



AEROSPACE RECOMMENDED PRACTICE

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Guide for Conducting an HIRF and Lightning Safety Assessment (HLSA)

RATIONALE

Guidance for the Particular Risk Analysis (PRA) process is found in ARP4761/EUROCAE ED-135, recognizing HIRF and lightning as particular risks but not providing guidance classifying systems HIRF and lightning certification levels. The guidance presented within this document addresses electrical/electronic system HIRF and lightning certification aspects, supplementing the guidance in ARP5583/EUROCAE ED-107 and ARP5415/EUROCAE ED-158.

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1. SCOPE

Highly integrated electrical and electronic systems that perform functions within an aircraft may have potential failure conditions during and after exposure to the High-Intensity Radiated Fields (HIRF) or lightning environments. It is therefore necessary to conduct an HIRF and Lightning Safety Assessment (HLSA) that can identify potential failure conditions resulting from exposure to the aircraft HIRF and lightning environments. The failure conditions, failure conditions classifications, and independence principles identified by Aircraft Functional Hazard Assessment (AFHA), Preliminary Aircraft Safety Assessment (PASA), System Functional Hazard Assessment (SFHA), and Preliminary System Safety Assessment (PSSA), and lessons learned from previous experience, are used to identify proposed requirements during the development process. Ultimately, these requirements will result in a design capable of demonstrating that exposure to the HIRF and lightning environments will not result in adverse effects to the operation of the aircraft. This document provides guidance for conducting the HLSA process to classify the system and its equipment to the appropriate HIRF and Lightning Certification Levels (HLCLs).

1.1 Introduction

HIRF compliance guidance in AC 20-158B/AMC 20-158A identifies the need for an HIRF Safety Assessment (HSA), and lightning protection guidance in AC 20-136B/AMC 20-136A identifies the need for a Lightning Safety Assessment (LSA); together, these safety assessments are the HIRF and Lightning Safety Assessment (HLSA). The HLSA process starts with the general safety assessment, and then it is evaluated using the HIRF and lightning requirements and guidance. It is one step in the certification processes discussed in ARP5583/EUROCAE ED-107 and ARP5415/EUROCAE ED-158. The HIRF and lightning environments may cause redundant electrical and electronic systems to suffer simultaneous effects (common cause failures), compromising system safety margins and intended system independence.

When analyzing failure conditions associated with HIRF and lightning, consideration is given to the unique effects of HIRF and lightning on the aircraft functions since the presence of these environments may induce failures in ways not encountered under other operating conditions.

Elements of the general safety assessments may be used as tools in conducting the HLSA. For example, the aircraft level functional hazard assessment (AFHA) and systems functional hazard assessment(s) (SFHA) are used to define aircraft functional hazards and the failure conditions that cause them. From this, the failure conditions due to exposure to the HIRF and lightning environment can be identified, and the HLSA process will establish the resulting system HIRF Certification Level (HCL) and, respectively, the system Lightning Certification Level (LCL) classification; together, they are HIRF and Lightning Certification Level (HLCL). The HLSA is a top-down approach that establishes the system, channel, and equipment HLCL according to HIRF and lightning rules and supports the identification of pass criteria in HIRF/lightning system and component testing.

HIRF protection and lightning protection certification processes share common elements, including a lightning safety assessment process that is similar to the HIRF safety assessment process. As a result, the HIRF and lightning safety assessments are typically performed together as the HLSA. From the HLSA, failure conditions due to exposure to the HIRF environment and the lightning environment can be identified to establish the resulting system HLCL. Guidance on the processes for performing the general safety assessments can be found in ARP4761/EUROCAE ED-135. The HIRF and lightning environments are considered under the particular risk analysis of the general safety assessment. The assessment performed in accordance with this document, together with guidance of ARP5583/EUROCAE ED-107 and ARP5415/EUROCAE ED-158, satisfies the requirement for particular risk analysis from HIRF and lightning events. Particular risk analysis is defined in ARP4761/EUROCAE ED-135.

For previously certified products, if a safety assessment is not available to classify the failure effect of the function being implemented by the system, the applicant is required to demonstrate a suitable or equivalent process that has been approved by the certifying airworthiness authority.

