibly reciprocating engine-generators)..." to "However, turbogenerators and piston engine generators..."</p>	
response	Accepted. The wording will be modified accordingly.	
comment	82	comment by: <i>Rolls-Royce plc</i>
	<p>Page 6 Section 3.3</p> <p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p> <p>Formatting</p> <p><u>PROPOSED TEXT</u></p>	



	Change "Therefore, it makes sense to integrate the turbogenerator in the extended engine definition for EHPS" to "Therefore, it makes sense to integrate the turbogenerator or piston engine generator in the extended engine definition for the EHPS."
response	Accepted. The wording will be modified accordingly.

comment	<p>83 comment by: <i>Rolls-Royce plc</i></p> <p>Page 6 Section 3.3</p> <p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p> <p>Formatting</p> <p><u>PROPOSED TEXT</u></p> <p>Change "Following this reasoning, as the power management and the distribution make the link between the electric engines and the turbogenerator, they are necessary for the functioning and control and therefore belong to the extended engine definition" to "Furthermore, as the power management and distribution make the link between the electric engines and the turbogenerator or piston engine generator, they are necessary for the functioning and control of the engine and therefore belong to the extended engine definition."</p>
response	Accepted. The wording will be modified accordingly.

comment	<p>84 comment by: <i>Rolls-Royce plc</i></p> <p>Page 6 Section 3.3</p> <p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p> <p>Formatting</p> <p><u>PROPOSED TEXT</u></p> <p>Delete "Fuel tank and propulsion battery:"</p>
response	Accepted.

comment	<p>85 comment by: <i>Rolls-Royce plc</i></p> <p>Page 6 Section 3.3</p> <p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p> <p>Formatting</p> <p><u>PROPOSED TEXT</u></p>
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	<p>Change "They differ as regards two aspects:" to "They differ in the following two aspects". Also, move these words to previous line.</p>
response	Accepted. The wording will be modified accordingly.
comment	<p>86 comment by: <i>Rolls-Royce plc</i></p>
	<p>Page 7 Section 3.3</p>
	<p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p>
	<p>Formatting</p>
	<p><u>PROPOSED TEXT</u></p>
	<p>Change "...the associated fans are certified..." to "...the associated fans shall be certified..."</p>
response	Accepted. The wording will be modified accordingly.
comment	<p>87 comment by: <i>Rolls-Royce plc</i></p>
	<p>Page 7 Section 3.3</p>
	<p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p>
	<p>Typo</p>
	<p><u>PROPOSED TEXT</u></p>
	<p>Change "...an engine TC cannot be granted for a propulsion battery only" to "...an engine TC cannot be granted for a propulsion battery only."</p>
response	Accepted. The proposed wording is identical to the current one.
comment	<p>100 comment by: <i>Diamond Aircraft Industries GmbH</i></p>
	<p>There is no clear definition of active and passive in this context. The use of these terms to justify inclusion or exclusion from engine TC seems arbitrary.</p>
	<p>It is not understood especially when considering CS-E 50, why power levers are excluded. On electronically controlled engines the power lever sensors are normally part of the engine TC.</p>
response	<p>Not accepted. As explained in the CM, "active" refers here to a certain level of dependency between the engine control systems and systems in interface.</p>
	<p>Propulsion batteries may have an impact on the engine control laws, which is not the case for power levers for instance.</p>
	<p>Moreover, human-machine interface is a predominant aspect when developing and certifying power levers, explaining why they must be part of the Aircraft TC. Finally, power levers sensors are not normally part of the Engine TC.</p>

Generally speaking, the introduction of EHPS does not question the current practices in terms of certification. For instance, fuel systems are currently certified as part of the Aircraft.

comment **104** comment by: *DGAC France*

DSAC France

Reference: §3.3, end of page 7 - "The engine TC must always include the engine(s) used or intended to be used for aircraft propulsion. For example, an engine TC can not be granted for a propulsion battery only."

Comment: We support the approach. However, some design organisations are specialized in the design of propulsion batteries only. Should we consider the development of a TSO at some point?

response Not accepted. There are currently no existing mature industry standards and, as a consequence, no E/TSO standards for EHPS components that can be certified as part of the Engine.

comment **114** comment by: *Jorge Rodriguez ADSE*

Regarding "Following this reasoning, as the power management and the distribution make the link between the electric engines and the turbogenerator, they are necessary for the functioning and control and therefore belong to the extended engine definition"

It can be understood that the linked components can only be a part of extended engine definition if they are located between two engines. Is this the case?

If the turbogenerator is a separate TC engine (as in figure 1 bottom), should battery-power management-distribution elements be part of A/C TC?
or could they be part of TC engine with the electrical engine (then battery-power management-distribution-electrical engine as TC)?

In this second scenario, the CS definition "components and equipment necessary for the functioning and control of the engine" should be used.

