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GUIDANCE FOR CLASSIFICATION AND ANALYSIS OF DEPENDABILITY EVENTS

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NORTH ATLANTIC TREATY ORGANIZATION

ALLIED DEPENDABILITY MANAGEMENT PUBLICATION

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NATO LETTER OF PROMULGATION

4 May 2022

1. The enclosed Allied Dependability Management Publication ADMP-03, Edition A, version 1, GUIDANCE FOR CLASSIFICATION AND ANALYSIS OF DEPENDABILITY EVENTS, which has been approved by the nations in the LIFE CYCLE MANAGEMENT GROUP (AC/327 LCMG) is promulgated herewith. The recommendation of nations to use this publication is recorded in STANREC 4174.

2. ADMP-03, Edition A, version 1, is effective upon receipt.

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4. This publication shall be handled in accordance with C-M(2002)60.

Dimitrios SIGOULAKIS
Major General, GRC (A)
Director, NATO Standardization Office

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CHAPTER 1 INTRODUCTION

1.1. GENERAL

1. Dependability is a key characteristic of all items[1], having a direct impact on mission performance and thus mission success. The dependability characteristics of any item are inherent in its design; thus, dependability should be considered from the very beginning of the pre-concept stage and be continued, in a disciplined manner, throughout the whole life cycle by the implementation of dependability disciplines as described in the IEC 60300 series standards referenced at Section 1.4 in this document.

2. Dependability is the collective term describing the continued and safe operation of any simple or complex item. The factors that influence the dependability performance of any item are reliability, maintainability, availability, testability, maintenance, and safety. In most items reliability and maintainability are the key performance characteristics of interest as they have a direct impact on mission success, but when considering life cycle cost testability should also be considered. The logistic and maintenance strategy of the item are mainly external, but can have significant impact on its availability performance, as it reflects the ability to provide the necessary resources to implement optimised maintenance procedures developed and refined through the life cycle of the item.

3. In the same way as all other performance characteristics defined in procurement specifications, those relating to dependability need to be properly researched and considered in order that they can be specified in a coherent way, that can be assessed by analyses and / or measured to give assurance that when the item is accepted into service the required levels will be achieved. Further, once the item is in service, it is necessary to assure that the inherent levels of dependability as specified in the requirements and proven at qualification continue to be achieved while in use.

4. The primary challenges are:

   a. to be able to quickly identify and correct technical problems that cause levels of dependability performance to deteriorate relative to requirements; and

   b. to ensure dependability is appropriately factored into changes in design, support, operating environment and procedures that will arise over an item's life cycle.

5. This requires a continuous process of collecting data from testing, operations and maintenance, analysing the data to extract information about dependability performance, and when required, making decisions for sustaining dependability performance and optimising life cycle cost. To develop this information, it is necessary to conduct an analysis and review of the data to identify those data points that are appropriate for the decisions that need to be made.

[1] Item includes systems, equipment, be it hardware or software based, and services.

1.2. PURPOSE

1. The purpose of this document is to provide a standardised review and classification system for event data, collected during a period of interest, and to give guidance on how the classified data can be analysed to support claims in respect of the dependability requirements.

2. It is not intended that this document will cover the levels and types of staff required at classification meetings, analysis techniques for the classified data or provide a template from which a functional breakdown and failure definitions can simply be selected, nor can it give a step by step guide to cover every eventuality. It will consider in Annexes 2 and 3 the concepts, issues and factors that influence how failure definitions can be developed and how functional breakdown can be undertaken, whilst the main document will give guidance on how dependability events can be classified.

3. This document supports ADMP-01 and ADMP-02, as the event classification process may be implemented at any phase of the life cycle i.e. during development production, utilization and support phases.

1.3. APPLICABILITY

1. This document applies to dependability activities of all items procured for military use within NATO Nations when there is a need to assess the performance of an item from a dependability perspective, or to make decisions based on data collected during testing, operations and maintenance at all phases of the life cycle.

2. It should be used by all members of projects and in-service organizations, including the various NATO Agencies, who are responsible for dependability.

1.4. NORMATIVE REFERENCES

A. ADMP-01 (B)(1) Guidance for Developing Dependability Requirements

B. ADMP-02 (B)(1) Guidance for Managing Dependability In-Service

C. AECTP-100 Ed 4 Environmental Guidelines for Defence Materiel

D. AOP-15 - Guidance on the Assessment of the Safety and Suitability for Service of Non-Nuclear Munitions for NATO Armed Forces

E. IEC 60300-1:2014 Ed 3 Dependability management - Part 1: Guidance for management and application

F. IEC 60605-4:2001 Statistical Procedures for Exponential Distribution - Point Estimates, Confidence Intervals, Prediction Intervals and Tolerance Intervals

G. IEC 60812:2018 - Analysis techniques for system reliability - Procedure for failure mode and effects analysis (FMEA)

H. IEC 61164:2004 Reliability Growth - Statistical Test and Estimation Methods

I. IEC 62740:2015 Root cause analysis (RCA)

J. ISO/IEC 15288:2015 - Systems & software engineering — System life cycle processes

K. MIL-HDBK-189C - Reliability growth management – Notice 1 - 2016/03/08

CHAPTER 2 CLASSIFICATION OF DEPENDABILITY EVENTS

2.1. GENERAL

1. During trials, testing or in service use it is inevitable that events will occur which lead to some sort of deficiency report being raised against the item of interest, each one being a potential information source for inclusion in an analysis to understand its dependability attributes. This process is commonly known as event classification, failure consequence classification or incident sentencing. This document will use the term event classification for consistency.

2. As the event classification process may be implemented at any phase of the life cycle (Development, Production, Utilization and Support) it could not be integrated in ADMP-01 or ADMP-02 thus this bespoke document has been developed to cover the subject.

