Definition of Loss Of Power Control

Webinar - Online event

Authorities Task Force on Electric/Hybrid Propulsion System

Presented to: Industry

By: CMT TST on EHPS

Date: April 03, 2023

Agenda

- Overview
- Task Force Description
- Background and assumptions
- Proposed approach LOPC of electric engines
- Interactions between the engine and the aircraft certification processes
- Next steps and future work

DISCLAIMER

- Along the Webinar, the TST EHPS team is looking for feedback on:
  - Any showstopper on the technical proposal
  - The planning of the next activities
  - Any other valuable point that you may identify

- **This is not a “standard” rulemaking task process** → received comments/feedbacks won’t be answered by the team

Overview

- All participating authorities have been working with electric propulsion products domesticaly; building own expertise.

- To-date, authority interactions limited to:
  - concurrent participation in industry working groups,
  - concurrent validation of various TC applicants, and
  - informal specialist-level discussions.

- The CMT (Certification Management Team), as well as industry, have voiced concerns over potential disharmonisation.

- The CMT created the EHPS Task Force to address the most pressing topics in electric engine (EE) certification, as identified by it’s membership.
  - Allows for formal collaboration between authorities; aiming to issue joint decision documents.
  - Bi-weekly discussions; bi-annual face-to-face meetings.

Scope and deliverables

- **Scope:**

1. Electric engine control system architecture and reliability
    a. Definition of LOPC (Loss of Power Control) for electric engine
    b. Methodology to define the applicable components falling under the requirement: covered by the Industry in SAE E40/36 → not addressed by TST EHPS deliverables but coordination ensured
    c. Reliability demonstration for components of electric engine electrical system: covered by the Industry in e.g. IEC and SAE AE10 → not addressed by TST EHPS deliverables but coordination ensured
2. Energy Storage integration and its interactions with the EHPS and the Aircraft

- **Deliverables**

TODAY'S TOPIC

- Topic 1 a): Decision document: Definition of LOPC for electric engine
    - 1st issue dedicated to GA level 1 and level 2 single engine aircrafts (step by step approach + support most mature on-going projects)
    - 2nd issue dedicated to other A/C (multi-engine A/C, rotorcrafts, VTOL, distributed propulsion…)
- Topic 2: Interactions between the energy storage and the engine (energy voltage level and its impact on electric engine control system, minimum energy storage at the end of the flight and displays)

Deliverables

Name of the document	Type of document	Expected date
LOPC definition for electric engine intended to be installed on GA A/C level 1 and level 2	Decision document	April 2023
LOPC definition for electric engine intended to be installed on other category of products	Decision document	Q4 2023
Interactions between the energy storage and the engine	TBD	Q3 2024

TODAY'S TOPIC

Participants

- ANAC:
  - Marcelo Saito - Civil Aviation Regulation Specialist, Propulsion System & Environmental Protection
  - Sergio Roberto Ferreira Machado - Electroelectronics Systems and Software Engineering Group- GTEN/CESS
- EASA:
  - Carlos Munoz - Panel 5 new technologies expert
  - Ralph Menzel – Powerplant expert
  - Regis Rossotto (co-chair) - Senior Expert Powerplant GA and VTOL / PCM EHPS
- FAA:
  - Gary Horan (co-chair) – Electric/Hybrid-Electric Propulsion Focal
  - Mark Bouyer - Electric/Hybrid-Electric Propulsion Focal
- TCCA:
  - Eric Fleurent-Wilson – Powerplants and Emissions
  - Raoufou Ganiou – Electrical Systems

