DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE LIFE CYCLE MANAGEMENT CENTER
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United States Air Force (USAF) Airworthiness Bulletin (AWB)-150A

Subject: Airworthiness (AW) Risk Assessment and Acceptance

Attachments: (1) Glossary of References and Supporting Information
(2) Severity Categories, Probability Levels, and Risk Assessment Matrix
(3) Amplifying Information for Preparing System Safety Risk Assessments (SSRAs)

1) **Purpose:** Provide instruction for AW risk assessment and acceptance.

2) **Office of Primary Responsibility (OPR):** USAF Airworthiness Office (AFLCMC/EZSA; usaf.airworthiness.office@us.af.mil).

3) **Applicability:** This bulletin applies to programs that design, acquire, own, lease, contract for, operate, modify, or acquire the service of aircraft and air systems.

4) **Policy:** The following policy applies to USAF AW risk assessments:

   a) **MIL-STD-882E, System Safety:** Identifies the Department of Defense (DoD) approach for identifying hazards and assessing and mitigating associated risks encountered in the development, test, production, use, and disposal of defense systems. It conforms to requirements levied by Department of Defense Instruction (DoDI) 5000.02, Operation of the Defense Acquisition System.

   b) **Air Force Instruction (AFI) 91-202, The US Air Force Mishap Prevention Program:** Establishes mishap prevention program requirements, assigns responsibilities for program elements, and contains program management information. AFI 91-202, Attachment 15, Preparation of Risk Assessments, describes the SSRA format. AFI 91-202 and its Supplements conform to requirements levied by MIL-STD-882E.

   c) **AFI 62-601, USAF Airworthiness:** AFI 62-601, paragraph 1.16.1, requires resolution of safety hazards identified from non-compliances to AW criteria or acceptance of their residual risk by the appropriate authority prior to issuance of an AW flight authorization.

5) **Discussion:**

   a) Use of the AW risk assessment process is applicable to systems and their components that 1) meet fundamental engineering processes and 2) are designed to achieve compliance with applicable AW certification criteria. Noncompliance with an applicable AW certification criterion is an indication of a potential safety hazard or other limitation in the design of the

system and may have AW ramifications. Each hazard carries an associated risk (or possibly multiple risks).

b) The risk of mishap associated with a hazard is the combination of the severity of the loss incurred by the mishap and the probability of occurrence of the mishap. As it applies to AW, the probability of occurrence of a mishap is defined as the probability of that mishap occurring either during a single flying hour (FH) or during a single sortie or flight cycle. (Without loss of intent, this bulletin consolidates the terms sortie and flight cycle, simply using "sortie.")

c) The impact of a risk of mishap associated with a hazard is the expected cost of that risk over some specified future period of exposure. "Expected Future Losses" (i.e., risk impact) is distinct from the risk of mishap (which is determined for a point in time and does not consider a period of exposure beyond a single FH or sortie) and is a required part of SSRAs as defined by AFI 91-202, Attachment 15.

d) Instructions in this bulletin are mandatory for aircraft systems undergoing airworthiness assessments, regardless of additional requirements (e.g., test safety review).

6) **AW Risk Assessment and Acceptance Process:** The following process shall be used by the program office (PO) in coordination with AFLCMC/EN-EZ when assessing and accepting risk related to AW:

a) Identify hazards and mishaps that could reasonably occur due to the hazards.

i) Hazards may be identified from sources including, but not limited to, noncompliance with applicable AW certification criteria, non-design based AW assessments, System Safety Group (SSG) findings, or mishap investigations.

ii) The PO should correlate hazards identified from AW assessments with those tracked by System Safety to prevent redundant risk assessments.

iii) Multiple non-compliances with applicable AW certification criteria may be associated with the same hazard.

iv) Example: If a PO responsible for a modification does not present evidence that the installation maintains positive separation of wiring from hydraulic lines, then the design is noncompliant with MIL-HDBK-516C, Criterion 12.2.6.3, Wiring Separation. The hazard associated with this non-compliance is the lack of positive separation of wiring from hydraulic lines. A potential mishap that could occur as a result of this hazard is an uncontrolled fire.

b) Determine the severity category(ies) of mishap(s) associated with the hazard using the definitions in Attachment 2, Table 1 (reproduced from MIL-STD-882E).

c) Determine the mishap probability level(s).

i) When practical, identify the probability level of the mishap using the quantitative thresholds in Attachment 2, Table 2 and document the use of appropriate mathematical and probabilistic methods.