3. In order to undertake event classification, it will be necessary to have access to the Mission or Usage profile, referred to in NATO documents as the Life Cycle Environment Profile, a functional breakdown and the failure definitions that were derived when the requirements for the item of interest were being set. It is important to note that, once agreed, the Life Cycle Environment Profile and the failure definitions should remain unchanged throughout the life of the project to ensure that all analyses are undertaken against a common baseline. For the remainder of this document the NATO term of Life Cycle Environment Profile will be used.

4. Whilst there are text books and 'standard like documents' available to assist with development of all these artefacts, Annex A of this document provides additional information on Life Cycle Environment profiles, Annex B provides further information on developing Failure Definitions whilst Annexes C, D and E discuss approaches to achieving functional and physical breakdown with Annex F giving a detailed example of how the output of this could look.

5. Event classification should be established with all stakeholders: design authority, procurement agency, safety officer, and users (maintenance & operations). It should be recognised that the various stakeholders may have different point of views about the event classification, which should be based on an in-depth technical analysis of all the information available, thus at times it will be necessary to accept a consensus view.

6. If the cause of the event is not readily apparent then technical analysis may be supported by Root Cause Analysis which includes equipment teardown, radiography, software inspection, data logger analysis, simulations etc. IEC 62740 contains further information on root cause analysis.

7. The following sections of chapter 2 will provide a process which, if followed, will result in a repeatable classification of any event. This process is represented 'graphically' in figure 1 below.

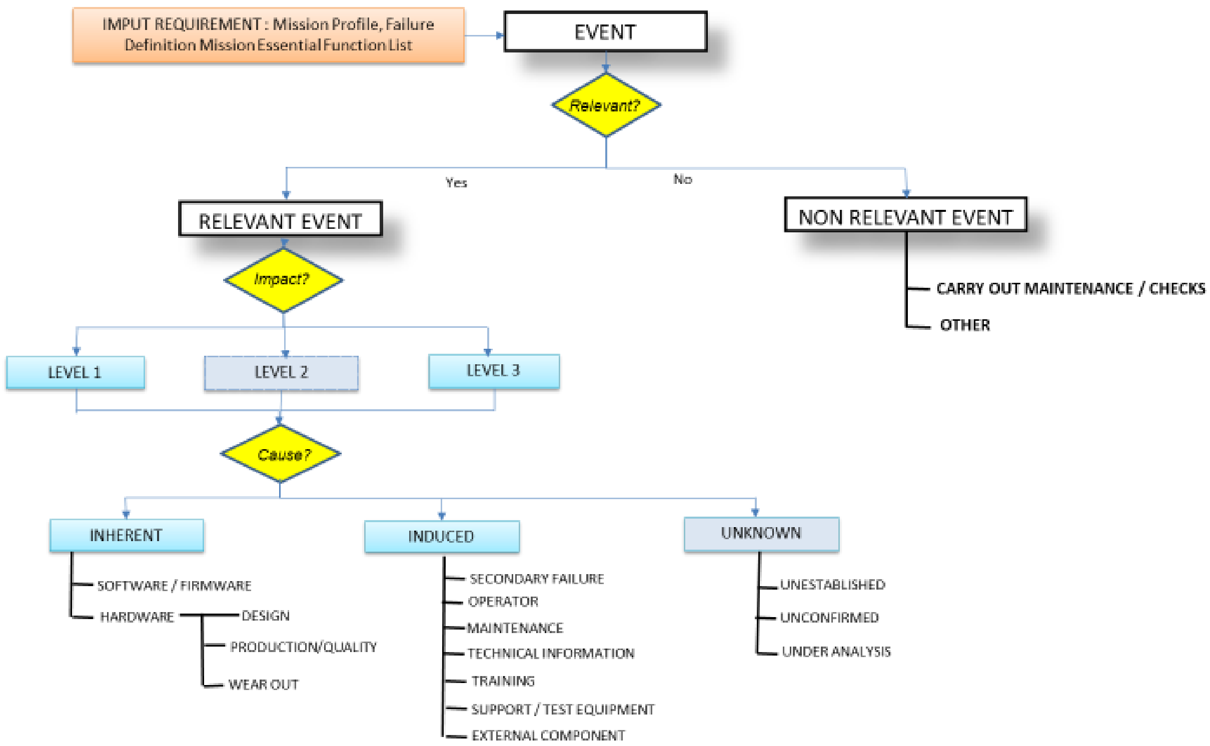

FIGURE 1: EVENT CLASSIFICATION

2.2. RELEVANCE OF THE EVENT

1. In this document relevance of an event is related to reliability, availability, maintainability, testability and safety assessments.

2. The first step in any review is to understand if the reported event is relevant to the assessment being undertaken. There is no simple rule that defines which events will be relevant to the assessment, their inclusion being highly dependent on the analysis that is being performed.

3. If the data being assessed is specific to a test, and the reported event is unrelated to that test, it is likely that the event would be discounted from the analysis. As an example, the reliability of an Armoured Fighting Vehicle is being established through a Qualification Trial when a tree is blown down directly in front of the moving vehicle causing damage to the front end. This event would not be included in the assessment of reliability as its cause was outside the scope of the trial.

4. If however it could be shown that the vehicles distance from the tree, and its speed at the time it fell was such that the operation of the brakes should have prevented impact, or that the specification required the vehicle to be able to sustain that level of impact without interruption to its progress, then the event would need to be included in the analysis.

5. It is not uncommon for recorded events to be caused by outside influences such as falling objects, lightning strike, power fluctuations or accidents wholly caused by 3rd parties. These types of events will not be included in the analysis and should be recorded against the 'non-relevant – other category'.

6. The configuration of an item may also need to be checked / reviewed to ensure that the configuration of the item on which the event was reported is representative of the final configuration.

7. Every event within the data set will need to be reviewed and agreed by all the stakeholders as being relevant to the assessment before any further classification work is undertaken. It should be noted that subsequent detailed investigation of an event could result in a change to this assessment, removing an event previously thought to be relevant or bringing in an event that was previously thought not to be relevant.

2.3. IMPACT OF THE EVENT

1. Having established that an event is to be included in the assessment it is then necessary to consider the impact it had on the ability of the item to perform as required, this being dependent on the previously identified failure definitions, as described in Annex 2, which will lead to the agreement of a level of failure.