Please, if the second scenario is possible rewrite the sentence to highlight that the criteria is that they are necessary and not that they are a link

response Partially accepted. In principle, yes, the propulsion battery, power management and distribution could be included in the electric Engine TC (this can be derived from the Examples 1 and 3 of Figure 1). However, the CM cannot cover all possible cases and specific project are to be discussed with EASA on a case-by-case basis.

comment **115** comment by: *Jorge Rodriguez ADSE*

Minor comment on title figure 3 "Figure 3-Components of an EHPS that can be included under Engine TC"



	Actually the figure shows all components related with EHPS, which includes possible Engine but also Propeller(s).
response	Accepted. The Figure will be modified to only show components that can be included under an Engine TC.
comment	119 comment by: <i>Voltaero</i> Regarding the fuel tank and propulsion battery: could you clarify, for both functional and integration point of view, the case of a parallel EHPS with the fuel tank/system that feed the TE only and the battery that feed the EE only?
response	Accepted. Examples have been added in §3.2 to cover parallel architectures. Moreover, the comparison with the fuel tank has been removed, while only keeping the analysis on the battery system.
comment	121 comment by: <i>Leonardo Helicopters</i> The distinction criteria between "passive" and "active" elements is unclear. Either a more exhaustive list of examples or a certification approach for undefined element is recommended.
response	Not accepted. As explained in the CM, "active" refers here to a certain level of dependency between the Engine control systems and systems in interface. The CM aims at providing guidances and examples but cannot cover all possible cases, and specific projects are to be discussed with EASA on a case-by-case basis.
comment	124 comment by: <i>Airbus Helicopters</i> Comment: §3.3, Figure 3: The propeller is described as an EHPS sub-component. This is not in line with the SC E-19 EHPS definition in which the propeller is clearly excluded. It is also in contradiction with current engine definition. This propeller system should more adequately appear as an EHPS interface, and not as an EHPS sub-component.
response	Accepted. The Figure will be modified accordingly.
comment	125 comment by: <i>Airbus Helicopters</i> Comment: §3.3 For the extended engine definition the text states that power levers should be excluded from this extended engine definition. The term "power lever" is considered as too restrictive / non-exhaustive, it is proposed to change it as "power lever or any other type of aircraft control input"
response	Accepted. The document will be modified accordingly.
comment	132 comment by: <i>Pratt & Whitney Canada</i> This comment is provided on behalf of Pratt & Whitney Canada (P&WC), Collins, and Pratt & Whitney (P&W), collectively referred to as "RTX". Regarding fuel tank and propulsion battery:

The first paragraph is written very much with a series hybrid view regarding the importance and interaction of the fuel system vs a battery system. In a parallel hybrid system there are more direct interactions between fueling of the thermal engine and the electrical energy sources to the electric motors. → **Accepted. Examples will be added to cover parallel architectures.**

The bulleted items on the bottom of page 6 are true for series systems more than parallel systems. If the document scope is increased to include parallel this paragraph/section should be modified to reflect the closer relationship between fuel delivery to the thermal engine and electrical energy to the motor. → **Partially accepted. The comparison with the fuel tank has been removed, while only keeping the analysis on the battery system. However, the explanations regarding the consideration of the battery system as an 'active' element remain applicable regardless of the architecture of the system (serie or parallel).**

For the first two bullets on the top of page 7, RTX recommend either correcting or removing the statement that electrical engine efficiency is dependent on voltage level of the propulsion batteries. This is not necessarily true, there are various factors that drive efficiency (e.g. system design, discharge current, converter efficiency and machine characteristics). → **Accepted. The document will be modified accordingly.**

For the third bullet on th top of page 7, RTDX request clarification if 'Engine Controller' in this context is a motor controller or is this intended to mean the traditional FADEC for a thermal engine/Turbogen and be clear which block in the various figures includes this engine controller. → **Accepted. The document will be modified to specify "electric Engine controller", which is therefore not part of the "Power management" box.**

response See EASA responses integrated in the Comment above (in bold type).

comment **133** comment by: *Pratt & Whitney Canada*

This comment is provided on behalf of Pratt & Whitney Canada (P&WC), Collins, and Pratt & Whitney (P&W), collectively referred to as "RTX".

Regarding Figure 3:
Previous figures include turbogenerators, which should be also included in this figure for consistency.

For the first paragraph after Figure 3:
RTX recommend removing the “engine definition should however exclude...” sentence or augmenting to include that the decision should be determined by the safety analysis.

response Partially accepted.
- Turbo/piston engine generators previously mentioned in the document can basically be seen as a combination of a turbo/piston Engine and of an electric Engine, meaning they are covered by Figure 3. This will be specified in the CM.

- SSHA are usually provided too late in the certification process compared to the need of defining the certification strategy at TC application. However, this type of safety analysis can be indeed useful to define the certification strategy.

- Moreover, we confirm the Aircraft systems currently listed is the CM (cockpit displays, power levers ...) cannot be certified under an Engine TC.

comment

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comment by: Pratt & Whitney Canada

This comment is provided on behalf of Pratt & Whitney Canada (P&WC), Collins, and Pratt & Whitney (P&W), collectively referred to as "RTX".