(1) The probability of a mishap's occurrence per FH or sortie may change over time. Efforts should be made to identify an increasing (or decreasing) probability of occurrence. If the probability level changes during the expected lifecycle of the platform, document the time at which such a change occurs. (Reference Attachment 3, Amplifying Information for Preparing SSRAs, Note 1 for further guidance.)

(2) Attachment 2, Table 2 may be used (equivalently) with either probability per FH (or sortie) or frequency per 100K FH (or 100K sorties). (Reference Attachment 3, Note 2.)

(3) The choice of whether to evaluate probabilities per FH or per sortie (or per flight cycle, if an aircraft or engine hazard is best described as a function of cycles) is left to the PO. (Reference Attachment 3, Note 3.)

ii) If a quantitative assessment is not practical, identify the qualitative probability level in accordance with (IAW) Attachment 2, Table 3 (reproduced from MIL-STD-882E) and document the rationale. When determining the probability level qualitatively, consider the probability level's corresponding quantitative probability range.

d) Identify the Risk Assessment Code (RAC) and the corresponding risk category at the intersection of the mishap severity category and probability level, using the USAF Airworthiness Risk Assessment Matrix in Attachment 2, Table 4. This matrix is required for risk determination and risk acceptance for USAF airworthiness assessments and is IAW MIL-STD-882E, Table III, Risk Assessment Matrix.

e) Determine the risk impact. (Reference Attachment 3, Determining Expected Future Losses.)

f) Document the risk assessment(s).

i) For Serious and High risks, programs shall prepare SSRAs using the guidance in AFI 91-202, Attachment 15, and Attachment 3 of this bulletin. If multiple potential mishaps identified for a hazard have different severities, the SSRA will be written to reflect the mishap that produces the greatest risk. (Determine the RAC for each mishap, if necessary.) Reference Attachment 3 for amplifying information on constructing SSRAs; note that instructions in this bulletin conform to standards that allow an SSRA to be submitted both to the Risk Acceptance Authority (RAA) for risk acceptance and, subsequently, the Technical Airworthiness Authority (TAA) for AW assessment.

ii) For Low and Medium risks, programs are encouraged to use the SSRA format but may document risks in a manner acceptable to the Program Manager (PM).

iii) Include sufficient details (e.g., drawings, dimensions, etc.) that clearly describe the hazard. Show calculation details to include assumptions, inputs, confidence or conservatism of inputs, etc.

g) Obtain risk acceptance from the appropriate authority IAW DoDI 5000.02 and MIL-STD-882E. For Serious and High risks, obtain TAA (as AFLCMC/EN-EZ) coordination (IAW AFI 91-202 AFMCSUP) prior to obtaining risk acceptance. Contact the USAF Airworthiness Office to obtain the TAA coordination. All risks must be accepted prior to issuance of an AW flight authorization.

7) Updates to Program Risk Assessments

a) POs shall track and manage all hazards in the System Hazard Tracking Log throughout the lifecycle IAW AFI 91-202, to include mitigation status and on-going risk reduction efforts.

b) POs shall obtain TAA coordination on SSRAs when re-accomplishing risk assessments as required by AFI 91-202 and AFI 91-202 AFMCSUP. The TAA may review and modify the AW flight authorization as appropriate to address the updated risk assessment(s).

c) POs shall notify the TAA as soon as practical upon discovery of probable Serious or High risks that impact AW and keep the TAA informed of significant developments during the assessment process.

d) POs shall ensure risk assessments are accepted and current and are provided to the TAA as necessary, prior to renewal of, or extensions or other updates to, AW flight authorizations.