2. For the purposes of this document the generic terms Level 1, Level 2, Level 3 and Level 4 will be used to describe failure, with Level 1 being the most severe, and Level's 2 to 4 having reducing levels of severity.

3. When making the level assessment consideration needs to be given to the overall objective of the item at the time, or sometimes the most severe consequence of that event occurring over the whole Life Cycle Environment profile. For example:

   a. The effect of an event occurring during training should consider the immediate effect on that training profile and / or the effect it would have had during combat. So, for an Armoured Fighting Vehicle undertaking live firing training, the inability to fire ammunition should be considered as a level 1 failure even if training continues in a different form. Similarly, if that same vehicle is conducting manoeuvre training when the inability to fire becomes apparent this could be considered as either a low level failure as it had no effect on the training or, more likely, it could be considered as a level 1 failure because it would have unacceptable consequences during combat.

   b. Where items are required to be kept in long term storage, the effect of an event being detected during storage should be considered during all phases of the life profile. So, for a missile which has a reported event that was discovered during storage, the impact on its successful operation needs to be considered when assessing the level of failure, not just the immediate impact to it whilst in storage.

4. The safety and environmental consequence of an event could also have a significant impact on this assessment. For example, a minor fuel leak that has no mission effect could have an unacceptable environmental or safety impact in which case the minor fuel leak should be considered as level 1 failure. Also, if an event concerns a safety-related component or function that is redundant, the failure could be considered level 1 as whilst it may be acceptable to complete the current assigned mission, it may be not be acceptable to start a further mission until a maintenance activity has been undertaken.

5. Some events can be recovered by the user, these typically being item reboots, hardware jams, flat tyres etc. If the user can recover from the event with on-board spares or tools and is authorised so to do, without significant impact to the mission, then the event may be classified at a lower level than if correction was not possible. However, this practice must be carefully

considered, because the frequency of these type of events may be unacceptable, the event may occur at a critical moment (such as during a combat situation) or where the occurrence is not acceptable regardless of how quickly it can be recovered. If the failure criterion includes an allowance for user repairable events, it must also carefully specify the allowable times, frequencies, conditions, and may only apply to certain functions, or specifically exclude certain essential functions.

2.4. CAUSE OF THE EVENT

1. Once a level of failure has been assigned it will then be necessary to review the evidence available to understand the cause of the event, the outcomes for this normally indicating if it is inherent to the items design or induced by external influences.

2. An event that is considered to be inherent is defined as one where the item is incapable of withstanding the levels of stress it encounters during its normal mode(s) of operation. So, if an event on an Armored Fighting Vehicle reported suspension damage, and this was concluded to have occurred whilst the vehicle was travelling on a primary road at or below the required speed, this would most likely be classified as an in inherent event as the suspension was unable to withstand the normal levels of stress encountered during routine operation.

3. An event that is considered to be induced is defined as one where the initiation of the event was caused by an external influence. So, if the reported suspension event on the Armored Fighting Vehicle was concluded to be as a result of the user driving too fast over rough terrain, this would most likely be classified as an induced event due to user error. Similarly, if the damage was concluded to be as a result of a previous maintenance action on the suspension not being conducted correctly, this would most likely be classified as a maintenance induced error.

4. Having established that an event is either inherent to the design or induced by external factors, it is then necessary to further investigate that event to understand its root cause and what action could to be taken to prevent it from recurring in the future, should that be necessary.

5. As shown in Figure 1, for inherent events classification is restricted to understanding if the root cause is related to the hardware or the software used in the design of the item.

6. If the cause can be shown to be a hardware related then it is usual to classify this further by the use of the following 3 categories.

a. Design: An event that has occurred where the item of interest is being used within its design intent, but a component part is not capable of withstanding the stress and strain of normal operation. The Armoured Fighting Vehicle example identified at paragraph 2.4.2 above would fall into this category as it was unable to withstand the expected usage.

b. Production / Quality: An event that has occurred where a component part has failed due to a non-conformance of the manufactured item with its design specification. If it could be shown that the failed suspension component of the Armoured Fighting Vehicle example identified at paragraph 2.4.2 above had not been manufactured to the required specification then it would fall into this category.

c. Wear Out: The item has suffered from wear which was either not anticipated or has occurred earlier than anticipated. The brake pads on any vehicle will be subject to wear and thus need routine replacement to ensure the braking function is not compromised. If during normal usage it becomes apparent that the brake pads need to be replaced twice as often as anticipated, then any reported replacement event would fall into this category.

7. Care needs to be taken when considering items that fall under the production / quality category above to ensure the correct classification is achieved. As stated above, a component part that has failed as a result of not being manufactured in accordance with its design specification will clearly fall in the production / quality category; however a failed component correctly manufactured to an incorrect specification should be recorded against the design category.

8. Any event that can be shown to have been caused purely as a result of an issue with the software, e.g. an error in the way the software was coded, a result of stack overflow or non-clearance of memory, should be classified under the software category.

9. As shown in Figure 1, for induced events there are more categories that need to be considered to fully understand the cause of the event.

a. Secondary Failure – An event would be considered a secondary failure when the failure of a component occurs due to abnormal stresses being applied as a result of an issue elsewhere in the item of interest. A voltage regulator failure in an item could result in higher than expected voltage being applied to multiple sub components, causing each of those sub components significant damage. For the purposes of event classification, assuming that the failure of the voltage regulator was inherent to the design, it would be recorded against the design but failures to the subcomponents would be recorded as secondary events i.e. they were wholly caused by the failure of the regulator.

b. Operator Error – An event where the item failure is directly caused by the operator not using it in accordance with the user documentation or operating it outside of its design specification. As illustrated at 2.4.3 above, an event caused by an Armoured Fighting Vehicle being driven too fast over rough terrain would be recorded as Operator Error. Note that Operator Error can also be covered by use of the term ‘outside specification’ as exceedance of the design specification is often directly attributable to the operator.

