7 Subparagraph 25.1707(b) requires that each EWIS be designed and installed to limit electrical interference on the aeroplane.

One type of electrical interference is electromagnetic interferences (EMI). Electromagnetic interference can be introduced into aeroplane systems and wiring by coupling between electrical cables or between cables and coaxial lines or other aeroplane systems. Function of systems should not be affected by EMI generated by adjacent wire. EMI between wiring which is a source of EMI and wire susceptible to EMI increases in proportion to the length of parallel runs and decreases with greater separation. Wiring of sensitive circuits that may be affected by EMI should be routed away from other wiring interference, or provided with sufficient shielding to avoid system malfunctions under operating conditions. EMI should be limited to negligible levels in wiring related to systems necessary for continued safe flight, landing and egress. The following sources of interference should be considered:

a. Conducted and radiated interference caused by electrical noise generation from apparatus connected to the busbars.

b. Coupling between electrical cables or between cables and aerial feeders.

c. Malfunctioning of electrically-powered apparatus.

d. Parasitic currents and voltages in the electrical distribution and grounding systems, including the effects of lightning currents or static discharge.

e. Different frequencies between electrical generating systems and other systems.

8 This paragraph 25.1707(c) contains the wire-related requirements formerly located in CS 25.1353(b). Coverage is expanded beyond wires and cable carrying heavy current to include their associated EWIS components as well. This means that all EWIS components, as defined by CS 25.1701, that are associated with wires and cables carrying heavy current must be installed in the aeroplane so damage to essential circuits will be minimised under fault conditions.

9 Subparagraph 25.1707(d) contains wire-related requirements from CS 25.1351(b)(1) and (b)(2) and introduces additional requirements.

a. Subparagraph (d) requires that EWIS components associated with the generating system receive the same degree of attention as other components of the system, such as the electrical generators.

b. Subparagraph (d)(1) prohibits aeroplane independent electrical power sources from sharing a common ground terminating location. Paragraph (d)(2) prohibits aeroplane static grounds from sharing a common ground terminating location with any aeroplane independent electrical power sources. The reason for these paragraphs is twofold:

(1) to help ensure the independence of separate electrical power sources so that a single ground failure will not disable multiple power sources; and

(2) to prevent introduction of unwanted interference into aeroplane electrical power systems from other aeroplane systems.

10 Subparagraphs 25.1707(e), (f), (g), (h) contain specific separation requirements for the fuel, hydraulic, flight and mechanical control system cables, oxygen, hot bleed air systems, and waste/water systems. They require adequate EWIS separation from those systems except to the extent necessary to provide any required electrical connection to them. EWIS must be designed and installed with adequate separation so a failure of an EWIS component will not create a hazardous condition and any leakage from those systems (i.e., fuel, hydraulic, oxygen, waste/water) onto EWIS components will not create a hazardous situation.

a. Under fault conditions and without adequate EWIS separation a potential catastrophic hazard could occur should an arcing fault ignite a flammable fluid like fuel or hydraulic fluid. Also an arcing fault has the potential to puncture a line associated with those systems if adequate separation is not maintained. If there is leakage from one of those systems and an arcing event occurs, fire or explosion could result. Similarly, leakage from the water/waste system can cause damage to EWIS components and adversely affect their integrity. An EWIS arcing event that punctures a water or waste line could also introduce fluids into other aeroplane systems and create a hazardous condition.

b. In addition to the required separation distance, the use of other protection means such as drip shields should be considered to prevent the potential for fluids to leak onto EWIS.

11 Subparagraph 25.1707(i). To prevent chafing, jamming, or other types of interference, or other failures that may lead to loss of control of the aeroplane, EWIS in general and wiring in particular must be physically separated from flight control or other types of control cables. Mechanical cables have the potential to cause chafing of electrical wire if the two come into contact. This can occur either through vibration of the EWIS and/or mechanical cable or because of cable movement in response to a system command. A mechanical cable could also damage other EWIS components, such as a wire bundle support, in a way that would cause failure of that component. Also, if not properly designed and installed, a wire bundle or other EWIS component could interfere with movement of a mechanical control cable by jamming or otherwise restricting the cable's movement.

Without adequate separation, an arcing fault could damage or sever a control cable. A control cable failure could damage EWIS. Therefore, paragraph (i) requires an adequate separation distance or barrier between EWIS and flight or other mechanical control systems cables and their associated system components. It also requires that failure of an EWIS component must not create a hazardous condition and that the failure of any flight or other mechanical control systems cables or systems components must not damage EWIS and creates a hazardous condition. Clamps for wires routed near moveable flight controls should be attached and spaced so that failure of a single attachment point cannot interfere with flight controls or their cables, components, or other moveable flight control surfaces or moveable equipment.