The HLSA is based on an approach to identify systems (comprised of equipment, components, and wiring) that are necessary to provide the aircraft and system level functions in accordance with the HIRF requirements for 2X.1317/23.1308/23.2520 and the lightning requirements for 2X.1316/23.1306/23.2515.

The system HLCL assignment is a first step for supporting the identification of the applicable certification requirements for each system. The certification requirements drive hardening of the installed system to protect the system when exposed to these environments. HLCL A systems require a more extensive compliance verification and typically require qualification to higher levels than HLCL B/C systems. The proposed HLCL process can be used for Part 23/25/27/29 aircraft. It can also be used in lieu of ASTM F3367 for Part 23 normal category aircraft, levels 1 through 3.

The output of this process is a list of systems and equipment with their applicable HLCLs, as well as a description of their adverse effects which are used to develop the pass criteria for equipment and system tests.

Early submission or coordination of the HLSA to the certifying airworthiness authorities is recommended.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE and EUROCAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of publication of this document. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. When the latest issue of the reference is after the date of publication of this document, it is up to the reader which should take precedence. Nothing in this document supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 1-877-606-7323 (U.S. and Canada only) or 1-724-776-4970 (outside U.S. and Canada), www.sae.org.

- ARP4761 Guidelines for Conducting the Safety Assessment Process on Civil Aircraft, Systems, and Equipment
- ARP5415 User's Manual for Certification of Aircraft Electrical/Electronic Systems for the Indirect Effects of Lightning
- APR5577 Aircraft Lightning Direct Effects Certification
- ARP5583 Guide to Certification of Aircraft in a High-Intensity Radiated Field (HIRF) Environment

2.1.2 FAA Publications

Available from Federal Aviation Administration, 800 Independence Avenue SW, Washington, DC 20591, Tel: 866-835-5322, www.faa.gov.

- AC 20-136B Aircraft Electrical and Electronic System Lightning Protection
- AC 20-158B The Certification of Aircraft Electrical/Electronic Systems for Operation in the High-Intensity Radiated Fields (HIRF) Environment
- AC 25-11B Electronic Flight Displays

2.1.3 Code of Federal Regulations (CFR) Publications

Copies of these documents are available online at www.ecfr.gov.

14 CFR 21.101, 23.1306 (Amendment 63 and lower), 23.1308, 23.2515 (Amendment 64 and higher), 23.2520, 25.1316, 25.1317, 27.1316, 27.1317, 29.1316, 29.1317, and applicable HIRF special conditions

2.1.4 EASA Publications

Available from European Union Aviation Safety Agency, Konrad-Adenauer-Ufer 3, D-50668 Cologne, Germany, Tel: +49 221 8999 000, www.easa.europa.eu.

AMC 20-136A Aircraft Electrical and Electronic System Lightning Protection

AMC 20-158A Aircraft Electrical and Electronic System High-Intensity Radiated Fields (HIRF) Protection

CS 23.1306/2515, CS 25.1316, CS 27.1316, and CS 29.1316 for Electrical and Electronic System Lightning Protection

CS 23.1309, CS 25.1309, CS 27.1309, and CS 29.1309, Equipment, Systems, and Installations

CS 23.1529, CS 25.1529, CS 27.1529, and CS 29.1529, Instructions for Continued Airworthiness

EASA Certification Specifications CS-23/25/27/29, CS 23.1308/2520, CS 25.1317, CS 27.1317, and CS 29.1317 for High-Intensity Radiated Fields (HIRF) Protection, and applicable HIRF Certification Review Items/Special Conditions based on Interim Policies INT/POLs 25/2, 23/1 and 27&29/1

2.1.5 EUROCAE Publications

Available from EUROCAE, The MINT Building, 2 Avenue François Mitterrand, 93210 Saint-Denis, France, Tel: +33 1 49 46 19 65, www.eurocae.net.

EUROCAE ED-107 Guide to Certification of Aircraft in a High Intensity Radiated Field (HIRF) Environment

EUROCAE ED-113 Aircraft Lightning Direct Effects Certification

EUROCAE ED-135 Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment

EUROCAE ED-158 User's Manual for Certification of Aircraft Electrical/Electronic Systems for the Effects of Lightning

EUROCAE ED-338 Guide for Conducting a HIRF and Lightning Safety Assessment (HLSA)

2.1.6 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9500, www.astm.org.

