



# Federal Aviation Administration

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## Memorandum

Date: August 25, 2016

To: Manager, Wichita ACO, ACE-115

From: Manager, Transport Airplane Directorate, ANM-100

Prepared by: Jeffrey Englert, ACE-116W

Subject: INFORMATION: Equivalent Level of Safety (ELOS) Finding for Digital-Only Display of Engine Operating Parameters for the Garmin G5000 Integrated Flight Deck on a Beechcraft Model 400A airplane, FAA Project No. ST05883WI-T

ELOS Memo #: ST05883WI-T-P-1

Regulatory Ref: §§ 25.1305 and 25.1549

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This memorandum informs the certificate management aircraft certification office of an evaluation made by the Transport Airplane Directorate (TAD) on the establishment of an equivalent level of safety (ELOS) finding for the Digital-Only Display of Engine Operating Parameters for the Garmin G5000 Integrated Flight Deck on a Beechcraft Model 400A airplane.

### Background

Title 14, Code of Federal Regulations (14 CFR) 25.1549 “Powerplant and auxiliary power unit instruments” at Amendment 25-40 requires:

- (a) Each maximum and, if applicable, minimum safe operating limit must be marked with a red radial or a red line;
- (b) Each normal operating range must be marked with a green arc or green line, not extending beyond the maximum and minimum safe limits;
- (c) Each takeoff and precautionary range must be marked with a yellow arc or a yellow line beyond the maximum and minimum safe limits.

The Garmin G5000 Electronic Flight Instrument System (EFIS) design for the display of various Powerplant instruments does not have indicators and/or appropriate color markings. Therefore, the G5000 does not comply with § 25.1549(a), (b) and (c).

The primary engine displays on turbine engine powered transport aircraft have traditionally displayed the required engine rotor speeds, oil temperature, oil pressure and fuel flow required by § 25.1305 in an analog-only or an analog and digital format. Standby Engine Indicators (SEIs), when provided, have typically displayed these parameters in either analog-only or digital-only format. An increasing demand to conserve primary display space has led to digital-only primary displays for various engine parameters including those rotor speeds not normally used for power setting. This situation may result in a small, cluttered, low-resolution primary display.

The FAA generally considers that digital-only displays are less effective than conventional analog displays at providing the crew with discernible indication of the parameter during a rapid transient, and quick intuitive indication of the parameters approximate level, direction and rate of change, proximity to limits, and relationship to other parameters on the same engine or the same parameter on other engines. Therefore, Advisory Circular (AC) 20-88A, paragraph 4(c), states that “digital indicators are most valuable when integrated with an analog display.”

While many of the rules do not require an analog format, § 25.1549 actually does require instrument markings which presumes an analog type display format. Therefore, the FAA considers that features of the digital format must at least provide a level of safety equivalent to that intended by compliance with § 25.1549.

#### **Applicable regulation(s)**

§§ 21.21(b)(1), 25.1305 and 25.1549(a), (b), (c)

#### **Regulation(s) requiring an ELOS finding**

§§ 25.1549(a), (b) and (c)

#### **Description of compensating design features or alternative Methods of Compliance (MoC) which allow the granting of the ELOS (including design changes, limitations or equipment need for equivalency)**

The Garmin G5000 EFIS design includes analog gauges and digital-only display for engine parameters in lieu of dedicated gauges assumed when the regulations were promulgated. For certain parameters, the Garmin G5000 EFIS design eliminates the gauge format. Most analog gauge format instruments have a white arc accompanied by precautionary (yellow) and limit (red) radials as applicable. Additionally, each instrument uses a radial pointer and digital numeric readout to provide trending data, sensory cues and precise operating values to the crew.

The remaining engine indications are presented in the form of digital numeric readouts including: high pressure rotor speed (N2), oil pressure, oil temperature, and fuel temperature. Each instrument provides a numerical display where the digits change color to indicate parameter status. The normal white digits on a standard black background change to white digits on a bright red (warning) or black digits on a yellow (caution) background. The red or yellow backgrounds convey to the pilot that the engine parameter is outside of the normal operating range and the system may require crew action.