c. Maintenance Error – An event where the item failure is directly caused by a maintenance activity that was incorrectly carried out prior to the event occurring. A brake failure event during operation is recorded for an Armoured Fighting Vehicle. Investigation finds that the failure is a result of air in the braking system, and that the front nearside brake calliper had been subject to maintenance prior to use. Further investigation reveals it is highly likely that the braking system was not bled in accordance with the technical publication following that maintenance, thus this event would be recorded as maintenance error.

d. Technical Information – An event caused by the user following the guidance provided in the documentation, but the guidance being incorrect. While investigating the brake failure described at c above, it is found that the maintenance manual does not instruct the maintainer to bleed the braking following the work undertaken on the brake calliper, thus the event would be recorded as technical information error.

e. Training – An event caused by the training given to the user or maintainer being incorrect or inadequate. A number of events have been reported stating that it has not been possible to start up a mobile network, and that in these cases the same error code of “Required frequency band is unavailable” has been recorded. Investigation finds the items to be fully functional, but that during operational training the users have not been informed of the correct start up sequence, thus this event would be recorded as an error in training.

f. Support & Test Equipment – An event caused by use of the supplied support & test equipment which is not suitable for the job or by the use of incorrect support & test equipment.

g. External Component– An event caused by a component that is outside of the agreed boundary of the equipment.

10. On some occasions, even after in depth technical analysis is completed, it is not possible to unambiguously identify the cause of the event, thus it remains unknown.

a. An engine management system warning light has displayed to, and been reported by, the user during an operation. During following operations, and when under test to determine the cause of the event, even where the usage is similar to, or the same as, when it originally occurred the event does not recur. As the engine management system is effectively reset every time the vehicle is switched off, it is probable that information relating to the incident will not be available, thus technical analysis of the event is not possible. When these cases occur then the cause can be recorded as “unconfirmed” i.e. the reported failure was unable to be repeated during any test.

b. An electronic ‘black box’ fitted to a vehicle has been identified as the cause of an event. A replacement ‘black box’ has been fitted to the vehicle which is now back in use and operating correctly. Despite extensive work, expertise was unable to identify a single root cause for the event. When these cases occur then the cause can be recorded as “unestablished” i.e. expertise was not able to isolate a single root cause for the event.

11. The “unconfirmed” and “unestablished” categories should only be used when all routes of investigation have been exhausted and with full agreement of all stakeholders.

12. In both of these cases it is often suggested that the event is recorded as a random failure, but this is not recommended. All events have a deterministic cause but on some occasions the data and the analysis techniques available are not sufficient to identify exactly what has occurred.

13. If a formal review is being undertaken and some of the analysis work is not complete, then a classification of “Under Analysis” can be used to describe the event until such time as the formal analysis is complete.

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CHAPTER 3 ANALYSIS

3.1. GENERAL

1. Once event data classification has taken place in accordance with the methodologies stated in chapter 2, data analysis can take place to estimate the required dependability characteristic(s) of the item of interest and to support data driven decision making. Data analysis relies on dependability events classification, as described in paragraph 2 of this document, and the data collection process (usage and failure data) as described in ADMP-02 (§ 3.3).

2. Before dependability analysis is undertaken any rules relevant to the assessment being undertaken should be established and agreed with all stakeholders. For example, the same event may occur several times on one item or on several items. If the analysis being undertaken relates to inherent reliability a common practice is to record only one failure against all the events on the condition that a corrective action has been identified and implemented. If however the analysis relates to an operational reliability, all the events that occurred must be counted in the assessment.

3. The final goals of dependability classification and analysis may be:

   a. To assess the effectiveness of fixes during reliability growth tests.

   b. To confirm if the dependability requirements e.g. availability, reliability, maintainability, etc., as specified in the contract, have been met.

   c. To compare achieved levels of availability, reliability and / or maintainability during operational life with the levels predicted during acquisition phase.

   d. To understand trends in availability, reliability and / or maintainability over a period of time.

   e. To estimate the availability, reliability and / or maintainability characteristics of the item.

4. In addition to the quantitative assessments described in this document, qualitative assessments can also be performed. Examples of qualitative assessments include: design maturity assessments (completion and quality of design activities such as failure modes and effects analysis, fault tree analysis, etc.), identifying and implementing fixes to improve dependability, risk assessments, and subject matter expert assessments. Qualitative assessments are also used when a dependability requirement is more qualitative than quantitative. Some maintainability requirements are more qualitative in nature, such as only allowing a set of standard tools (or limiting special/unique tools), using common fastener types, as well as human factors-related considerations (accessibility, maintainer skill level, etc.). These qualitative requirements may be assessed via physical/virtual mock-ups, design reviews, etc.

5. It is recognised that the most common analyses relate to the reliability of an item thus further information relating to reliability is provided in the following sections.

3.2. RELIABILITY METRICS

1. Various reliability metrics can be assessed using the classified event data. Reliability metrics can differ based on the types of failure they encompass, the following being a few of the more common metric types.

2. Reliability metrics based on the severity of the event include:

Mission Reliability – A measure of item reliability including only those failures which render the item inoperable or non-mission worthy.

Mission reliability often includes only Level 1 failures, although the definition may be modified as desired, e.g., to include degrading (Level 2) failures.

Basic Reliability – A measure of item reliability reflecting the overall failure rate of the item.

Basic reliability includes all levels of failure to properly reflect the total failure frequency of the item. For example, an item experiences five (5) Level 1 failures, ten (10) Level 2 failures, and twenty (20) Level 3 failures, the calculation of basic reliability will include all 35 failures.

3. Reliability metrics based on the cause of the event include:

Operational Reliability – A measure of item reliability that encompasses the inherent causes (hardware, software/firmware) and induced causes (typical operators and maintainers, technical information, training, support/test equipment, and other external components).

Operational reliability reflects actual reliability experienced by the user under fielded conditions.

Inherent Reliability – A measure of item reliability that encompasses the design, manufacturing, quality and wear outs of hardware and software.