Regarding the final sentence on page 7: ("The engine TC must always include the engine(s) used or intended to be used for aircraft propulsion. For example, an engine TC can not be granted for a propulsion battery only.")

This may be mis-interpreted to mean that a Turbogenerator cannot obtain an Engine TC alone without the Electric Engine, if a turbogenerator is treated like a battery.

Clarification requested.

Also, Figure 3 does not include generators or turbogenerators. Perhaps this is a mistake, or it might be a result of EHPS definition on page 10 (which references SC E-19 EHPOS Issue 01).

Considering that Figure 1 shows that an Engine Type Cert can be obtained for a Turbogenerator, perhaps the above could be addressed, for clarity.

response

Partially accepted.

- It is clear that a turbogenerator is not a battery and cannot be treated as a such in terms of certification. Moreover, Example 3 of Figure 1 clearly shows that a turbogenerator used for the propulsion system may receive its own Engine TC.

- Turbo/piston engine generators previously mentioned in the document can basically be seen as a combination of a turbo/piston Engine and of an electric Engine, meaning they are covered by Figure 3. This will be specified in the CM.

comment

139

comment by: MTL Aerostructure

I believe the connection between the power lever and power management should either be a two-way arrow or flow from the power lever to power management. Additionally, I think an arrow is missing from the turbogenerator to the propulsion battery:

Another way would be represent the interaction between the turbogenerator and the propulsion battery thru a two-way arrow as below:

response

Partially accepted.

- Agreed for the arrow from the power lever to the power management.

- Regarding the connection between the turbogenerator and the propulsion battery, this may be possible, but the CM cannot cover all cases.



comment	142	comment by: TCCA
	In Figure 3-Components of an EHPS that can be included under Engine TC, the two elements “Piston engines” and “Turbine engines” do not seem to be consistent with those in Figs. 1 & 2, and the discussions. Suggest changing these to “Turbogenerator/Pistongenerator”.	
response	Partially accepted. Turbo/piston engine generators previously mentioned in the document can basically be seen as a combination of a turbo/piston Engine and of an electric Engine, meaning they are covered by Figure 3. This will be specified in the CM.	
comment	151	comment by: TCCA
	Referring to statement “This extended engine definition should however exclude aircraft cockpit displays, power levers, fuel tanks and their fuel distribution systems usually certified within the aircraft TC” suggest adding text to the effect of the following: “ At the functional level, parts certified under engine definition may also need to satisfy aircraft level requirements not covered under EHSP certification such as those relating to powerplant cockpit indication, controllability of the particular aircraft and similar. “	
response	Partially accepted. §3.2 of the CM, already covering this topic, will be adapted to take into account this comment.	
comment	155	comment by: TCCA
	In section 3.3 paragraph 5 where it clarifies the fuel tank as a 'passive' element and the battery system as an 'active' element. This differentiation between battery storage and fuel storage can be more relevant in the architectures where the electrical engine is only providing the propulsive energy to the aircraft. In the architectures where both thermal and electrical engines are used to drive propeller, rotor, or fan, this definition may not be exact. Therefore, I suggest adding notes to cover all other possible architectures.	
response	Partially accepted. The comparison with the fuel tank has been removed, while only keeping the analysis on the battery system, which is valid for all architectures. Examples of other architectures have been added.	
comment	156	comment by: TCCA
	In section 3.3, I suggest elaborating more on the installation of the batteries and the different approaches that can be taken. For instance, the containment of batteries burst or thermal runaway can be challenging in terms of certification approach and interfaces between EHPS and aircraft, whether it is part of engine TC or AC TC. Although it is said, in section 3.2 of this CM, that "The final integration needs to be demonstrated at aircraft TC level (including installation instructions addressing potentially complex interfaces)", I suggest that the battery installation aspects to be elaborated in the section 3.3.	