ASTM F3367 Standard Practice for Simplified Methods for Addressing High-Intensity Radiated Fields (HIRF) and Indirect Effects of Lightning on Aircraft

NOTE: Only ASTM F3367-23 or later is recognized by EASA.

2.2 Definitions

ADVERSE EFFECT: Effect that results in system failure, malfunction, or misleading information to a degree that is unacceptable for the specific aircraft function or system and results in a catastrophic, hazardous, or major failure effect when addressing the applicable parts of the regulations.

AVAILABILITY: Qualitative or quantitative attribute that a system or equipment is in a functioning state at a given point in time.

CATASTROPHIC FAILURE CONDITION: Refer to certifying airworthiness authority documents related to 2X.1309/23.2510 and AC/AMC 20-158/20-136.

CHANNEL: A subset of a system consisting of equipment, components, and interconnections that performs an aircraft function provided by the system. A system could be composed of redundant similar or dissimilar channels in order to maintain the function at the aircraft level in case of failure on one or several channels.

COMMON CAUSE: A single failure, error, or event that can produce undesirable effects on two or more systems, equipment, items, or functions.

CONTINUED SAFE FLIGHT AND LANDING: Capability for continued controlled flight and landing at a suitable location, possibly using emergency procedures but without requiring exceptional pilot skill or strength. Some aircraft damage may occur because of a failure condition during flight or on landing. For CS-23/Part 23 airplanes, it is not necessary to land at an airport. For CS-25/Part 25 airplanes, the pilot must be able to land safely at a suitable airport. For Part 27 and Part 29 rotorcraft, the rotorcraft must continue to cope with adverse operating conditions, and the pilot must be able to land safely at a suitable site.

NOTE: The above definition should be used, regarding the method provided by the applicable AC/AMC, for all aircraft except normal category airplanes with a Part 23 (Amendment 23-64 or later) certification basis, for which the definition of “continued safe flight and landing” in § 23.2000(b) applies.

EQUIPMENT: A component of an electrical or electronic system with or without interconnecting electrical conductors.

FAILURE: An occurrence that affects the operation of an aircraft, system, equipment, item, or piece-part such that it does not function as intended (this includes both loss of function and malfunction). In the context of an HIRF or lightning system test, a failure is an unacceptable upset.

FAILURE CONDITION: A condition having an effect on the aircraft and/or its occupants, either direct or consequential, which is caused or contributed to by one or more failures or errors, considering flight phase and relevant adverse operational or environmental conditions or external events.

FAILURE EFFECT: A description of the operation of an aircraft, system, equipment, or item as the result of a failure, i.e., the consequence(s) a failure mode has on the operation, function, or status of an aircraft, system, equipment, item, or aircraft occupants.

FAILURE MODE: A specific way in which a system, equipment, hardware item, or piece-part may fail.

FUNCTION: The specific action of a system, equipment, or flight crew performance aboard the aircraft that, by itself, provides a completely recognizable operational capability. For example, “display aircraft heading to the pilots” is a function. One or more system channels may perform a specific function, or one system may perform multiple functions.

HAZARD: A condition resulting from failures, external events, errors, or a combination thereof where safety is potentially affected.

HAZARDOUS FAILURE CONDITION: Refer to certifying airworthiness authority documents related to 2X.1309/23.2510 and AC/AMC 20-158/20-136.

INTEGRITY: Qualitative or quantitative attribute of a system, equipment, or item indicating that it can be relied upon to work as intended.

MAJOR FAILURE CONDITION: Refer to certifying airworthiness authority documents related to 2X.1309/23.2510 and AC/AMC 20-158/20-136.

MINOR FAILURE CONDITION: Refer to certifying airworthiness authority documents related to 2X.1309/.2510 and AC/AMC 20-158/20-136.

NON-NORMAL SITUATION: An event, condition, or situation that requires non-normal, abnormal, emergency, or unusual procedures or configurations for operating the aircraft.