12 Subparagraph 25.1707(j) requires that EWIS design and installation provide adequate physical separation between the EWIS components and heated equipment, hot air ducts, and lines. Adequate separation distance is necessary to prevent EWIS damage from extreme temperatures and to prevent an EWIS failure from damaging equipment, ducts, or lines. High temperatures can deteriorate wire insulation and other parts of EWIS components, and if the wire or component type is not carefully selected, this deterioration could lead to wire or component failure. Similarly, should an arcing event occur, the arc could penetrate a hot air duct or line and allow the release of high pressure, high temperature air. Such a release could damage surrounding components associated with various aeroplane systems and potentially lead to a hazardous situation.

13 Subparagraph AMC 25.1707(k). For systems for which redundancy is required either by specific certification requirements, operating rules or by CS 25.1709, each applicable EWIS must be designed and installed with adequate physical separation. To maintain the independence of redundant systems and equipment so that safety functions are maintained, adequate separation and electrical isolation between these systems must be ensured as follows:

a. EWIS of redundant aircraft systems should be routed in separate bundles and through separate connectors to prevent a single fault from disabling multiple redundant systems.

Segregation of functionally similar EWIS components is necessary to prevent degradation of their ability to perform their required functions.

b. Power feeders from separate power sources should be routed in bundles separate from each other and from other aircraft wiring in order to prevent a single fault from disabling more than one power source.

c. Wiring that is part of electro-explosive subsystems, such as cartridge-actuated fire extinguishers and emergency jettison devices, should be routed in shielded and jacketed twisted-pair cables, shielded without discontinuities, and kept separate from other wiring at connectors.

14 Subparagraph 25.1707(l) requires that EWIS be designed and installed so they are adequately separated from aircraft structure and protected from sharp edges and corners. This is to minimise the potential for abrasion and chafing, vibration damage, and other types of mechanical damage. This protection is necessary because over time the insulation on a wire that is touching a rigid object, such as an equipment support bracket, will fail and expose bare wire. This can lead to arcing that could destroy that wire and other wires in its bundle. Structural damage could also occur depending on the amount of electrical energy the failed wire carries.

[Amdt 25/5]

# CS 25.1709 System Safety; EWIS

*ED Decision 2008/006/R*

(See AMC 25.1709)

EWIS must be designed and installed so that:

(a) Each catastrophic failure condition

(1) is extremely improbable; and

(2) does not result from a single failure; and

(b) Each hazardous failure condition is extremely remote.

[Amdt 25/5]

# AMC 25.1709 System safety; EWIS

*ED Decision 2008/006/R*

25.1709 requires applicants to perform a system safety assessment of the EWIS. The analysis required for compliance with CS 25.1709 is based on a qualitative approach to assessing EWIS safety as opposed to numerical, probability-based quantitative analysis. The safety assessment must consider the effects that both physical and functional failures of EWIS would have on aeroplane safety. That safety assessment must show that each EWIS failure considered hazardous is extremely remote. It must show that each EWIS failure considered to be catastrophic is extremely improbable and will not result from a single failure.

1 Objective.

The objective of CS 25.1709 is to use the concepts of CS 25.1309 to provide a thorough and structured analysis of aircraft wiring and its associated components. As in CS 25.1309, the fail-safe design concept applies. Any single failure condition, such as an arc fault, should be assumed to occur regardless of probability.

2 Inadequacies of CS 25.1309 in relation to EWIS safety assessments.

CS 25.1309 requires the applicant to perform system safety assessments. But current CS 25.1309 practice has not led to the type of analysis that fully ensures all EWIS failure conditions affecting aeroplane level safety are considered. This is because wiring for non-required systems is sometimes ignored. Even for systems covered by CS 25.1309(b), the safety analysis requirements have not always been applied to the associated wire. When they are, there is evidence of inadequate and inconsistent application. Traditional thinking about non-required systems, such as IFE, has been that, since they are not required, and the function they provide is not necessary for the safety of the aeroplane, their failure could not affect the safety of the aeroplane. This is not a valid assumption. Failure of an electrical wire, regardless of the system it is associated with, can cause serious physical and functional damage to the aeroplane, resulting in hazardous or even catastrophic failure conditions. An example of this is arcing from a shorted wire cutting through and damaging flight control cables. There are more failure modes than have been addressed with traditional analyses. Some further examples are arcing events that occur without tripping circuit breakers, resulting in complete wire bundle failures and fire; or wire bundle failures that lead to structural damage