response	Partially accepted. Though EASA agree with these thoughts, this CM aims at providing general guidances regarding the certification strategy of an EHPS and is not intended to discuss technical requirements.
comment	<p>174 comment by: <i>Kevin R Bruce</i> <i>Aircraft Electronics Association</i></p> <p>1/6 This section assumes that the definition of engine is changed or should be changed. I would argue it does not. First the interpretation being applied in this CM is removing the intent of the definition of engine. The components and equipment necessary for functioning in this definition obviously did not include the fuel tanks, pumps or lines. Those are necessary for function of the engine. Also, in the CS, engine is used 101 times. Changing the definition of engine affects the use of the term through out the EASA published data. Refer to the FAA definition: "means an engine that is used or intended to be used for propelling aircraft. It includes turbosuperchargers, appurtenances, and accessories necessary for its functioning, but does not include propellers." This is closer to the intent.</p> <p>We are focusing on how to cram into one thing a bunch of stuff that each individual element needs standards for on how to design it. Then we need standards for how to install it on a unique aircraft. Trying to cram all these elements into an engine TC limits its application to a specific install. If someone can show how one could put all these suggested elements under the engine and then prove it can be installed on several unique aircraft then this CM should provide clear guidance on criteria, when and why this could be accomplished.</p>
response	<p>Not accepted. The definition of an Engine is not changed. The definition as per CS-Definition is kept and is used to identify components and pieces of equipment that can be considered as part of the Engine TC.</p> <p>It is the applicant's decision to choose whether they want to certify certain elements under an Engine or an Aircraft TC. It is just an additional possibility, under certain conditions.</p> <p>Moreover, the CM does not aim at questioning technical requirements. As explained in the CM "whatever certification approach is chosen by an applicant, it is essential to maintain the same level of safety of the end-product. This means that the EHPS certification requirements will be the same, independently from the selected certification approach".</p>
comment	<p>175 comment by: <i>Kevin R Bruce</i> <i>Aircraft Electronics Association</i></p> <p>2/6 The CM refers to propulsion battery, it should be propulsion battery system. Refer to MOC-3, ARP 8676 and other documents for definitions being accepted in industry.</p>
response	Accepted. The document will be modified accordingly.
comment	<p>176 comment by: <i>Kevin R Bruce</i> <i>Aircraft Electronics Association</i></p> <p>3/6 A battery system is not equivalent to a fuel tank and turbo generator in that both provide energy, however the requirements for each and how they are installed are</p>

	<p>unique. How they are installed and used in the aircraft is unique to the aircraft. How would you certify all of this with the motor/engine under an engine TC.</p>
response	<p>Not accepted. In practice, each engine model is today certified for a specific A/C application. The proposed CM is consistent with this approach.</p>
comment	<p>177 comment by: Kevin R Bruce Aircraft Electronics Association</p> <p>4/6 A good electric motor design and selection will have small changes in efficiency based on voltage. Also, most electric motors in play for aviation have a upper and lower limit on the voltage which gets 93% plus efficiency. So, the comment on the comparison on the effective on efficiency is irrelevant. → Not accepted. Even if the changes are small, this has a safety impact on the mission preparation.</p> <p>In this section it also discusses forcing the engine designer to change control laws due to changing voltage. This is a necessary fact and is being accounted for in electric motor designs. It does not really justify the ability to certify the battery system, fuel tanks and/or the turbo generator with the electric motor. → Not accepted. Certifying the battery as part of the Engine TC is not an obligation, it is a possibility, based on conditions. Moreover, as explained in the CM, fuel tanks cannot be certified under the Engine TC.</p> <p>The active nature of the battery could mean it is part of the components necessary for functioning. However there needs to be clear criteria. It is clear that fuel is necessary for the functioning of the turbine or piston engine, yet we don't certify the fuel tanks with the engine. And there is good reasons for it. → Partially accepted. The comparison with the fuel tank has been removed, while only keeping the analysis on the battery system. However, the active/passive determination is based on the impact on the Engine control system, hence considering the propulsion battery system as an active element of the EHPS and then as an "equipment necessary for the functioning and control of the Engine" .</p>
response	<p>Not accepted. See EASA responses integrated in the Comment above (in bold type).</p>
comment	<p>178 comment by: Kevin R Bruce Aircraft Electronics Association</p> <p>5/6 The figure shown here as a possibility leaves so many questions. First why would we suggest certifying a piston engine with the electric motor/engine.</p> <p>We have a cert path for the piston engine and the only difference may be some elements added to the piston to allow it to be used as a generator only or be set in series or parallel with the electric motor. → Noted. As already explained, this is a possibility under conditions, not an obligation.</p> <p>As stated earlier the Verdeggo concept provides a picture into criteria as to when combine the piston engine and electric motor would be suitable under one TC. → Noted. This example confirms the point of the CM.</p> <p>We need to focus on this criterion which is not really contained in this CM. → Not accepted. The CM aims at providing guidances and examples. Specific projects will be discussed on a case-by-case basis with EASA. If deemed relevant, more specific criteria may be developed in a second time.</p>
response	<p>Not accepted. See EASA responses integrated in the Comment above (in bold type).</p>