Inherent reliability is often used to measure contractor's performance.

Note: Depending on the terms of the contract, the reliability can include other causes such as technical information, support/test equipment as well as inherent causes.

4. The reliability metrics described above can be combined. For example, a user requirements document may have Operational Mission Reliability and Operational Basic reliability requirements, while a contractual specification may have Inherent Mission Reliability and Inherent Basic Reliability requirements.

5. During the utilization phase, the Effective Life Cycle Environment Profile may be temporarily significantly different from what was predicted, thus failure rates derived from observed data cannot always be directly compared to the system level requirement e.g. training instead of combat. In such a case the observed reliability data must be introduced into the system reliability model based on the original predicted Life Cycle Environment Profile so as to compare predicted and observed system level reliability performance. One should be aware that comparing estimated reliability with a requirement is a tricky exercise. Magnitudes should be compared rather than precise values

6. When considering the duration to take into account in reliability assessments, only the time before the last test was undertaken should be included for storage and operation duration

assessments otherwise there is a risk that the assessment will be optimistic as there may be failures during period since the last test that are unknown. This point particularly applies to systems (such as missiles) whose usage profiles contain long storage phases.

3.3. CONFIDENCE INTERVAL DEFINITION AND ILLUSTRATION

1. Having established which events are relevant to the reliability metric of interest, a calculation can be performed to derive a reliability value.

2. Whilst a point value can be compared against a requirement to ascertain a pass / fail result, it may be necessary to derive a level of confidence associated with the value. The confidence level is a measure of how repeatable the result is likely to be and is best explained by considering a test that is repeated many times. If the result of the test is the same most of the time, then confidence in the result will be high, but if the result fluctuates widely then confidence in that result will be low. Confidence Intervals may vary according to the assessment, 90% for example being common for safety.

3. When considering reliability data, it is normally considered that the more failures recorded, the higher the level of confidence in the result can be. As an example, if 4 failures have occurred in 100 hours of operation then a point estimate for reliability of 25 hours can be calculated. Confidence in this result will be low as there are not many data points and a single outlier can have a significant effect on the result. Conversely if 400 failures have occurred in 10,000 hours then confidence in the point estimate of 25 hours will be higher as the effect of one or two outliers on the result will be negligible. More information relating to confidence intervals can be found in IEC 61164.

4. It is also important to recognize that whilst simply deriving a point value will give a measure, it does not give a full picture of the reliability of the equipment and more work may be required. To gain more knowledge it is recommended that the data is reviewed and split into blocks, the reliability of each block is calculated and then plotted to look for trends e.g. is the reliability increasing, decreasing or remaining constant. The blocks of data may be based on functional and technical breakdown, calendar time, distance travelled, grouping together higher and lower usage items or items of a similar age and it may be beneficial to try several groupings to gain a good understanding of the reliability. These block analyses may contribute to event classification as it may highlight premature wear out failures, design defect (when items facing a specific environment systematically fail), or manufacturing defect (when items from the same manufacturing batch fail).

3.4. RELIABILITY METRIC ASSESSMENT AND RELIABILITY TEST TYPES

1. Two of the more common types of reliability test are Reliability Verification Tests and Reliability Growth Tests, where Reliability Qualification Test (RQT) and Production Reliability Acceptance Test (PRAT) are examples of Reliability Verification Tests. The following paragraphs provide details on these two types of reliability tests, including how Reliability Growth Tests can be further categorized based on the timing of fixes.

2. **Reliability Verification Test.** Reliability verification tests are conducted to measure the reliability of the system and verify compliance against requirements. The philosophy of a Reliability Verification Test is to use event data to reach statistically valid decisions regarding whether an item has achieved its specified reliability or not (that is, it is either accepted or rejected). In this context, surfacing too many events in a Reliability Verification Test could

ultimately lead to a rejection decision. Fixes are typically not implemented during these types of tests. Reliability metrics such as mean time (kilometres, etc.) between failures (MTBF) are calculated by simply dividing the test length by the number of failures. Confidence intervals, as described in section 3.3 above, are often calculated using the chi-squared distribution to account for the uncertainty with reliability test results. RQT should be carried out according to qualification plan agreed by the customer and the supplier on a system representative of the serial production and undergoing combat mission.

3. **Reliability Growth Test**. Reliability Growth Tests are conducted to both estimate the reliability of the system and to improve reliability by implementing fixes. The philosophy of a Reliability Growth Test is to use test and event data to identify and fix root failure causes, thereby improving the inherent reliability of the item. With respect to Reliability Growth Tests, surfacing events is encouraged because it is only through the mitigation of those events that reliability growth can occur. Events are analysed down to root failure cause, fixes are implemented, and design or process modifications are tested to verify the effectiveness of the fixes. A Fix Effectiveness Factor (FEF) is the fraction reduction in failure rate after implementation of a fix. For example, an FEF of 0.70 means that 70% of the initial failure rate has been addressed by the fix. Reliability can be assessed by applying FEFs and/or by using the reliability growth models identified in the following paragraphs. Reliability Growth Testing can be categorized into three different approaches, each of which depends on the timing of fix implementation.

a. **Test-Analyse-Fix-Test (TAFT)** is used during reliability growth tests to identify events and implement fixes to address them. In this test approach, testing is stopped when an event is identified and testing only resumes once a fix has been implemented. Reliability tracking models are used to estimate reliability for these types of tests as the models are able to account for the impact of fixes implemented during testing. In addition to estimating the demonstrated reliability from testing, reliability tracking models can also identify if reliability is increasing over time and at what rate. The U.S. Department of Defence Handbook on Reliability Growth Management (MIL-HDBK-189C) details the use of reliability tracking models.

b. **Test-Find-Test (TFT)** is when fixes are not implemented during the test and instead are delayed until testing has been completed. As tracking models leverage fixes during testing and all fixes are delayed in this scenario, reliability projection models should be used instead. Reliability projections are an assessment of reliability at a future point in time. Several reliability projection models developed by the U.S. Army Materiel System Analysis Activity (AMSAA) are used to estimate reliability for these types of tests as they are able to account for fixes implemented after testing. The AMSAA-Crow Projection Model (ACPM), AMSAA Maturity Projection Model based on Stein Estimation (AMPM-Stein), and the AMSAA Discrete Projection Model based on Stein Estimation (ADPM-Stein) can be used in this scenario. See MIL-HDBK-189C for details on these projection models.

c. **Test-Analyse-Fix-Test (TAFT)** with Delayed Fixes is a combination of the two previous approaches. In this case, some fixes are implemented during the test, while the remaining fixes are delayed until testing has been completed. Projection models that can differentiate between fixes implemented during test and fixes implemented after test are used to estimate reliability in this scenario. Such models include the Crow Extended Reliability Projection Model and the AMSAA Maturity Projection Model (AMPM). MIL-HDBK-189C details the use of these projection models.