3 Integrated nature of EWIS.

The integrated nature of wiring and the potential severity of failures demand a more structured safety analysis approach than that traditionally used under CS 25.1309. CS 25.1309 system safety assessments typically evaluate effects of wire failures on system functions. But they have not considered physical wire failure as a cause of the failure of other wires within the EWIS. Traditional assessments look at external factors like rotor burst, lightning, and hydraulic line rupture, but not at internal factors, like a single wire chafing or arcing event, as the cause of the failure of functions supported by the EWIS. Compliance with CS 25.1709 requires addressing those failure modes at the aeroplane level. This means that EWIS failures need to be analyzed to determine what effect they could have on the safe operation of the aeroplane.

4 Compliance summary.

As specified above, the analysis required for compliance with CS 25.1709 is based on a qualitative approach to assessing EWIS safety as opposed to numerical, probability-based quantitative analysis. The intent is not to examine each individual wire and its relation to other wires. Rather, it is to ensure that there are no combinations of failures that could lead to a hazardous condition. However, in case the “top down” analysis process described in this AMC determines that a failure in a given bundle may lead to a catastrophic failure condition, the mitigation process may lead to performing a complete analysis of each wire in the relevant bundle.

5 Qualitative probability terms.

When using qualitative analyses to determine compliance with CS 25.1709, the following descriptions of the probability terms have become commonly accepted as aids to engineering judgment:

a. Extremely remote failure conditions.

These are failure conditions that are not anticipated to occur to an individual aeroplane during its total life but which may occur a few times when considering the total operational life of all aeroplanes of the type.

b. Extremely improbable failure conditions.

These are failure conditions so unlikely that they are not anticipated to occur during the entire operational life of all aeroplanes of one type.

6 Relationship to CS 25 system safety assessments.

The analysis described may be accomplished in conjunction with the required aircraft system safety assessments of CS 25.1309, 25.671, etc.

7 Classification of failure terms.

The classification of failure conditions is specified in AMC 25.1309.

8 Flowcharts depicting the analysis process.

Flowcharts 1 and 2 outline one method of complying with the requirements of CS 25.1709. The processes in both Flowcharts 1 and 2 identify two aspects of the analysis: physical failures and functional failures. The processes described in both flowcharts begins by using the aircraft level functional hazard analysis developed for demonstrating compliance with CS 25.1309 to identify catastrophic and hazardous failure events. A step-by-step explanation of the analysis depicted in the flowcharts is given in paragraphs 11 (for flowchart 1) and 12 (for Flowchart 2).

a. Flowchart 1.

This flowchart applies to applicants for pre-TC work and for amended TCs, and STCs when the applicant has all data necessary to perform the analysis. If Flowchart 1 is used for post-TC modifications the available data must include identification of the systems in the EWIS under consideration for modification and the system functions associated with that EWIS.

b. Flowchart 2.

This flowchart applies to applicants for post-TC modifications when the applicant cannot identify the systems or systems functions contained in EWIS under consideration for modification.

9 Definitions applicable to CS 25.1709.

For this discussion the following definitions apply:

a. Validation. Determination that requirements for a product are sufficiently correct and complete.

b. Verification. Evaluation to determine that requirements have been met.