comment	<p>179 comment by: <i>Kevin R Bruce</i> <i>Aircraft Electronics Association</i></p> <p>6/6 The energies should be focused on the rules, standards and guidance for each element needed for electric hybrid propulsion first. Then let's look at what we can include in the engine TC, the criteria for it and what we can't. We should not let one specific design solution drive the rules. We run the risk of trying to include too much into one box that we either damage things by trying to shove too much in or things get left out. Break it into several smaller boxes first.</p>
response	<p>Partially accepted. Same comment as #171. See the associated response.</p>
comment	<p>182 comment by: <i>Vasilis G. GKOUTZAMANIS</i> <i>University of Thessaloniki</i></p> <p>However, turbogenerators (possibly reciprocating engine-generators)'... The turbogenerator configuration depends on the aeroplane type. Not only a reciprocating engine-generator but a turbine/gas-turbine engine type can be used. Fuel cells can also be considered.</p>
response	<p>Noted. A turbogenerator is by definition a turbine engine associated to a generator. As mentioned in the CM, hydrogen is for the moment not in the scope.</p>
comment	<p>183 comment by: <i>Melih YILDIZ</i> <i>Erciyes University</i></p> <p>Just as a short and brief comment, I would like to bring your attention to that the Battery Management System which will be used with the batteries shall also be evaluated in the certification of the electric propulsion system. As it is mentioned in page 7 as "The engine controller also has an influence on the energy drawn from the propulsion battery." The BMS itself have direct influence on battery as an electric energy consumer and as a safety protection subsystem (or means). There may be scenario's where chain reactions or iteration of events can cause unsafe states in its malfunction. Such as BMS is responsible for battery thermal issues and over discharge protection. As an example: we can assume an instant high power demand from the engine controller where BMS tends to shutdown the battery for protection.</p> <p>My proposal is addition of "Battery Management System (BMS)" as a point of interest for certification and also coin as a term in the CM. Reliability of BMS can be foreseen in a later version or even it can be added in this version.</p>
response	<p>Not accepted. Though EASA agree with these thoughts regarding BMS important role, this CM aims at providing general guidances regarding the certification strategy of an EHPS, not covering potential failure scenario of all systems or equipment that can be part of such an electrical system. Moreover, BMS is considered as being included in the "Propulsion Battery" block, as the Engine control system is included (but not shown) in the "Electric engine" block.</p>
comment	<p>187 comment by: <i>FAA</i></p> <p>Section 3.3, Paragraph 3 "Fuel tank and propulsion battery:"</p>



	<p>1) A fuel tank and propulsion battery share some common characteristics and some differences; they are both energy storage devices. In contrast, a turbogenerator converts one form of energy (hydrocarbon fuel) into another form (electricity).</p> <p>2) In the second bullet, the document states “From an integration point of view, the fuel tank is a ‘passive’ element in the EHPS...” The components within the fuel system are much more complicated, therefore most fuel systems are not passive. For example, fuel is circulated and moved between fuel tanks to maintain CG constraints.</p> <p>3) Aircraft engine efficiency is impacted at fuel flow rates and pressure below the min. established values.</p>
response	<p>1) Noted</p> <p>2) Partially accepted. The comparison with the fuel tank has been removed, while only keeping the analysis on the battery system. Moreover, "active" and "passive" have to be understood from the Engine control point of view.</p> <p>3) Accepted. As explained above, the comparison with the fuel tank has been removed. Moreover, as a general assumption, the CM considers that the Engines, either turbine or electric, are used within the approved operating and installation requirements.</p>
comment	<p>188 comment by: FAA</p> <p>Section 3.3, bottom of page 7</p> <p>Agree with the statement at the bottom of the page “...an engine TC cannot be granted for a propulsion battery only.” However, some would argue the following statement “The engine TC must always include the engine(s) used or intended to be used for aircraft propulsion.” contradicts with bottom diagram of Figure 1, that the turbogenerator could get an engine TC. See comment in Section 3.2, Figure 1.</p>
response	<p>Not accepted. In the examples provided in the CM, the turbogenerator is part of the propulsion function.</p>

3.4. Certification basis for the EHPS

p. 8

comment	<p>10 comment by: MTU Aero Engines AG</p> <p>The certification basis for EHPS must not be complete when using one of the proposed certification requirements in Figure 4. Additional requirements, such as those for high voltage distribution, should also be considered. MTU recommends adding a sentence that describes the need to take into account additional requirements.</p>
response	<p>Partially accepted. SC E-19 already covers distribution systems, including those using high voltage. Moreover, the CM also specifies that "Dedicated SCs complement SC E-18 and SC E-19 on the integration tailored to the Aircraft application [...]"</p>



