This document was created to make public non-proprietary data contained in Special Conditions, Deviations, Equivalent Safety Findings as referred to in the applicable Certification Basis as recorded in TCDS EASA.A.090.

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Special Condition SC-B23.div-01 “Human Factors in Integrated Avionic Systems“

Special condition	“Human Factors in Integrated Avionics Systems” (Ref. CRI B-52)

a) The design of the integrated flight deck interface must adequately address the foreseeable performance, capability and limitations of the pilot.

b) More specifically, the team must be satisfied with the following aspects of the flight deck interface design:

i. Ease of operation including automation;

ii. Effects of pilot errors in managing the aircraft systems, including the potential for error, the possible severity of the consequences, and the provision for recognition and recovery from error;

iii. Workload during normal and abnormal operation; and

iv. Adequacy of feedback, including clear and unambiguous:

- presentation of information;
- representation of system condition by display of system status;
- indication of failure cases, including aircraft status;
- indication when pilot input is not accepted or followed by the system;
- indication of prolonged or severe compensatory action by a system when such action could adversely affect aircraft safety.
- Indication of reversionary modes and back-up status

2.2 Demonstration of Compliance

2.2.1 Implementation

It is envisaged that the Flight Test Panel would manage implementation. The following is a proposal for interpretative material associated to the special condition. This will call for:

i) General Assessment: A general review of Human Factors issues arising from integrated use of the flight deck.

ii) Novel features: Careful exploration of specific Human Factors issues arising from the novel integrated avionic system in the flight deck.

2.2.2 It is important that the effort for consideration of human factors is focused upon any risks relevant to aircraft safety that may be raised by the novel features of the flight deck design. As clarification, some example topic areas have been suggested in italicised text beneath each of the specific criteria listed in paragraph 2.3 below. Examples are offered for illustration purposes, but evaluation against the listed criteria should not be restricted to only these examples.

2.2.3 The applicant should show how they have considered and applied a consistent approach across the flight deck in order to avoid confusion. This may be achieved by the use of a flight deck philosophy document that will :

a. Identify the Applicant’s philosophy on design principles such as:

- Crew alerting and prioritisation of aural alerting
- Use of colour
- Location of controls
- Menu structures
- Crew interaction with displays
- Display reversion
- Automation principles
- System feedback to the crew

b. Identify relevant assumptions concerning use of the Flight Deck Interface, such as:

- The pilot accommodation.
- The operational environment.
- The aircraft operator .

2.2.4 The applicant should prepare a dedicated plan for addressing human factors aspects in flight deck certification. This plan should include:

a. Identify items in the proposed design that are considered new or novel,

b. Identify how they will address the potential for crew related risk that may arise from these items, including their relationship to conventional features. For this purpose, they may select a format including each novel item:

- Novel Item name
- Risk Potential arising from crew interface
- Design Objectives in managing those risks
- How Foreseeable Performance of crew will be addressed
- How Ease of Use will be addressed
- How Effects of Error will be addressed
- How Task Distribution will be addressed
- How Adequacy of Feedback will be addressed
- Other foreseeable concerns
- How any special pilot training requirements will be addressed
- JAR / FAR paragraphs also relevant
- Certification credit events where the design will be exposed to the Team for formal evaluation of the item.

c. Show the planned development schedule including the manufacturer / customer internal assessments and ‘proof of concept’ activities, which may be observed by some Team members.

d. Describe the planned resources that will be available for development activity, in particular mock-ups, active representations and simulation.

2.2.5 Evaluation trials will need to include demanding scenarios representative of each flight phase (flight preparation, taxi, take-off, climb, cruise, approach, landing, go-around, and holding) with standard pilot tasks (flight path control, flight path management, communication, aircraft system management) and using all the available interface means (e.g. communication through data link if proposed). Scenarios shall include Normal, Abnormal and Emergency situations. The applicant should propose the means and methods by which these scenarios can be assessed in a realistic environment.

2.2.6 The applicant should identify, where appropriate, the recommended Pilot Operating Philosophy and the procedures.

2.2.7 A formal certification event should be designated by the applicant to permit an evaluation by the team in order that it might satisfy itself that compliance of the design with the Special Condition has been achieved.