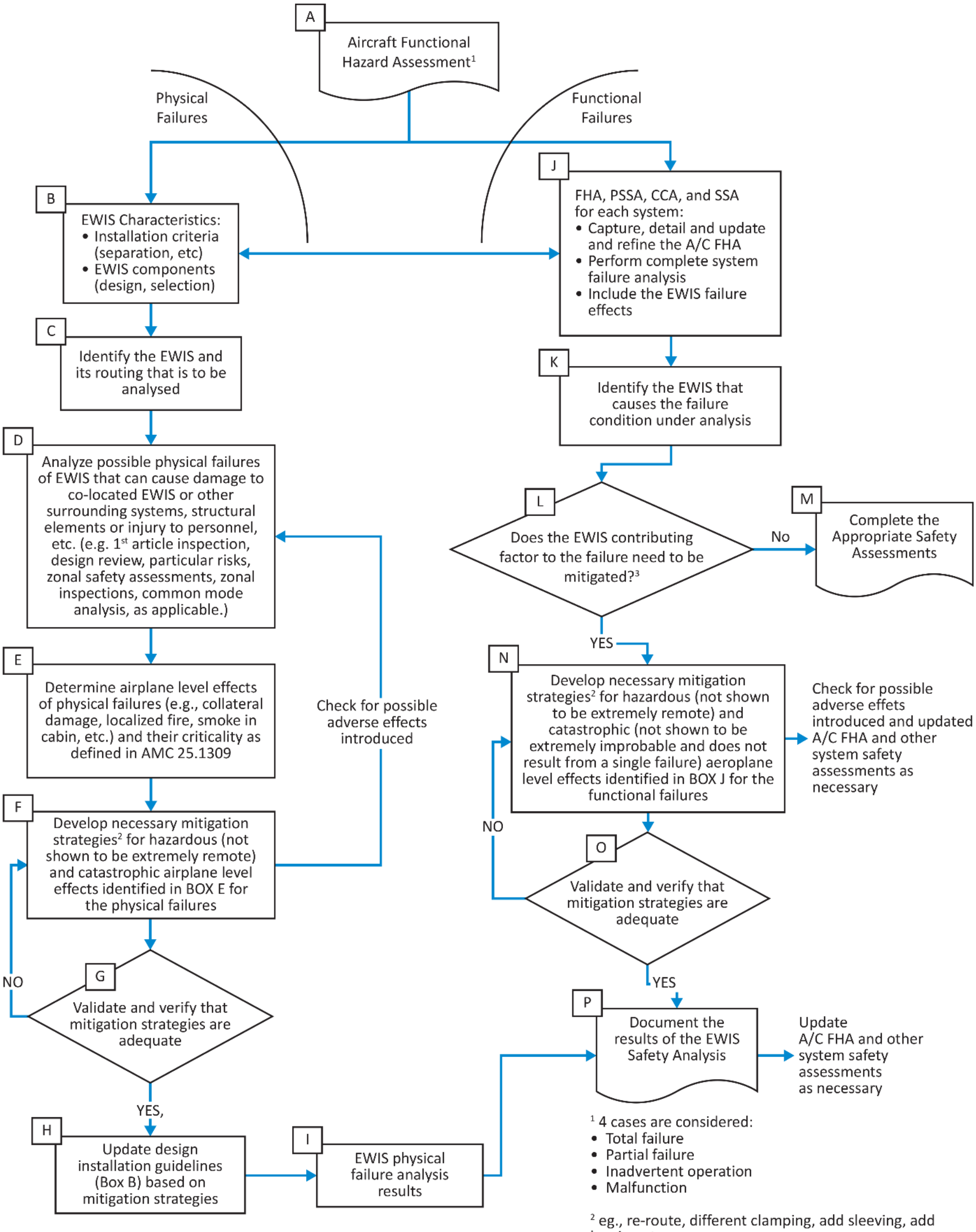
c. Mitigation. Elimination of the hazard entirely or suitable precautions taken to minimize the overall severity to an acceptable level.

10 Physical failure analysis.

a. Only single common cause events or failures need to be addressed during the physical failure analysis as described in this AMC and shown on the left hand sides of Flowcharts 1 and 2. Multiple common cause events or failures need not be addressed.

b. In relation to physical effects, it should be assumed that wires are carrying electrical energy and that, in the case of an EWIS failure, this energy may result in hazardous or catastrophic effects directly or when combined with other factors, for example fuel, oxygen, hydraulic fluid, or damage by passengers, These failures may result in fire, smoke, emission of toxic gases, damage to co-located systems and structural elements or injury to personnel. This analysis considers all EWIS from all systems (autopilot, auto throttle, PA system, IFE systems, etc.) regardless of the system criticality.

***Flowchart 1: Pre- and Post-Type Certification Safety Analysis Concept***




[1] 4 cases are considered:
- Total failure
- Partial failure
- Inadvertent operation
- Malfunction

[2] eg., re-route, different clamping, add sleeving, add barrier, etc

[3] Contributing means the EWIS causes the failure in whole or in part

Note: Mitigation as used in this flowchart means to eliminate the hazard entirely or minimise its severity to an acceptable level.

11 Descriptive text for flowchart 1

a. Box A: Aircraft functional hazard assessment.

(1) The functional failure analysis assumes that electrical wires are carrying power, signal, or information data. Failure of EWIS under these circumstances may lead to aircraft system degradation effects.