comment	<p>11 comment by: <i>MTU Aero Engines AG</i></p> <p>The last paragraph of chapter 3.4 (EASA is currently working on developing means of compliances...) could be confusing.</p> <p>Means of Compliance has two meaning within the EASA world.</p> <ol style="list-style-type: none"> 1. According "Appendix A to AMC 21.A.15(b) Means of compliance" (MC0 - MC9) 2. MoC related to AMC. Defined means how to show compliance with a specific certification requirement. <p>MTU recommend to define which definition of MoC is used in this paragraph. <u>Appendix A to AMC 2</u></p>
response	<p>Partially accepted. MoC mentioned in the CM (and which are being developed) have to be understood as means to show compliance with certification requirements.</p>
comment	<p>39 comment by: <i>Rolls-Royce plc</i></p> <p>Page 8 Section 3.4 Certification basis for EHPS</p> <p><u>Comment summary</u></p> <p>As stated SC E-19 EHPS is applicable to all aircraft except CS-22, CS-23 Level 1 Day VFR a, light UAS.</p> <p>While there is relatively good alignment between SC E-19, CS-E and CS-25 there is a number of requirements in SC E-19 that is not required in the smaller / less complex A/C certification categories. This makes the proposed approach to "consider the requirements from SC-E19" when using shared technology / product development from lower classes into SC-E19 extremely difficult as it results in more complex & expensive development programs for smaller platforms while limiting the design solutions in these classes of aircraft. It also means that the experience gained in these classes of aircraft cannot be read across to support reliability / certification of more larger aircraft.</p> <p><u>Suggested resolution</u></p> <p>When developing technology building blocks (like power electronics modules, controllers) the only practical resolution would be to either completely separate the CS-23 Level 2, 3, 4 and CS-25 building blocks to tailor them to the applicable requirements with the associated impact on development cost.</p>
response	<p>Partially accepted. This part of the CM is a recommendation for the applicants to anticipate future applications of their products. Moreover, SC E-19 EHPS.80 states that the EHPS safety objectives must be derived from the intended Aircraft application one, which allows adapting the requirements based on the intended Aircraft application.</p>

comment	<p>49</p> <p>comment by: <i>Rolls-Royce plc</i></p> <p>Page 8 Section 3.4</p> <p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p> <p>Technical clarity</p> <p><u>PROPOSED TEXT</u></p> <p>Regarding "This chapter proposes a set of guidance to support applications for the certification of EHPS powered by propulsion batteries and / or fuel", make it clear that that "fuel" does not include hydrogen?</p>
response	<p>Partially accepted. It is already written in §1.1 and it will be recalled in §2 that hydrogen is for the moment excluded from the scope of the CM.</p>
comment	<p>53</p> <p>comment by: <i>Rolls-Royce plc</i></p> <p>Page 8 Section 3.4 Second paragraph</p> <p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p> <p>Clarification</p> <p><u>PROPOSED TEXT</u></p> <p>Should eVTOL applications be mentioned here as well? It is understood that SC E-19 would be the certification basis for the engine certification of an eVTOL.</p>
response	<p>Not accepted. The applicability of SC E-19 is defined in the SC itself, which includes eVTOL.</p>
comment	<p>88</p> <p>comment by: <i>Rolls-Royce plc</i></p> <p>Page 8 Section 3.4</p> <p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p> <p>Formatting</p> <p><u>PROPOSED TEXT</u></p> <p>Change "The below figure list the available guidance and their applicability..." to "Figure 4 lists the available guidance and their applicability..."</p>
response	<p>Partially accepted. The document will be modified in this spirit.</p>
comment	<p>89</p> <p>comment by: <i>Rolls-Royce plc</i></p> <p>Page 8 Section 3.4</p>



	<p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p> <p>Typo</p> <p><u>PROPOSED TEXT</u></p> <p>Change "...propulsion system for a CS-23 level 2 aeroplane" to "...propulsion system for a CS-23 Level 2 aeroplane."</p>
response	Accepted. The document will be modified accordingly.
comment	<p>90 comment by: <i>Rolls-Royce plc</i></p> <p>Page 8 Section 3.4</p> <p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p> <p>Formatting</p> <p><u>PROPOSED TEXT</u></p> <p>Add an empty line before "Certification of an EHPS to be installed..."</p>
response	Partially accepted. The related sentence will be removed for other reasons.
comment	<p>91 comment by: <i>Rolls-Royce plc</i></p> <p>Page 8 Section 3.4</p> <p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p> <p>Typo</p> <p><u>PROPOSED TEXT</u></p> <p>Change "...the above performance based SCs... to "...the above performance-based SCs..."</p>
response	Accepted. The document will be modified accordingly.
comment	<p>92 comment by: <i>Rolls-Royce plc</i></p> <p>Page 8 Section 3.4</p> <p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p> <p>Formatting</p> <p><u>PROPOSED TEXT</u></p> <p>Remove brackets from "The (MoC) development will..."</p>



response Accepted. The document will be modified accordingly.

comment 93 comment by: *Rolls-Royce plc*

Page 8 Section 3.4

RATIONALE / REASON / JUSTIFICATION for the Comment

Typo

PROPOSED TEXT

Regarding "will strongly rely on Industry standards and close coordination with Industry", consider making industry lower-case.

response Accepted. The document will be modified accordingly.

comment 98 comment by: *Rolls-Royce plc*

Page 8 Section 3.4

RATIONALE / REASON / JUSTIFICATION for the Comment

Grammar

PROPOSED TEXT

Suggest to split the last sentence into two sentences. "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."

response Accepted. The document will be modified accordingly.

comment 101 comment by: *Diamond Aircraft Industries GmbH*

Currently SC E-19 is only applicable up to CS-23 level 1 certified for Day VFR.