2.3 Evaluation Criteria

For each feature to be evaluated, considerations may include:

2.3.1 Foreseeable Performance, Capabilities and Limitations of the Pilot

a. Occasional error is a normal characteristic of skilled human performance [*e.g., where a single error would impact safety, the pilot should be supported by the design or, if not practicable, operating procedures or training*].

b. Pilot capacity is not limitless in terms of working memory [*e.g. pilot should not be expected to hold in mind long alphanumeric sequences*] long term memory [*e.g. without regular practice, pilots training and skill may fade over time*] and attention [*e.g. supplemental systems may impact safety if they are slow, distracting or difficult to use; the presentation of non-functional information should be avoided; simultaneous tasks and demands on the pilot should be minimized*]

c. Established practices and conventions may influence pilot actions, especially under stressful conditions. [*e.g. if a certain location on the flight deck has been associated with a particular function in many previous aircraft, it is foreseeable that some pilots may erroneously reach to that position for the function even if trained to find it elsewhere.*]

d. Available pilot capacity may be reduced during failure conditions or under stress; hence the additional need to apply unfamiliar procedures at such a time should be avoided. This should be achieved within the design.

e. Expectation may bias pilot´s perception and thus important information that is contrary to expectation must be particularly explicit.

f. A high rate of false warnings is likely to reduce the effectiveness of genuine warnings.

g. Cultural differences may exist and could be relevant to some design expectations [*e.g. on use of English alphabet for sequencing;*].

2.3.2 Ease of Use [including Automation]:

a. Iterative involvement of test pilots and operational pilots in the development of such systems is likely to result in an improved product; this should include representations [e.g. simulation] that have a degree of realism appropriate to the level of assessment and the use of scenarios including those that are most likely to address system vulnerability and risk related situations.

b. The application of consistent philosophies may also contribute to 'ease of use'.

c. Further considerations in achieving 'ease of use' may be obtained from

EN ISO 14307 on Human Centered Design Processes for Interactive Systems.

Examples: Flight Deck Philosophies that are logical and consistently applied. The design should be such that effective use by pilots is likely, giving consideration to the expected pilot training [e.g. number of VNAV modes]. CCD(Cursor control device) characteristics, including accessibility; compatibility with existing CCD conventions; resistance to inadvertent operation (e.g. by position); software control laws / gains / operating characteristics for accuracy and speed; use with right and left hand, dominant and non-dominant hand; operation under vibration / turbulent conditions;

2.3.3 Effects of Error:

a. The systematic evaluation of the contribution of the effects of error to safety risk in the operational environment.

b. Error in routine tasks [such as data entry or misreading digits] is a normal characteristic of human performance, and such errors are considered probable.

c. The recognition that the absence of a particular pilot error during development simulation activity does not prove that such an error can never occur in service.
Examples: To include pilot response to system failure, and also error during normal (and abnormal) operations that do not occur during a response to a failure of the system on which the error is made. It is not acceptable to assume that all errors (e.g., simple slips and lapses) can be eradicated by training.

2.3.4 Workload

a. The introduction of new or novel design features may potentially affect workload or awareness across time; some tasks may become more time consuming or exclusive. Such effects should be explored.

b. The quantity, similarity and function of tasks that are conducted through a single device or access point should be investigated for peaks or 'bottlenecks' at busy or critical periods.

c. The risk from task interruption [and potentially remaining incomplete] may also be related to design characteristics [such as the need to withdraw from one menu to access another in an automated system].
Examples: Time taken to access features of systems that are time critical; time taken head down during busy phases of flight (especially where lookout required); time sharing of devices for dissimilar tasks (e.g. Multi-Function Display); critical task times in comparison with previous designs; system status following interrupted tasks.

2.3.5 Adequacy of Feedback

a. Consistent application of feedback philosophy *(Dark-Quiet, Green Light, ..).*

b. Evaluation of effectiveness of method and format of feedback *(look and feel).*

c. Sub-categories as outlined below:

i) Presentation of information

Examples: Symbol readability in vibrating conditions; display colour philosophy.

ii) Representation of system condition by display of system status

Examples: Awareness of system status despite extensive use of MFD and large number of display choices through "Windowing"; draws attention to status change.

iii) Indication of failure cases, including aircraft status

Examples: Potential obscuration of information by pop-up menus.

iv) Indication when pilot input is not accepted or followed by the system

v) Indication of prolonged or severe compensatory action by a system when such action could adversely affect aircraft safety

Examples: Automated flight control that may be designed such that the adjustment reaches the end of its travel before the pilot is made suddenly aware of the situation.