(2) The functional hazard assessment (FHA) referred to in this box is not a stand-alone separate document specifically created to show compliance with CS 25.1709. It is the aircraft level FHA that the applicant will have developed in compliance with CS 25.1309 to help demonstrate acceptability of a design concept, identify potential problem areas or desirable design changes, or determine the need for and scope of any additional analyses (refer to AMC 25.1309)

b. Analysis of Possible Physical Failures

(1) Box B: EWIS characteristics.

Use the results of the FHA (BOX A and BOX J) to identify EWIS installation criteria and definitions of component characteristics. Results from BOX B are fed into the preliminary system safety analysis (PSSA) and system safety analysis (SSA) of BOX J.

(2) Boxes C, D and E: Validation and verification of installation criteria.

(i) Ensure that the EWIS component qualification satisfies the design requirements and that components are selected, installed, and used according to their qualification characteristics and the aircraft constraints linked to their location (refer to the requirements of CS 25.1703 and CS 25.1707).

(ii) Use available information (digital mock-up, physical mock-up, aeroplane data, historical data) to perform inspections and analyses to validate that design and installation criteria are adequate to the zone/function, including considerations of multi-systems impact. Such inspections and analyses may include a 1st article inspection, design review, particular risk assessment, zonal safety assessment, zonal inspection, and common mode analysis, as applicable. Use such assessments and inspections to ascertain whether design and installation criteria were correctly applied. Special consideration should be given to known problem areas identified by service history and historical data (areas of arcing, smoke, loose clamps, chafing, arc tracking, interference with other systems, etc.). Regardless of probability, any single arcing failure should be assumed for any power-carrying wire. The intensity and consequence of the arc and its mitigation should be substantiated. Give special consideration to cases where new (previously unused) material or technologies are used. In any case CS 25.1703(b) requires that the selection of wires must take into account known characteristics in relation to each installation and application to minimise the risk of wire damage, including any arc tracking phenomena.

(iii) Deviations from installation and component selection criteria identified by these activities should be evaluated. A determination can then be made about their acceptability. Develop alternative mitigation strategies as necessary.

(3) Boxes F and G: Development and validation of mitigation strategy.

Identify and develop a mitigation strategy for the physical failures and their adverse effects identified in Boxes D and E. Validation and verification of the mitigation solution should ensure that:

(i) Hazardous failure conditions are extremely remote.

(ii) Catastrophic failure conditions do not result from a single common cause event or failure.

(iii) This mitigation solution does not introduce any new potential failure conditions.

(4) Box H: Incorporation of applicable mitigation strategies.

Incorporate newly developed mitigation strategies (BOX F) into guidelines (BOX B) for further design and inspection and analysis processes.

(5) Box I: Physical failure analysis results.

From the EWIS physical failure analysis, the following should be documented:

— Physical failures addressed.

— Effects of those physical failures.

— Mitigation strategies developed.

This information should be used to support the final analysis documentation (BOX P).

c. Analysis of Possible Functional Failures

(1) Box J: System safety assessments.

The results of the aeroplane level FHA (BOX A) should be used to guide the system level FHA (BOX J). Incorporate EWIS failures identified by CS 25.1709 into the system level and aircraft level FHA, the PSSA, the Common Cause Analyses (CCA), and the SSA. These analyses are performed to satisfy requirements of CS 25.1309. Use results of these analyses to update the EWIS definition (BOX B).

(2) Boxes K, L and M: Hazardous and catastrophic failure conditions.

Use the analyses in BOX J to determine if the EWIS associated with the system under analysis can contribute (in whole or in part) to the failure condition under study. Determine whether the EWIS failure needs to be mitigated. If so, develop, validate, and verify a mitigation strategy. If no mitigation is needed, complete the appropriate safety assessment per CS 25.1309, CS 25.671, etc..