Is this a typo or is there an intent to open up SC E-19 to CS-23 level 2?

response Not accepted. This is the opposite. As explained in the CM, SC-E 19 is applicable to any EHPS, which is used to provide or produce lift/thrust/power for flight in a manned and unmanned aircraft, during both normal and emergency operations, **except for CS-22, CS-LSA, CS-23 Level 1 Day VFR and Light UAS**. It can be noted that SC E-19, which may be more severe than these previously listed regulations, can also be used for these smaller categories of A/C.



comment	<p>109 comment by: AURA AERO</p> <p>AURA AERO encourages EASA (on behalf of the CMT task force) to pursue the development of safety objectives (i.e. LOPC) for CS23 level 4 aircraft.</p>
response	<p>Noted. Thank you for your comment.</p>
comment	<p>117 comment by: Jorge Rodriguez ADSE</p>
	<p>Sentence "Dedicated SCs complement SC E-18 and SC E-19 on the integration tailored to the aircraft application and with appropriate emissions requirements that are yet to be defined for EHPS", it looks is missing some text (or was originally part of a bulleted list), not consistent with rest of paragraph.</p> <p>Evaluate to change wording similar to "Dedicated SCs complement SC E-18 and SC E-19 on the integration tailored to the aircraft application and with appropriate emissions requirements that are yet to be defined for EHPS, shall be taken into account at the time of application"</p>
response	<p>Not accepted. The wording is correct as it is ("complement" is the verb of the sentence).</p>
comment	<p>134 comment by: Pratt & Whitney Canada</p>
	<p>This comment is provided on behalf of Pratt & Whitney Canada (P&WC), Collins, and Pratt & Whitney (P&W), collectively referred to as "RTX".</p> <p>Regarding the paragraphs after Figure 4 on page 8:</p> <p>There are many interactions to consider between the airframe and the many EHPS elements. Both the EHPS applicant and the airframer bear responsibility.</p> <p>The Airframer will need to consider the EHPS design and certification approach and how to safely integrate the EHPS with their airframe to ensure no design or certification gaps are present, reflect back to the critical importance of interface and scope definition for the EHPS and airframe.</p>
response	<p>Noted. Integrations aspects have to be assessed as mentioned in the CM.</p>
comment	<p>152 comment by: TCCA</p>
	<p>Regarding statement "An applicant intending to provide the same EHPS for installation on different aircraft applications ... may consider the requirements contained in SC E-19 if they intend to propose the same propulsion system for a CS-23 level 2 aeroplane."</p> <p>Aircraft level definition should not be understood as blanket coverage for the notion of producing one EHSP and providing it to multiple aircraft.</p>

	<p>With some of the EHSP manufacturers possibly being new in the industry, combined with every manufacturer's incentive to design one EHSP and market it for multiple applications, the statement as written can create unrealistic expectations and serious issues in certification practice. For these reasons, suggest adding text to the effect of the following:</p> <p>" It should be noted also that some requirements remain aircraft specific even for the aircraft in the same category (Level). Parameters of what constitutes controllable overthrust for example, or uncontrollable drag with which EHSP design must be compatible are typically aircraft specific. These aspects may present additional challenges to producing an entirely "common to multiple applications EHSP"; the higher the level of integration of the EHSP with aircraft level functions, the more influential this aspect becomes."</p>
response	<p>Partially accepted. This sentence aims at saying that, from an Engine certification perspective, the EHPS has to comply with the appropriate regulation, covering all potential A/C on which it will be mounted. It does not mean that having the EHPS certified against an Engine regulation is enough, and that no Aircraft requirement has to be taken into account.</p> <p>Following other comments, it will be specified in §3.2 that "The final integration needs to be demonstrated at Aircraft TC level, including installation instructions addressing potentially complex interfaces and compliance to Aircraft level certification requirements not 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".</p> <p>A sentence has also been added in §3.4: "As already mentioned in §3.2, in addition to Engine requirements discussed above, EHPS also has to comply with some specific Aircraft requirements. It can be noted that these Aircraft requirements may be different even if the Aircraft is from the same category (Level)."</p> <p>Moreover, it has to be noted that SC E-19 EHPS.80 states that the EHPS safety objectives must be derived from the intended A/C application one. This prevents installing any EHPS on any Aircraft.</p>
comment	<p>158 comment by: TCCA</p> <p>Suggest to define the terms "Electric Propulsion Unit" and "Electric Propulsion Powerplant" and what the differences are between EPU and EPP, or where the definitions be found.</p> <p>Rationale: To make sure that the Applicant understands the differences and avoid ambiguity during the certification process</p>
response	<p>Partially accepted. EPU will be replaced by "electric Engine" to be consistent with the Basic Regulation. EPU and EPP are not used any more.</p>
comment	<p>159 comment by: TCCA</p> <p>Suggest to consider adding references to the several SC published to date for propulsion batteries, which are considered "active" elements of the EHPS. For example, SC-LSA-F2480-01 and SC E-22.</p>

	Rationale: A recent EASA program included both SC E-18 and SC E-22 as part of the certification basis for the EHPS.
response	Not accepted. SC-22.2014-01 and CS-LSA - ASTM F2840-11 references have been removed from the CM (only Special Conditions providing propulsion requirements should be referenced in the CM).