For both types of instrument presentations, the digital numeric readouts are white while in the normal operating range; yellow while in the precautionary operating range; and red while outside of safe operating limits.

N2 speed is a secondary engine parameter not used for power setting and is mainly monitored during engine start to validate that the engine is indicating core rotation. Automatic monitoring by the electronic engine control provides overspeed protection for N2 during normal engine operation. Additional overspeed protection is accomplished via an independent dedicated device located within the fuel control on the engine in the event of a fault in the electronic engine control. The flightcrew is not required to rely on N2 to preclude exceeding a safe operating limit.

The engine oil temperature and engine oil pressure parameters are not used for controlling the engine. Low and high indications in the amber precautionary range have associated AFM procedures for flightcrew actions.

### **Explanation of how design features or alternative Methods of Compliance (MoC) provide an equivalent level of safety to the level intended by the regulation**

Section 25.1549 is intended to ensure engine limits are not exceeded and to ensure that engine abnormalities that could lead to engine failure or other undesirable engine behaviors are identified by the crew and addressed in a timely manner. At the time this rule was promulgated, the available technology primarily relied on crew awareness and direct action to respond to engine abnormalities. Analog instrumentation was required to provide appropriate crew awareness. Since that time, the development of FADEC systems has relieved the crew of much of the burden of monitoring engine indications, particularly for secondary engine parameters not directly used for power setting.

Section 25.1549 also requires the use of markings and colors to represent operating states with yellow to indicate takeoff and caution ranges, red to indicate minimum and maximum safe operating limits, and green to indicate the normal operating range. The proposed display scheme uses yellow and red as envisioned by § 25.1549 and white to meet the intent of the color green. The use of colors (red and yellow) is adequate to indicate caution and warning conditions as intended by the rule. The use of white as an indication of the normal operating range has been accepted in the past as providing an ELOS when its use meets the flight deck philosophy for use of white.

Although noncompliant with § 25.1549(a), (b) and (c), the electronic engine control continuous monitoring in-flight of the operating condition of the engine high pressure rotor speed (N2), automatic generation of warnings to the cockpit, with associated flightcrew procedures, and engine automatic shutdown if a limit is exceeded are considered to provide an ELOS as that established by providing analog displays.

Although noncompliant with § 25.1549(a), (b) and (c), the automatic indications of oil pressure, oil temperature and fuel temperature out of limit conditions (high or low, as applicable), with

associated crew procedures, and no immediate action required to respond are considered to provide an ELOS as that established by providing analog displays.

Additionally, although noncompliant with § 25.1549(b), the powerplant parameters displayed in white, in place of green, to indicate normal operating range is consistent with the rest of the flight deck philosophy and is considered to provide an ELOS as that established by providing green indications.

**FAA approval and documentation of the ELOS finding**

The FAA has approved the aforementioned ELOS finding in project Issue Paper P-1. This memorandum provides standardized documentation of the ELOS finding that is non-proprietary and can be made available to the public. The TAD has assigned a unique ELOS memorandum number (see front page) to facilitate archiving and retrieval of this ELOS finding. This ELOS memorandum number must be listed in the Limitations and Conditions section of the supplemental type certificate (STC). An example of an appropriate statement is provided below:

Equivalent Level of Safety Findings have been made for the following regulation(s):

14 CFR 25.1549(a), (b) and (c) Powerplant and auxiliary power unit instruments.

(Documented in TAD ELOS Memorandum ST05883WI-T-P-1)

 *acting for VW*  
 Transport Airplane Directorate,  
 Aircraft Certification Service

25 August 2016  
 Date

ELOS Originated by: Wichita Aircraft Certification Office	ACO Manager: Margaret Kline	Routing Symbol: 115W
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