NORMAL OPERATION: A status where the system performs its intended function. When addressing compliance with CS and 14 CFR 23.1308/23.1306(a)(2), 23.2520/23.2515(a)(2), 25.1317/25.1316(a)(2), 27.1317/27.1316(a)(2), and 29.1317/29.1316(a)(2), the function whose failure would prevent the continued safe flight and landing should be in the same undisturbed state as before exposure to the HIRF or lightning threat. However, the system that performs the function may be nevertheless in a different state as long as the function is not adversely affected. The other functions provided by the same system, subject to CS and 14 CFR 23.1308/23.1306 (b) and (c), 23.2520/23.2515 (b), 25.1317/25.1316 (b) and (c), 27.1317/27.1316 (b) and (c), and 29.1317/29.1316 (b) and (c), are not required to be recovered.

SYSTEM: A system can include equipment, components, parts, wire bundles, software, and firmware - all of which are required to perform one or more functions.

TIMELY MANNER: The necessary period for systems to reconfigure safely after a disruption. The meaning of “in a timely manner,” therefore, depends upon the function performed by the system to be evaluated, the specific system design, the interactions between that system and other systems, and interactions between the system and the flight crew.

UPSET (i.e., SYSTEM FUNCTIONAL UPSET OR EFFECT): An impairment, either permanent or momentary, of the system operation. For example, a change of digital or analog state that may or may not require a manual reset. An upset may or may not be acceptable for the specific aircraft function or system addressed.

2.3 Abbreviations

AP	autopilot
CAT	catastrophic
COM	communication
HAZ	hazardous
MAJ	major
MIN	minor
STBY	standby

2.4 Acronyms

AC	Advisory Circular
AFCS	Automatic Flight Control System
AFHA	Aircraft Functional Hazard Analysis
APU	Auxiliary Power Unit
CFR	Code of Federal Regulations (FAA)
CS	Certification Specification (EASA)
DAL	Development Assurance Level
EASA	European Union Aviation Safety Agency
EE	Electrical/Electronic
ETOPS	Extended-Range Twin-Engine Operations Performance Standards
EUROCAE	European Organization for Civil Aviation Equipment
FAA	Federal Aviation Administration
FDAL	Function Development Assurance Level
FTA	Fault Tree Analysis
GNSS	Global Navigation Surveillance System
GPS	Global Positioning System
HCL	HIRF Certification Level
HLCL	HIRF and Lightning Certification Level
HLSA	HIRF and Lightning Safety Assessment
HF	High Frequency
HIRF	High-Intensity Radiated Fields
HMI	Hazardously Misleading Information
HSA	HIRF Safety Assessment
IDAL	Item Development Assurance Level
IFR	Instrument Flight Rules
LCL	Lightning Certification Level
LRU	Line Replaceable Unit
LSA	Lightning Safety Assessment

MHP	Mechanical/Hydraulic/Pneumatic
PRA	Particular Risk Analysis
PFD	Primary Flight Display
PSSA	Preliminary System Safety Assessment
RF	Radio Frequency
SDD	System Description Document
SFHA	System Functional Hazard Assessment
SSA	System Safety Assessment
VFR	Visual Flight Rules
VHF	Very High Frequency

3. BACKGROUND

The HLSA should be based on the general safety assessment conducted for compliance with 2X.1309/23.2510, as well as other safety requirements as specified in the certification basis of the aircraft type under consideration. The safety process under 2X.1309/23.2510 is also referred to as “general safety assessment.”

Note that the use of Development Assurance Level (DAL) practiced under ARP4761/EUROCAE ED-135 is not appropriate for an HLSA due to the common cause nature of those environments and due to specific HIRF and lightning rules.

The HLSA should be conducted to address the potential impacts of HIRF and lightning. Guidance for the Particular Risk Analysis (PRA) process can be found in ARP4761/EUROCAE ED-135; the following guidance addresses electrical/electronic system HIRF and lightning certification aspects, supplementing the guidance in ARP5583/EUROCAE ED-107 and ARP5415/EUROCAE ED-158. The HLSA focuses on system performance effects when exposed to the HIRF and lightning environments and does not require unrelated system failures to be addressed in combination with that exposure. Additionally, failure rates and probabilities should not be considered in the HLSA.