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Attachment 1

GLOSSARY OF REFERENCES AND SUPPORTING INFORMATION

References

AFI 62-601, *USAF Airworthiness*, 11 June 2010
AFI 63-101/20-101, *Integrated Life Cycle Management*, 9 May 2017
AFI 91-202, *The US Air Force Mishap Prevention Program*, AFGM 2017-01, 25 May 2017
AFI 91-202, AFMCSUP, *The US Air Force Mishap Prevention Program,* 17 May 2017
AFPD 62-6, *USAF Airworthiness*, 11 June 2010
DoDI 5000.02, *Operation of the Defense Acquisition System*, Incorporating Change 2, 2 Feb 2017
MIL-HDBK-516C, Airworthiness Certification Criteria, 12 December 2014
MIL-STD-882E, *System Safety*, 11 May 2012

Abbreviations and Acronyms

AFGM – Air Force Guidance Memorandum
AFI – Air Force Instruction
AFPD – Air Force Policy Directive
AW – Airworthiness
AWB – Airworthiness Bulletin
DoD – Department of Defense
DoDI – Department of Defense Instruction
FH – Flying Hour
HRI – Hazard Risk Index
IAW – In Accordance With
MIL-HDBK – Department of Defense Handbook
MIL-STD – Department of Defense Standard Practice
OPR – Office of Primary Responsibility
PM – Program Manager
PO – Program Office
RAA – Risk Acceptance Authority
RAC – Risk Assessment Code
SSG – System Safety Group
SSRA – System Safety Risk Assessment
TAA – Technical Airworthiness Authority
UAS – Unmanned Aircraft System
USAF – United States Air Force

Terms

Frequency – Number of occurrences of an event during a specified exposure period.

Hazard – Per MIL-STD-882E: "A real or potential condition that could lead to an unplanned event or series of events (i.e., mishap) resulting in death, injury, occupational illness, damage to or loss of equipment or property, or damage to the environment."

Hazard Rate – Frequency of a mishap, also known as failure rate. This apparent misnomer (i.e., hazard rate as opposed to mishap rate) is intentional to align the term with the standard probability definition. The specified exposure period may be a FH, sortie, or cycle or, equivalently when multiplied by 100,000, 100K FH, 100K sorties, or 100K cycles.

Hazard Function – A function that specifies the hazard rate for a given time.

Initial Risk – Per MIL-STD-882E: "The first assessment of the potential risk of an identified hazard. Initial risk establishes a fixed baseline for the hazard."

Interim Risk – Risk during the mitigation period (including any non-material mitigation actions imposed during this period).

Mishap – Per MIL-STD-882E: "An event or series of events resulting in unintentional death, injury, occupational illness, damage to or loss of equipment or property, or damage to the environment."

Probability – Per MIL-STD-882E: "An expression of the likelihood of occurrence of a mishap." Probability is expressed by a number from 0 to 1, with 0 implying no possibility of occurrence and 1 implying certainty of occurrence during a specified exposure period.

Residual Risk – Per AFMC Supplement to AFI 91-202: "The remaining mishap risk that exists after all mitigation techniques have been implemented or exhausted, in accordance with the system safety design order of precedence."

Risk – Per MIL-STD-882E: "A combination of the severity of the mishap and the probability that the mishap will occur."

Risk Assessment Code (RAC) – Per MIL-STD-882E, Para 4.3.3.c: "A combination of one severity category and one probability level." While MIL-STD-882E labels RACs as the combination of one severity category and one probability level (given as a numeral from 1 through 4 followed by a letter from A through F, e.g., 1A or 4E), with no loss of significance this bulletin uses a single number from 1 through 20 where 1 through 5 represents High risk, 6 through 9 represents Serious risk, 10 through 17 represents Medium risk, and 18 through 20 represents Low risk. Other sources may term RAC as Hazard Risk Index (HRI).