Very good cooperation

High involvement of all members

Background and assumptions

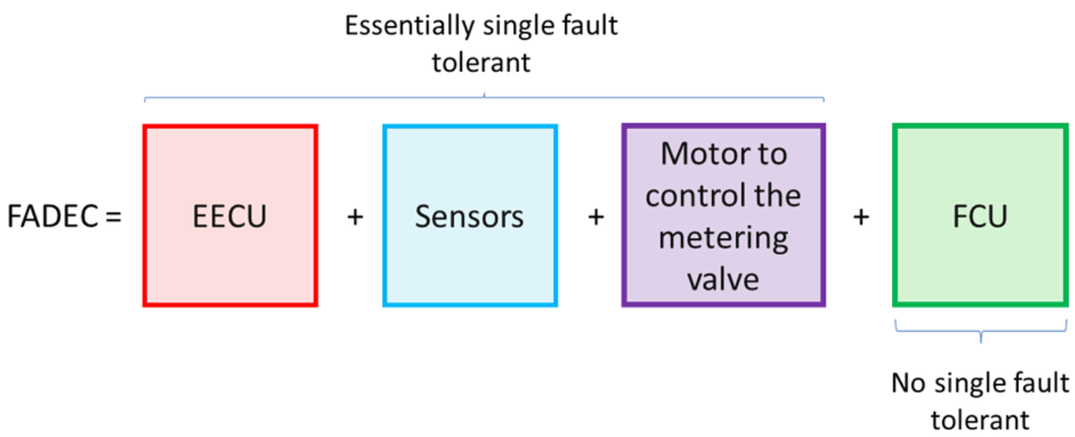
Design differences between ICE and EE

- An internal combustion engine (ICE) also has mechanical parts and rotors, but the motive forces that create torque for propulsion are mainly created by thermal properties.
- Electric engines are, by definition, “fully” electric. They have mechanical parts and rotors, but the motive forces that create torque for propulsion are electromagnetic. A single electrical or electronic failure affects their ability to function as an aircraft engine.

- Therefore, a precise application of the existing LOPC definition to both engine technologies does not seem appropriate.

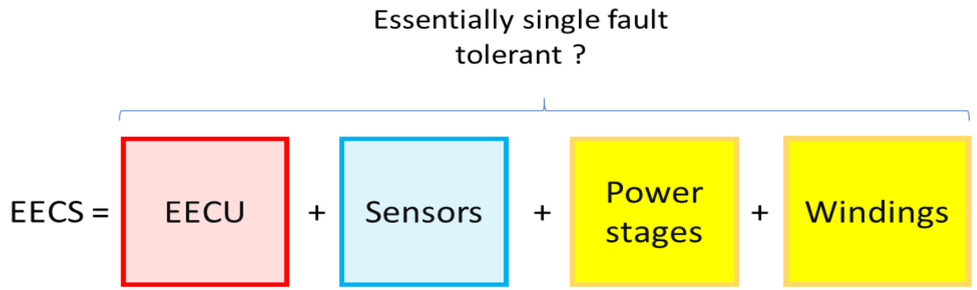
Applicability of the requirement to ICE

TURBINE



Applicability of the requirement for electric engines

ELECTRIC ENGINE



Background and assumptions

- **Firstly: need to understand the effect of an electrical failure in an EE**
- **2 natures of electrical failures:**
  - Open-circuit → must be able to provide enough power with the remaining parts of the engine
  - Short-circuit → back-EMF in the short-circuited system due to the fact that the rotor (and the magnets) are still driven by the remaining good windings
- **In both cases, running an EE with an electrical failure will lead to higher temperatures**
- **That's why the EE can run with open-circuit or short-circuit for a certain amount of power and time different from normal conditions (if they have enough phases)**

EXAMPLE:

Ratings for an electric engine	Duration	Power	Temperature limitation
MCP	unlimited	80%	160°C
MTOP	3min	100%	160°C
ESDP	2min	80%	240°C
ECDP	unlimited	50%	240°C

•ESDP: Emergency Short Duration Power (used in case of electrical failure when multiphase engine)

•ECDP: Emergency Continuous Duration Power (used in case of electrical failure when multiphase engine)

Background and assumptions

- **LOPC effects at aircraft level:**
  - LOPC is critical close to the ground when the pilot does not apply the emergency procedure
  - Partial power loss is complex to manage

- **Objectives of the EE LOPC proposal:**
  - If the EE design can comply with today's def → OK to follow today's guidance AMC 20-3B
  - If not:
    - It is important to ensure power availability close to the ground (take-off and landing phases) to allow the pilot to reach a safe altitude
    - The power level in itself may not be the appropriate safety criteria. We should better define A/C capabilities in terms of performance in the case of a single electrical failure
  - Being able to reuse existing material in the regulation

Definition of LOPC

An electric engine used on a single engine GA A/C level 1 or level 2,

Has a two part definition:

Close to the ground

And

In other flight phases

Definition of LOPC for Electric Engine

For a single electric engine powered GA A/C level 1 or level 2, LOPC/LOTC is defined as an event where the pilot **cannot** perform the following **at the most critical declared OAT**

Close to the ground	
• Be able to maintain A/C speed above 1.2 (TBC) x Vs	*rationale: keeping controllability of the A/C by making sure the aircraft speed can be sufficiently maintained above stall speed*
and • Have a 1% positive climb rate	*rationale: to exit the ground conditions*
and • Have capability to reach 500ft AGL starting from ground level	*rationale: to exit the ground conditions*
• at MTOM	*rationale: to account for the maximum mass of the A/C*

Definition of LOPC for Electric Engine

For a single electric engine powered GA A/C level 1 or level 2, LOPC/LOTC is defined as an event where the pilot **cannot** perform the following **at the most critical declared OAT**

In other flight phases	
• Be able to maintain level flight at 5000ft MSL or 1000ft AGL whichever is higher	*rationale: to give time to the pilot to spot an airfield where to land*
and • Be able to maintain A/C speed above 1.2 (TBC) x Vs	*rationale: keeping controllability of the A/C by making sure the aircraft speed can be sufficiently maintained above stall speed*

Interactions between the engine and the aircraft certification processes

Impact on engine certification

- **Engine manufacturer to declare the ratings**

To be used close to the ground to reach a safe altitude

Declared ratings	Duration	Power	Temperature. limitation
MCP	unlimited	80%	130°C
MTOP	5min	100%	130°C
ESDP	3min	80%	200°C
ECDP	unlimited	50%	200°C

To be used while in other flight phases

- ESDP: Emergency Short Duration Power (used in case of electrical failure when multiphase engine)
- ECDP: Emergency Continuous Duration Power (used in case of electrical failure when multiphase engine)

But is this enough? NO

Importance of the initial temperature!

Impact on engine certification

- **ESDP rating will be used close to the ground to allow the A/C to reach a safe altitude**
  - Maximum temperature of the engine before using this rating will be defined to be the maximum of the two below temperatures as determined at the Max declared OAT:

1. Maximum temperature of the engine when the A/C is about to take-off.

   This temperature is obviously expected to be far below the 130° C, declared as the temperature limitation of the MTOP rating, because the MTOP rating won't have been used for that long (only during the rolling on the runway).

2. Maximum temperature of the engine after a descent and just before performing a rejected landing.

   This temperature is obviously expected to be far below the 130° C declared as the temperature limitation of the MCP rating, because during the descent phase, the engine power is highly reduced allowing to it to be cooled.

Declared ratings	Duration	Power	Temperature. limitation	Maximum initial temperature
MCP	unlimited	80%	130°C	130°C
MTOP	5min	100%	130°C	70°C
ESDP	3min	80%	200°C	100°C
ECDP	unlimited	50%	200°C	200°C

Impact on aircraft certification

– Cooling tests:
  - Maximum engine temperature is less than the limitations, and
  - Maximum initial temperatures are less than the limitations

– Performances tests: at the most critical declared OAT
  - When using the ESDP close to the ground, the pilot
    – is able to maintain A/C speed above 1.2 (TBC) x Vs, and
    – is able to demonstrate a 1% positive climb rate, and
    – has capability to reach 500ft AGL starting from ground level starting from ground level at MTOM
  - When using the ECDP in other flight phases, the pilot
    – is able to maintain level flight at 5000ft MSL or 1000ft AGL whichever is greater, and
    – is able to maintain A/C speed above 1.2 (TBC) x Vs

Task Force Next Steps

Task Force Future

- **First Deliverable: Decision document:**
  - Definition of LOPC for electric engine scoped to GA level 1 and level 2 single engine aircrafts (End of April 2023)

- **Second Deliverable: Mature draft of 2nd issue**
  - Address other A/C applications (Q2 2023):
  - Strong industry need identified for single engine GA A/C level 3 and VTOL
  - Final version 2nd issue to address other A/C applications (Q4 2023):

- **Start in parallel the deliverable 2 (Q3 2024)**
  - Interactions between the energy storage and the engine (voltage level and its impact on electric engine control system, minimum energy storage at the end of the flight and displays)

Thank you for your attention!

Questions?