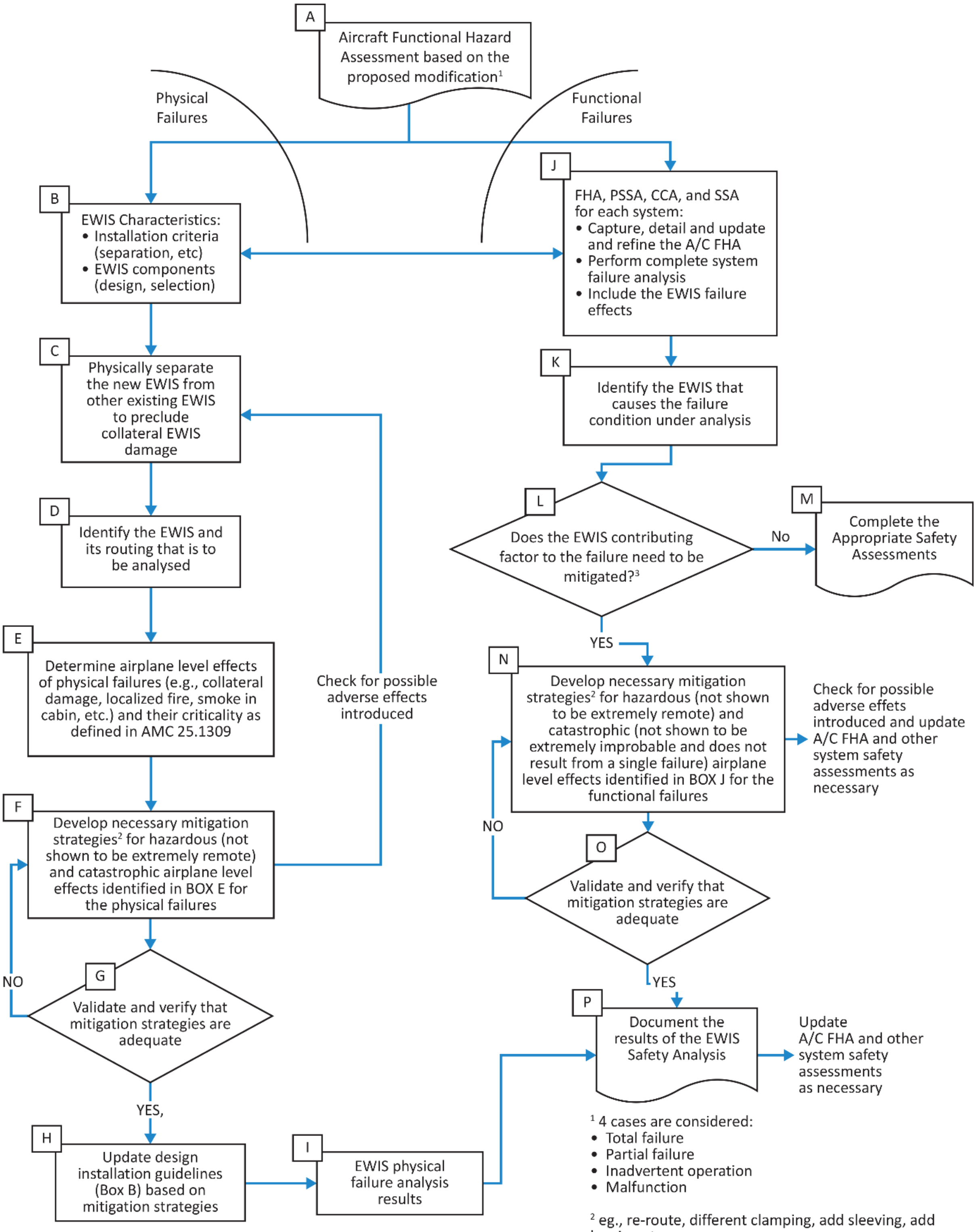
(3) Boxes N and O: Development and validation of mitigation strategy.

Identify and develop a mitigation strategy for the functional failures and adverse effects identified in BOX J. Validation and verification of the mitigation solution should determine if initial objective is fully reached; and confirm that this mitigation solution is compatible with existing installations and installation criteria. If the EWIS was the failure cause, the subsequent mitigation strategy developed may introduce new adverse effects not previously identified by the analysis. Check for any new adverse effects and update the aircraft level FHA and other system safety assessments as necessary.

(4) Box P: Documentation of EWIS safety analysis results.

After mitigation strategies have been validated and verified, the results of the CS 25.1709 analysis should be documented. Update as necessary the aircraft level FHA that has been developed in support of certification of the proposed modification, in compliance with CS 25.1309 (BOX A).

***Flowchart 2: Post-TC Safety Analysis Concept***




[1] 4 cases are considered:
- Total failure
- Partial failure
- Inadvertent operation
- Malfunction

[2] eg., re-route, different clamping, add sleeving, add barrier, etc

[3] Contributing means the EWIS causes the failure in whole or in part

Note: Mitigation as used in this flowchart means to eliminate the hazard entirely or minimise its severity to an acceptable level.