Severity – Per MIL-STD-882E: "The magnitude of potential consequences of a mishap to include: death, injury, occupational illness, damage to or loss of equipment or property, damage to the environment, or monetary loss."

Target Risk – Per MIL-STD-882E: The projected risk level the PM plans to achieve by implementing mitigation measures consistent with the design order of precedence described in [paragraph] 4.3.4." of MIL-STD-882E.

Attachment 2

SEVERITY CATEGORIES, PROBABILITY LEVELS, AND RISK ASSESSMENT MATRIX

Table 1: Severity Categories (MIL-STD-882E, Table I)

SEVERITY CATEGORIES		
Description	**Severity Category**	**Mishap Result Criteria**
Catastrophic	**1**	Could result in one or more of the following: death, permanent total disability, irreversible significant environmental impact, or monetary loss equal to or exceeding $10M.
Critical	**2**	Could result in one or more of the following: permanent partial disability, injuries or occupational illness that may result in hospitalization of at least three personnel, reversible significant environmental impact, or monetary loss equal to or exceeding $1M but less than $10M.
Marginal	**3**	Could result in one or more of the following: injury or occupational illness resulting in one or more lost work day(s), reversible moderate environmental impact, or monetary loss equal to or exceeding $100K but less than $1M.
Negligible	**4**	Could result in one or more of the following: injury or occupational illness not resulting in a lost work day, minimal environmental impact, or monetary loss less than $100K.

Table 2: Quantitative Probability Level Thresholds

QUANTITATIVE PROBABILITY LEVEL THRESHOLDS			
Description	**Level**	**Probability per FH or Sortie**	**Frequency per 100K FH or 100K Sorties**
Frequent	**A**	10^{-3} per FH or Sortie ≤ Probability	Frequency ≥ 100 per 100K FH or 100K Sorties
Probable	**B**	10^{-4} ≤ Probability < 10^{-3} per FH or Sortie	10 ≤ Frequency < 100 per 100K FH or 100K Sorties
Occasional	**C**	10^{-5} ≤ Probability < 10^{-4} per FH or Sortie	1 ≤ Frequency < 10 per 100K FH or 100K Sorties
Remote	**D**	10^{-6} ≤ Probability < 10^{-5} per FH or Sortie	0.1 ≤ Frequency < 1 per 100K FH or 100K Sorties
Improbable	**E**	0 < Probability < 10^{-6} per FH or Sortie	Frequency < 0.1 per 100K FH or 100K Sorties
Eliminated	**F**	Probability = 0 per FH or Sortie	Frequency = 0 per 100K FH or 100K Sorties

Table 3: Qualitative Probability Levels (MIL-STD-882E, Table II)

QUALITATIVE PROBABILITY LEVELS			
Description	**Level**	**Specific Individual Item**	**Fleet or Inventory**
Frequent	**A**	Likely to occur often in the life of an item.	Continuously experienced.
Probable	**B**	Will occur several times in the life of an item.	Will occur frequently.
Occasional	**C**	Likely to occur sometime in the life of an item.	Will occur several times.
Remote	**D**	Unlikely, but possible to occur in the life of an item.	Unlikely but can reasonably be expected to occur.
Improbable	**E**	So unlikely, it can be assumed occurrence may not be experienced in the life of an item.	Unlikely to occur, but possible.
Eliminated	**F**	Incapable of occurrence. This level is used when potential hazards are identified and later eliminated.	Incapable of occurrence. This level is used when potential hazards are identified and later eliminated.