Special Condition "Security Protection of Aircraft Systems and Networks"

Special condition	"Security Protection of Aircraft Systems and Networks" (Ref. CRI F-90)

APPENDIX I – Special Condition

a) The applicant shall ensure security protection of the systems and networks of the aircraft from any remote or local access by unauthorized sources if corruption of these systems and networks (including hardware, software, data) by an inadvertent or intentional attack would impair safety, and

b) The applicant shall ensure that the security threats to the aircraft, including those possibly caused by maintenance activity or by any unprotected connecting equipment/devices inside or outside the A/C, are identified, assessed and risk mitigation strategies are implemented to protect the aircraft systems from all adverse impacts on safety, and

c) Appropriate procedures shall be established to ensure that the approved security protection of the aircraft's systems and networks is maintained following future changes to the Type Certificated design.

APPENDIX II – definitions and glossary

Definitions:

See also ED-202A for a complete set of definition.

Terms	Definitions
Asset	Systems or Functions which have a safety effect and their level of protection depends of the safety effect for the safety.
Cyber security	In the context of aircraft certification, cyber security is commonly defined as the protection of electronic systems from malicious electronic attack and the

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	means of dealing with the consequences of such attacks on safety. It comprises managerial, operational and technical activities, and relates to the electronic systems themselves and to the information held and processed by such systems.
Security	Safeguarding civil aviation against acts of unlawful interference, which consist in this context of threats to the integrity and availability of aircraft systems and data, including operational software, over networks and network interfaces but excluding consideration for or mitigation of physical threats that does not involve propagation of data or information over a network or manipulation of data by a computer system.
Security Effectiveness	Property of system demonstrating that security features are sufficient against security objectives (which includes considered threat sources).
Threat	Any potential violation of security that could cause direct or indirect damages to an asset
Vulnerability	A flaw or weakness in system security procedures, design, implementation, or internal controls that could be exercised (accidentally triggered or intentionally exploited) and result in a security breach or a violation of the system's security policy.

ESF FLIGHT INSTRUMENTS, Stabilized Magnetic Compass”

ESF	“FLIGHT INSTRUMENTS, Stabilized Magnetic Compass” (Ref. CRI F-201)

According to CS 23.1303(c), up to amendment 4, a non-stabilized magnetic compass is required to be installed. With FAR 23, Amdt. 62, any kinds of magnetic compasses have been permitted to be installed. This change acknowledges state of the art small airplane designs which are equipped with all-electrical primary and standby instrumentation. This change has not been introduced in CS 23, amendment 4, yet.

If a type certificate holder (TCH) does not comply with CS 23.1303(c) up to amendment 4, by using an electronic backup display providing stabilized magnetic heading information instead of a non-stabilized magnetic compass the TCH has to demonstrate that the electronic stabilized magnetic direction indicator provides an equivalent level of safety to a non-stabilized compass. To do so following compensating standards have to be shown:

1) Loss of all heading displays in the cockpit has to be shown to be extremely improbable.
2) Standby heading information shall be automatically provided to the pilot after loss of normal electrical power.
3) A dedicated emergency power source shall be available to power the SBY instrument unit and sensors independently in case of a primary electrical power loss.
4) The standby instrument suite and its installation have to meet the appropriate HIRF requirements corresponding to the functions provided.
5) The standby instrument suite and its installation have to meet the appropriate indirect effects of lightning requirements for the functions provided.
6) Required Software and Complex Hardware Assurance Levels appropriate to the airplane class have to be shown.

ESF “POWERPLANT INSTRUMENTS, FUEL FLOW INDICATION”

ESF	"POWERPLANT INSTRUMENTS, FUEL FLOW INDICATION" (Ref. CRI F-203)

According to CS 23.1305(b)(4), up to amendment 4, a fuel pressure indicator is required for pump fed piston engines. With FAR 23, Amdt. 52, also fuel flow meters or monitoring systems have been permitted as an alternative means of warning pilots of fuel system problems. This change has not been introduced in CS 23, up to amendment 4, yet

If a type certificate holder (TCH) does not comply with CS 23.1305(b)(4) up to amendment 4, by using a fuel flow indication instead of a fuel pressure indication the TCH has to demonstrate that the fuel flow indication provides an equivalent level of safety to a fuel pressure indication.

This can be done by following means:

1. Fuel flow indicator can be used to indicate the primary pump is operating normally if there is either a placard or AFM to advise the pilot on how to determine primary pump condition from fuel flow information, and

2. A fuel system failure analysis shows that any failures in the fuel system detectable by a fuel pressure indication will also be detectable by the fuel flow indication installed.

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