3.5. OTHER DEPENDABILITY METRICS ASSESSMENT

1. As described in section 1 of this document, Dependability is the collective term describing the continued and safe operation of any simple or complex item. Dependability requirements correspond to system level performances, the factors that influence the dependability performance of any item being reliability, maintainability, availability, testability, maintenance, and safety as well as life cycle environment profile, failure rates and fault coverage (cf. ADMP-01 / §3.4.6.a).

2. This document mainly focuses on classification from a reliability perspective; nonetheless, it can be useful to deal also with other dependability and safety performances. For example:

a. The process may be used to identify events that are suitable for including in a maintainability analysis. Classification of maintainability events often involves identifying where or at what “level” the maintenance takes place. For example, a two-level maintenance system may have separate metrics for field level and sustainment level maintenance, thus the data will need to be classified for that specific analysis. Similarly, consideration should also be given to whether the event involved unscheduled, scheduled, or condition-based maintenance, as various maintainability metrics may or may not include each type of maintenance.

b. Testability considerations when classifying events include built in test (BIT)/built in test equipment (BITE) false alarms, detection failures/successes, and isolation failures/successes (isolating the event to the correct subsystem/part/etc.). Detection failures/successes and isolation failures/successes only apply when the BIT/BITE was designed to detect/isolate the particular event.

c. Availability is a function of the item’s reliability and maintainability, along with logistics delays. Therefore, the methodologies used to classify reliability and maintainability events will support availability assessments.

d. Safety demonstrations conducted during the acquisition phases rely on a specific Life Cycle Environment Profile and the reliability data of components involved in safety. It is essential to ensure that the achieved levels of reliability for safety related components do not invalidate the initial safety case. For example, if a fault tree basic event failure rate is higher than initially predicted, the safety case has to be updated.

ANNEX A LIFE CYCLE ENVIRONMENT PROFILES

All military items are procured to undertake a specific task or tasks, those tasks being detailed in a Life Cycle Environment Profile, which is often referred to as a Usage or Mission Profile. This document details how the item is expected to be used and is developed from current or previous experience, or a predicted pattern based on future expectation.

However the anticipated usage is derived, it should include for each phase of the life cycle from production to retirement:

1 **Time Required** – How long the item is required to be in a fully operational state, a lower level or stand by state or a non-operational state during the defined period of interest.

2 **Number of Repetitions** – In some circumstances it may be preferable to define usage in terms of a single “operation” coupled with the number of times that “operation” is required to be repeated during the period of interest e.g. a 2-hour flight for an air vehicle which needs to be capable of being repeated 4 times during a 24-hour period with a minimum time between repetitions of half an hour.

3 **Environment** – The physical conditions that the item is expected to encounter e.g. temperature, humidity, and air contaminants.

4 **Terrain** – The natural features that the item is expected to traverse during operation e.g. metalled road, ‘off road’, sea state, salinity. It is important to note that where no recognised definitions of the features exist, for example ‘off road’, additional information will be needed to define and bound those conditions.

More information on the Life Cycle Environment Profile can be found in Chapter 2 of ADMP-01 and AECTP-100.

ANNEX B FAILURE DEFINITION

1 During the early phases of a project it is normal to consider when an item no longer meets the requirement set for it, i.e. its failure definitions. This is done through the definition of the point(s) when the item is considered to be in a degraded state and the point at which the item is considered to have no further military worth until a maintenance action is undertaken to restore functionality.

2 Detailed failure definition is supported by the system functional analysis. A number of functional analysis methodologies exist; Annex C proposes a methodology based on the concept of using essential functions and clarifying questions to define Acceptable Performance Levels (APLs).

3 Failure can be quantified at a number of different levels, the most common being 2 or 3 but occasionally up to 4 as shown in Table 1 below, where failures with the most severe impact are on the left:

4 It is normal to assign descriptors to each level, examples being critical, major and minor or System Abort, Essential Function Failure and Non Essential Function failure for a 3-level definition, mission and basic or Essential Function Failure and Non Essential Function for a 2-level system, noting that each organisation will usually have their own preferred set.

5 An essential function is defined as the fundamental description of the primary operations the item of interest must be capable of performing (e.g. Move, Shoot, Communicate) and are derived from the requirements document. Specific threshold requirements such as speed, accuracy, range etc. are used to clarify the performance levels of those functions.

6 Essential Functions vary from system to system but can be common across equipment types and / or military domains e.g. all military vehicles need to be capable of moving and communicating whether they are being used by Army, Navy or Airforce personnel so it is often possible to gain inspiration from examples that already exist rather than start from a clean sheet of paper.