Note: "Specific Individual Item" is defined as a single, entire aircraft system

Table 4: USAF Airworthiness Risk Assessment Matrix

USAF Airworthiness Risk Assessment Matrix			Severity Category			
Probability Level	**Probability per FH or Sortie**	**Freq per 100K FH or 100K Sorties**	**Catastrophic (1)**	**Critical (2)**	**Marginal (3)**	**Negligible (4)**
Frequent (A)	$10^{-3} \leq$ Prob	100 ≤ Freq	1	3	7	13
Probable (B)	$10^{-4} \leq$ Prob < 10^{-3}	10 ≤ Freq < 100	2	5	9	16
Occasional (C)	$10^{-5} \leq$ Prob < 10^{-4}	1 ≤ Freq < 10	4	6	11	18
Remote (D)	$10^{-6} \leq$ Prob < 10^{-5}	0.1 ≤ Freq < 1	8	10	14	19
Improbable (E)	0 < Prob < 10^{-6}	0 < Freq < 0.1	12	15	17	20
Eliminated (F)	Prob = 0	Freq = 0	**Eliminated**			

High	CAE Risk Acceptance RAC = 1 - 5	**Medium**	PM Risk Acceptance RAC = 10 - 17
Serious	PEO Risk Acceptance RAC = 6 - 9	**Low**	Risk Acceptance as Directed RAC = 18 - 20

Attachment 3

AMPLIFYING INFORMATION FOR PREPARING SYSTEM SAFETY RISK ASSESSMENTS (SSRAs)

This attachment provides clarifying information for creating SSRAs. The process used to establish RACs and create SSRAs is outlined in MIL-STD-882E and refined in AFI 91-202 and its Supplements. AFI 91-202, Attachment 15, Preparation of Risk Assessments shall be used to document SSRAs for High and Serious risks that support AW assessments. (Use all sections, as applicable, including repeating applicable sections for each mitigation strategy option; Target Risk sections need not be used unless different from the associated Residual Risk sections.)

NOTE 1: Constant hazard rates should be used only when warranted. Examples include but are not limited to hazards associated with random external phenomena such as bird strikes or lightning strikes. Hazards associated with the failure of components with break-in (e.g., electronic components) or wear-out (e.g., fatigue, corrosion, wear and tear, etc.) characteristics will seldom have constant hazard rates. Appropriate methods of determining hazard functions include estimation with a Weibull or other distribution.

NOTE 2: The probability and frequency of a mishap are distinct concepts (see Attachment 1, Terms); however, for values less than 10^{-2}, probabilities per FH (or sortie) and frequencies per FH (or sortie) are essentially equal. For example, probabilities and frequencies differ by 0.5% at 10^{-2}, 0.005% at 10^{-4}, and 0.00005% at 10^{-6}. For this reason, it is not problematic to consider the probability and the frequency of mishap occurrence per FH (or sortie) to be equal, allowing conversion to frequency per 100K FH (or 100K sorties) by multiplying the probability or frequency per FH (or sortie) by 100,000. (Probability of mishap per 100K FH or per 100K sorties is not appropriately used within Attachment 2, Table 2.)

NOTE 3: All USAF manned aircraft have average sortie durations greater than one hour. For these, using probability per sortie will be more conservative than using probability per FH by a factor equal to the average sortie duration in hours. This conservatism is deemed appropriate for valuable assets (both monetarily and in terms of crew safety), and thus it is encouraged that manned aircraft programs evaluate probabilities per sortie. Unmanned Aircraft System (UAS) aircraft that fly an average sortie duration of many hours may not deem extra conservatism necessary and therefore justifiably evaluate probabilities per FH.

NOTE: In determining Interim Risk, include information on production break-in schedule, retrofit kit production schedule, retrofit hours, retrofit schedule, etc. (i.e., describe the schedule for the "burndown" of risk), and the potential of accelerating the schedule. In addition, provide interim options such as operational limitations or restrictions that could significantly reduce the risk during this time.

NOTE: For all mishap types with High or Serious residual risk (without credible possibility of further materiel mitigation, i.e., as low as reasonably practicable), provide all options such as operational limitations or restrictions that could potentially mitigate the risk as much as possible.