The general safety assessment employs principles of investigating functional independence where the compliance must address whether failure of one function can cause the failure of another function. The same safety assessment also provides the applicable failure conditions and their hazard classifications for that function. Some functions are supported by systems made up of multiple channels producing the function, and the general safety assessment will consider and assign hazard classifications for failure of individual channels as well as simultaneous failures of multiple channels. For the HLSA, the common cause nature of HIRF and lightning must be considered because all of the channels will be exposed to those environments simultaneously.

The HLSA should be a collaborative effort between the HIRF and lightning specialists, system specialists, and system safety specialists. The primary objective is to consider HIRF and lightning-specific requirements in combination with the general safety assessment. Significant safety work will have been produced by the general safety assessment process that results in defined aircraft and system functions and failure conditions via functional hazard assessments; also, systems, channels, and equipment that contribute to the failure conditions are defined via Preliminary System Safety Assessments (PSSA) and System Safety Assessments (SSA). This information will help to define the boundaries of the system as referenced in the HIRF and lightning rules.

The general safety assessment should produce the following outputs that can be used by the HLSA:

- The functions performed by the aircraft systems and their associated failure conditions and hazard classifications. This information comes from the systems and aircraft functional hazard assessments.
- The electrical and electronic, mechanical, hydraulic, and pneumatic system equipment that supports each function and contributes to each failure condition. This information typically comes from the architecture modeled or described in the PSSA/SSA/System Description Document (SDD).

When aircraft or equipment are new designs, the maturity of the general safety assessment is more dynamic during the project development. This situation can result in changes to the general safety assessment in the form of addition of failure conditions, changes to hazard classifications, and changes in system architecture. These changes can impact the HLSA. Therefore, regular reviews are necessary to ensure that the HLSA stays current. Some examples of changes that can impact the HLSA are provided below:

- Initial classification of loss of stall warning may be minor, which would mean no HIRF or lightning requirements. However, the flight test may come later in the program after the initial HLSA is performed and demonstrate the inherent aerodynamic characteristics are not as anticipated during all flight phases. In this case, the hazard may be changed to a classification higher than minor.
- The total loss of forward visibility in the cockpit may be catastrophic initially in the general safety assessment on an aircraft level. As the project matures, the system design architecture includes a windshield heat system consisting of independent heating zones on the forward windshield. The applicant may decide to show that the unheated side window does not lose visibility in icing conditions due to the aircraft aerodynamics, and it continues to provide forward visibility via the side window independent of the forward windshield and flight testing demonstrates the ability to safely land the aircraft using the side window. The system functional hazard assessment would include a reduced hazard classification to something less than catastrophic for loss of all windshield heat. As a result of this, the forward windshield heating system is not required to show compliance with 2X.1317(a) or 2X.1316(a).

Late changes to system architecture can drive updates to HIRF/lightning requirements. New or changed requirements identified late in the development of a program can add considerable cost and schedule delays. Given this variability, it may be practical to define HLCLs conservatively to reduce the impact of changes during the development and therefore certification risks.

When a PSSA is available, it should be used to develop an early draft of the HLSA and identify derived electrical/electronic qualification requirements. This will help prevent the required system functions and failure conditions from being inadvertently excluded from HIRF and lightning system level testing, which is typically defined early in the program.

4. HIRF AND LIGHTNING SAFETY ASSESSMENT (HLSA) PROCESS

A general overview of the HLSA is provided in [Figure 1](#), and further details on how to accomplish each step of the process are provided in the following paragraphs. The steps in the HIRF and Lightning Safety Process boxes are described in the following subsections to help identify the system/equipment criticality. In combination with AC 20-158/AMC 20-158 and AC 20-136/AMC 20-136, this will help determine when aircraft test data may be necessary and what system/equipment test levels are required.