7 Some examples of possible descriptors are included in table 1.

	LEVEL 1	**LEVEL 2**	**LEVEL 3**	**LEVEL 4**
Reliability Category				
	Critical	Major	Minor	
	Mission Completion	Mission Degraded Performance	Basic: Logistics, Sustainability, Maintenance Manpower	
	System Abort	Essential Function Failure	Non-Essential Function Failure	
	Essential Function Failure		Non-Essential Function Failure	
	Mission		Basic	
Safety Hazard Level (cf. AOP-15)	Catastrophic	Critical	Marginal	Negligible
Reliability &Safety	Catastrophic	Mission Completion	Mission Degraded Performance	Basic: Logistics, Sustainability, Maintenance Manpower

TABLE 1: Examples - Severity categories

8 Regardless of the number of levels chosen, which could be up to 10 in accordance with IEC 60812, it is necessary to define where the boundary between each level lies, noting that to minimise the need for interpretation hard values that can easily be measured e.g. incapable of achieving greater than 40 kph, are better than statements such as a 10% reduction in capability. Using more levels will require much more details to be included and can often lead difficulty in gaining the agreement of all interested parties.

9 It is important to note that, once agreed, the failure definitions should remain unchanged throughout the life of the project to ensure that all analyses are undertaken against a common baseline.

ANNEX C FUNCTIONAL ANALYSIS

1. During the early phases of a project, a functional analysis is needed to break an item down into smaller parts, called functional elements, that describe outputs the item is required to deliver, but not how that will be achieved in terms of detailed design.

2. If we consider any vehicle at a basic level, it needs to be capable of propelling itself in a forward or reverse direction, stopping within prescribed limits. This could be described in functional terms as the ability to move and the ability to stop.

3. According to "ISO/IEC 15288 - Systems and software engineering — System life cycle processes", "system requirements, functional and material architecture are defined iteratively and recursively to a system and its elements. Thus, the functional analysis is refined as the design matures."

4. The functional analysis, along with failure definitions, supports the classification process as events that occur in critical or essential functions will be classified differently to events that occur in non-critical or non-essential functions.

5. Many methods can be used to derive a functional analysis including IDEF0/SADT, APTE, Data Flow Diagram, State diagram, Harel state chart, time lines and SA-RT, but very few standards exist.

6. This annex proposes a methodology based on the concept of "essential function".

7. Once the list of Essential Functions is established, each of them can then be broken down further into sub functions by using an indentured decomposition tree that starts with one of the Essential Functions and is followed by clarifying questions, answers and Acceptable Performance Levels (APLs) as shown in Figure 2.

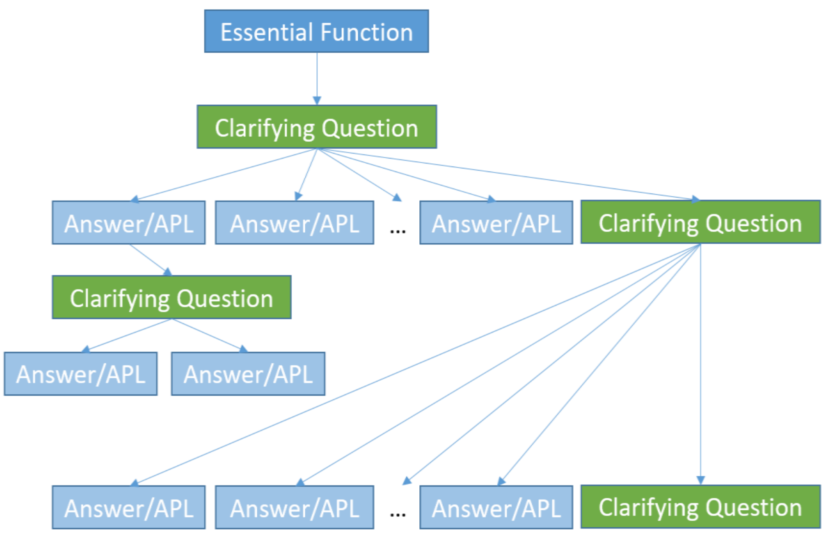

FIGURE 2: Generic Essential Function Decomposition Tree

ANNEX D FAILURE MODE IDENTIFICATION

1. Once the Essential Functions have been thoroughly broken down to the point where no further clarifying questions are necessary, APLs can be assigned along with the level of failure they correspond to.

2. Depending on circumstances, some APLs define a binary classification i.e. a level 1 failure or no failure whilst others define a classification spectrum where degradation leads to a level 2 or below failure, additional degradation having the potential to upgrade this to a level 1 failure. If we consider the ability of an item to move then one area for consideration is likely to be its ability to come to a controlled stop whilst another is likely to be the speed it can maintain.

a. The ability to come to a controlled stop (Braking APLs) is an area that will most likely lead to a binary classification type as typically, if it can stop within the required distance, then no failure has occurred but if it cannot stop in the required distance, it is most likely that a Level 1 failure has occurred.

b. The speed APLs however, are likely to be of the classification spectrum types. For movement on primary roads, if the item can move faster than 70 kph then no failure has occurred, however if the item is slightly degraded and can only travel at 60 kph, the incident leading to this degradation would most likely be of the Level 2 or below category. If the degraded state was more serious and the system could only move at 30 kph, the incident would most likely lead to a Level 1 failure.

3. The results of this decomposition of the various Essential Functions into APLs can be summarized in a matrix to define what types of situations should be considered Level 2 or below failures and which should be considered as Level 1 failures as shown in the following table.

INCIDENT DESCRIPTION (FUNCTIONAL DEGRADATION) RELATED TO THE MISSION ESSENTIAL FUNCTION (MEF) INDICATED	INCIDENT CLASSIFICATION			CONSIDERATIONS
	Level 1	Level 2	Level 3	
MEF (1) – Move. Clarifications to Move Function regarding acceptable degradation follow.				
• PRIMARY **BRAKING** SYSTEM (SERVICE BRAKES) NOT SERVICEABLE (I.E., ARE INOPERATIVE OR SEVERELY DEGRADED SO VEHICLE UNABLE TO STOP IN REQUIRED DISTANCE)	X			Safety implications may already dictate classification levels for loss of service brakes
• VEHICLE UNABLE TO SUSTAIN OPERATIONALLY ADEQUATELY FORWARD SPEED ON TRAILS TRAVELED DURING TYPICAL "IN THEATER" MISSION OPERATIONS •• SUSTAINED FORWARD SPEED LESS THAN 30 KPH	X			In this example, maintaining operational speed is a critical factor. Some degradation may be acceptable based on the distance needed to be traveled, the other capabilities performed by the system when it arrives at its destination, the terrain on which it is traveling, and the overall mission. Criteria may be based on average speeds over certain terrains.
•• SUSTAINED FORWARD SPEED IS LESS THAN 60 KPH BUT GREATER THAN 30 KPH		X		
•• SUSTAINED FORWARD SPEED IS LESS THAN 70 KPH BUT GREATER THAN 60 KPH			X	

TABLE 2. Populating Essential Function Decomposition with APLs

ANNEX E TRANSITION FROM FUNCTIONAL TO PHYSICAL FAILURES

1. The Essential Functions are initially described in terms of the functions and impacts to those functions which are either unacceptable (Level 1 failures), have acceptable degradation or workarounds (Level 2 failures), or which have no significant impact (Level 3, 4 failures).