NOTE: AFPD 62-6 reads, "This AFPD does not infringe on the MAJCOM commander's prerogative to operate airworthy but less than fully mission capable aircraft systems." Both AFI 63-101/20-101 and AFI 91-202 read, "Program risk acceptance packages and tracking are only necessary for those risks that are inside the design/specification/requirement envelope. Those outside the envelope are handled by using the user's/operator's risk management process." "Outside the envelope" indicates rare instances when vital mission requirements require operation outside the limits established by current flight releases and cannot reasonably be met by other means. Repeated operations "outside the envelope" indicate the current design/specification/requirement is insufficient, and the aircraft needs to be re-assessed for airworthiness with regard to the true requirements, including formal SSRAs and acceptances, as necessary.

Determining Expected Future Losses:

AFI 91-202, Attachment 15, describes the layout for SSRAs and includes a section to report "Expected Future Losses." That section provides insight into the recurring or total cost, both financially and in terms of injuries or fatalities (as applicable), of the aircraft type that operates with the level of risk identified by the SSRA, facilitating RAA risk acceptance (with appropriate coordination) and TAA issuance of a flight authorization upon acceptance of all risks at the appropriate level. For example, consider a Catastrophic severity (causing a loss of aircraft) High risk that has a probability of occurrence of 10^{-5} per FH. For a test program scheduled to fly a total of 100 FH, there is approximately a one in a thousand chance of an aircraft loss over the entire test program due to the hazard. However, for an operational fleet that flies 100,000 FH per year, one aircraft can be expected to be lost annually due to the hazard. The RAA and TAA need such information to make the most informed decision.

Step 1 – Determine the most appropriate period of exposure for the program. The most appropriate period of exposure can vary from program to program. For a test program or a program during its test phase, the most appropriate period of exposure may be the entire test period. For programs in the sustainment phase, the most appropriate period of exposure could be a year (particularly for risks with constant probabilities of occurrence) or a period that extends to the next required periodic risk review (particularly for risks with non-constant probabilities of occurrence, such as those affected by the implementation of mitigation strategies, or those worsening over time, such as those affected by increased wear and tear or fatigue). Reporting expected future losses for multiple periods of exposure (to include, perhaps, the entire lifecycle of the fleet) is an acceptable practice.

Step 2 – Determine the expected number of future mishaps due to the risk. For hazard rates expected to be constant over the appropriate period of exposure, find the expected number of mishap occurrences by multiplying the FH (or sorties) to be flown during the period of exposure by the hazard rate (i.e., frequency expressed as "per FH" or "per sortie"). (If frequency was reported "per 100K FH" or "per 100K sorties," divide by 100,000 to convert to a frequency "per FH" or "per sortie.")

For hazard rates not expected to be constant over the period of exposure, the expected number of future mishaps is determined by integration (or numerical integration) of either the hazard function or the probability density function.

NOTE: Integration of the hazard function implies that spare components of the type for which the SSRA is written are available (i.e., replacement of components means the population of components does not diminish with failures). Integration of the probability density function (or, equivalently, evaluating the cumulative distribution function) to determine the proportion of the population expected to fail and multiplying by the number of components in the inventory implies that failed components will not be replaced (i.e., the non-replacement of components implies the population of components diminishes with failures, and therefore the cumulative distribution function, representing the accumulated life of the entire population, is followed). These methods will likely not yield vastly different results, and the difference will be further blurred if a fixed number of spare components are available, but no more.

Step 3 – Determine the expected future loss due to the risk. To find the expected future loss for the period of exposure, multiply the expected future mishap occurrences determined in Step 2 by the expected cost per mishap (as defined when determining the mishap severity). The cost per mishap may be expressed as loss of life, loss of aircraft, monetary loss, or some combination of the three (or other loss type, such as environmental loss). The expected future loss will be reported for the appropriate period of exposure for all likely result types (i.e., report expected loss of life, loss of aircraft, and monetary loss, as applicable).