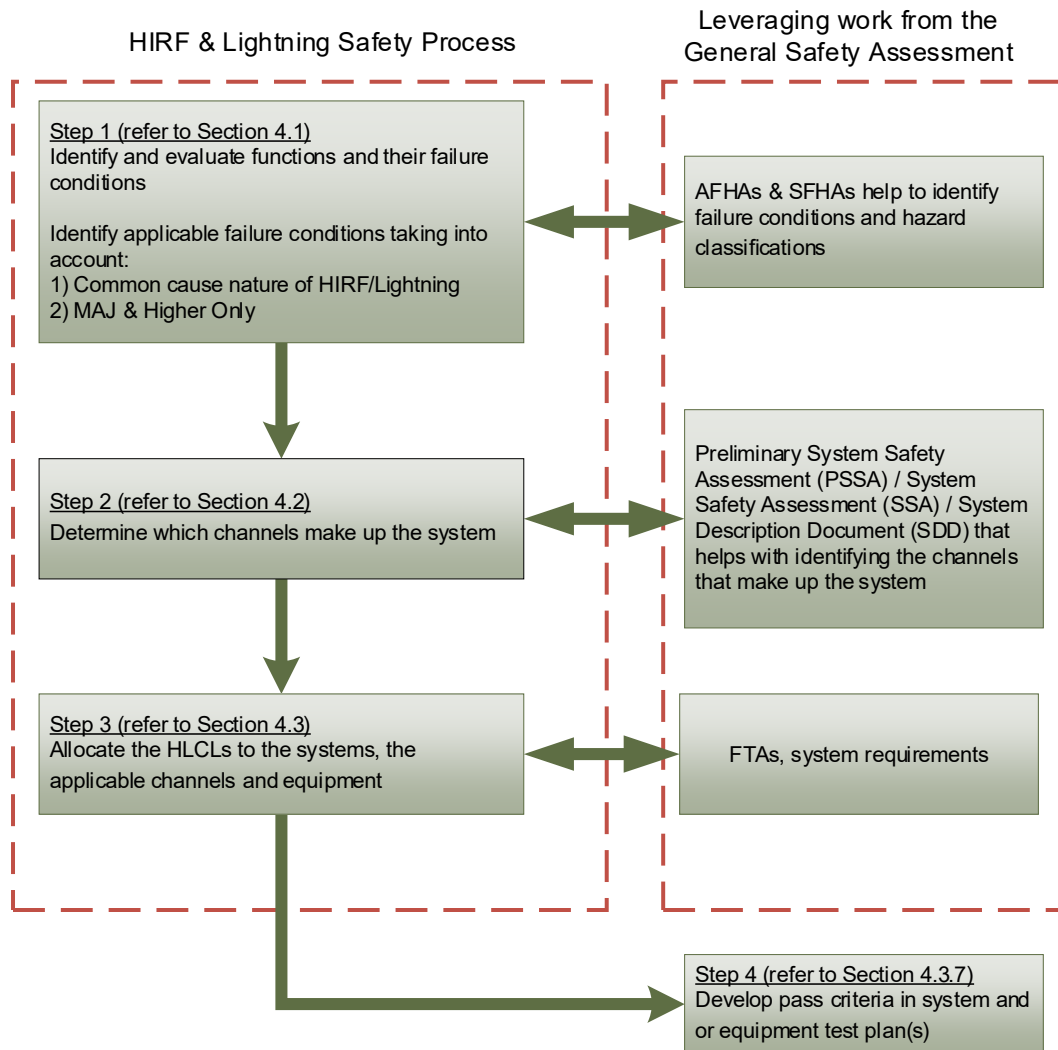


Figure 1 - HIRF and Lightning Safety Assessment (HLSA) overview

4.1 Identify and Evaluate Functions and their Failure Conditions

The list of aircraft functions and failure conditions are sourced from the Aircraft Functional Hazard Assessment (AFHA) and Systems Functional Hazard Assessment (SFHA), which are part of the general safety assessment. The goal is to identify functions and associated failure conditions, including all phases of flight that result in a catastrophic, hazardous, or major failure condition for the aircraft. See the worked example in [Table 3](#), where the failure conditions are identified from the general safety assessment documents, as the starting point for below:

1. In the general safety assessment, there are typically numerous failure conditions for any given function. All failure conditions associated with a function are considered for the HLSA. If applicable, ETOPS significant systems whose failure conditions could affect extended operations should also be considered. In this case, consider whether ETOPS significant systems have been addressed by the functional hazard assessment or should be included as part of the HLCL A for ETOPS significant systems.
2. Failure conditions that are not catastrophic, hazardous, or major do not need to be considered in the HLSA.