4.1. References

p. 9

comment	54	comment by: <i>Rolls-Royce plc</i>
	<p>Page 9 Section 4.1</p> <p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p> <p>Additional content?</p> <p><u>PROPOSED TEXT</u></p> <p>Should a reference to Special Condition VTOL be added here? SC VTOL already infers the use of electric/ hybrid electric propulsion as a possibility for this category of aircraft.</p>	
response	Partially accepted. Only Special Conditions providing propulsion requirements should be referenced in the CM. The document will be modified accordingly.	
comment	94	comment by: <i>Rolls-Royce plc</i>
	<p>Page 9 Section 4.1</p> <p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p> <p>Formatting</p> <p><u>PROPOSED TEXT</u></p> <p>Consider adding numbers/IDs to the table of references and citing them whenever a reference is made in the document.</p>	
response	Accepted. The document will be modified accordingly.	
comment	95	comment by: <i>Rolls-Royce plc</i>
	<p>Page 9 Section 4.1</p> <p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p> <p>Formatting</p>	



	<u>PROPOSED TEXT</u>
	Missing issue numbers.
response	Accepted. The document will be modified accordingly.
comment	157 comment by: TCCA
	AMC 20-8 mentioned in the body of the text, section 3.2, should be identified in the reference table, section 4.1.
response	Accepted. The document will be modified accordingly.

4.3. Definitions

p. 10

comment	18 comment by: Liliun
	Electric engine definition is missing. As the electric engine definition from ARP8676 was discussed and agreed with authorities and industries, it is recommended to include the ARP8676 electric engine definition in the CM, or to refer to ARP8676.
response	Not accepted. Only the term “Engine” is defined in the EASA regulatory framework (the one already used in piston or turbine Engines).
comment	50 comment by: Rolls-Royce plc
	Page 10 Section 4.3
	<u>RATIONALE / REASON / JUSTIFICATION for the Comment</u>
	Consistency
	<u>PROPOSED TEXT</u>
	Consider aligning definitions with other documents such as EUROCAE ER-025.
response	Accepted. ESS (Energy Storage System) will be removed as not used in the document. The other definitions are consistent with other applicable documents (Standards, SC E-19, etc.).
comment	55 comment by: Rolls-Royce plc
	Page 10 Section 4.3 Definitions, Line Electrical power generation
	<u>RATIONALE / REASON / JUSTIFICATION for the Comment</u>
	Technical clarity
	<u>PROPOSED TEXT</u>



	Wording is inconsistent. The item is called "power generation" but the definition refers to energy being converted to "electrical energy". Suggest to refer to either power generation or energy generation only.
response	Accepted. The document will be modified accordingly.
comment	<p>97 comment by: <i>Rolls-Royce plc</i></p> <p>Page 10 Section 4.3</p> <p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p> <p>Consistency</p> <p><u>PROPOSED TEXT</u></p> <p>Consider aligning definitions with other documents such as EUROCAE ER-025. E.g.: EHPS, ESS.</p>
response	<p>Same as Comment #50.</p> <p>Accepted. ESS (Energy Storage System) will be removed as not used in the document. The other definitions are consistent with other applicable documents (Standards, SC E-19, etc.).</p>
comment	<p>162 comment by: <i>TCCA</i></p> <p>Suggest to add definition for "Extended engine Type Certificate (TC)"</p> <p>Rationale: Term not typically used by other Airworthiness Authorities</p>
response	<p>Partially accepted. The way "extended Engine TC" has to be understood in the context of this CM is provided at the very beginning of §3.3, to explain that other elements can be included in the Engine TC.</p> <p>However, the official denomination remains "Engine TC".</p>

4.2. Abbreviations

p. 10

comment	<p>96 comment by: <i>Rolls-Royce plc</i></p> <p>Page 10 Section 4.2</p> <p><u>RATIONALE / REASON / JUSTIFICATION for the Comment</u></p> <p>Completeness and consistency</p> <p><u>PROPOSED TEXT</u></p> <p>The following abbreviations are missing: ASTM, CM, EASA, ED, EU, GM, UA. Also, ICAO is misspelled (O instead of O). Finally, ETSOA does not appear in the document.</p>
response	Accepted. The document will be modified accordingly.



comment	160 Suggest to delete "ETSO" and "ETSOA" as these terms are not used in the document. Rationale: Abbreviations that are not used in the document text are typically not included	comment by: <i>TCCA</i>
response	Accepted. The document will be modified accordingly.	

comment	161 Suggest to correct the Font for "ICAO" to read "ICAO" Rationale: "0" is zero not capital letter "O"	comment by: <i>TCCA</i>
response	Accepted. The document will be modified accordingly.	