2. As the item design matures, it is possible to begin associating specific hardware and software failure modes to the functional failure modes. It is not absolutely necessary to make this transition but using fully agreed physical failure modes removes some subjectivity and adds consistency to the event classification process. However, even with the most precise and comprehensive list of physical failure modes, it is likely that there will be cases where agreed-on physical failure mode results in a different level of failure under certain circumstances. It is equally difficult to take into account combinations of failures, e.g., a Level 3 alternator failure combined with a Level 3 battery failure resulting in an overall Level 1 or 2 failure.

3. A Failure Mode Effects Analysis (FMEA) is a highly recommended engineering tool for identifying potential failures in a system. When conducted early, properly, and comprehensively the FMEA identifies the failure modes which will lead to all failures and allows the designer to eliminate the most critical and/or most likely failure modes from the system. There are many references and tools available relating to performing FMEA including IEC 60812.

4. Some simple examples of the transition from Functional to Physical failures are shown in tables 3 and 4 below:

Move **Operate** **Provide fuel**	**Level 1**	**Level 2**	**Level 3**
Failure of Fuel Tank (rupture, major leakage)	**X**		
Failure of Fuel Pump (no fuel flow)	**X**		
Blockage of Fuel Filter	**X**		
Failure of Engine Control Unit	**X**		
Minor Fuel Leakage external to engine compartment*		**X**	
Fuel Gauge Inoperative		**X**	
Partial blockage of Fuel Filter (noticeable power loss)**		**X**	
Fuel Level Sensor Failure		**X**	
Fuel line fitting leakage (wetness around line/fittings)			**X**
Loss of low fuel alarm			**X**
Blockage of fuel filter (no power loss)			**X**
Fuel Gauge Inaccurate			**X**
* May cause Level 1 failure on environmental grounds **May cause Level 1 failure if required speeds cannot be maintained			

TABLE 3 Examples of functional to physical failure for fuel provision

Move Operate Engine cooling	Level 1	Level 2	Level 3
Engine Overheats	X		
Complete Failure of Engine Fan	X		
Coolant Hose Failure/Rupture	X		
Water Pump Fails	X		
Thermostat inoperative, stuck open/closed resulting in overheating	X		
Excessive Radiator Leakage (spray or steady stream)	X		
Water Pump Leakage (spray or steady stream)	X		
Clogging of Radiator	X		
Water Pump Drive Belt Severed or Off Pulleys	X		
Slow Water Pump Leak requiring Service after mission*		X	
Slow Coolant leak requiring Service after mission*		X	
Minor Cracks in Water Pump Fan Belt			X
Thermostat Inoperative, stuck open			X
Fan Duct/Housing Cracked or Damaged			X
Tripped Circuit Breaker that can be Reset			X
Minor fluid leaks which can be deferred indefinitely*			X
* May cause Level 1 failure on environmental grounds			

TABLE 4 Examples of functional to physical failure for engine cooling

5. A more detailed example of of the transition from Functional to Physical failures is shown in Annex F of this document covering the Move, Shoot, Communicate, Protect and Carry functions. It should be noted that, large as the annex may seem, this is only a small portion of what would be required for the whole vehicle and that its development will take significant effort in terms of man hours and calendar time.

ANNEX F COMBAT VEHICLE EXAMPLE X

INCIDENT DESCRIPTION (FUNCTIONAL DEGRADATION) RELATED TO MISSION ESSENTIAL FUNCTION (MEF)

INCIDENT DESCRIPTION (FUNCTIONAL DEGRADATION) RELATED TO THE MISSION ESSENTIAL FUNCTION (MEF) INDICATED	INCIDENT CLASSIFICATION			CONSIDERATIONS
	Level 1	Level 2	Level 3	
MEF (1) – Move. Clarifications to Move Function regarding acceptable degradation follow.				
• VEHICLE ENGINE WILL NOT START UNDER OWN POWER AND IS UNABLE TO BE SLAVE STARTED	X			Does vehicle operate alone or can it receive assistance in the event of difficulty starting? Considering can be given to the cause of the battery depletion. Is the system required to operate internal systems without engine running which may lead to depleted batteries? Or was it a malfunction which requires maintenance?
• VEHICLE ENGINE UNABLE TO START UNDER OWN POWER BUT CAN BE SLAVE STARTED •• INCIDENT CAUSED BY A MALFUNCTION OR DEGRADED EQUIPMENT CONDITION		X		
•• INCIDENT ATTRIBUTED TO EXCESSIVE BATTERY DRAINAGE (CAUSED BY EQUIPMENT USAGE WITH THE ENGINE POWERED-OFF)			X	
• VEHICLE UNABLE TO ADEQUATELY MOVE IN REVERSE ON TERRAIN ENCOUNTERED DURING MISSION OPERATIONS (PRIMARY/SECONDARY ROADS, TRAILS, CROSS-COUNTRY)	X			In this example, the ability to move in reverse is important. However, it is very unusual to have a failure which would impact only movement in reverse.
• VEHICLE UNABLE TO ADEQUATELY SUSTAIN FORWARD SPEED OF AT LEAST 45 KILOMETERS PER HOUR (KPH) ON IMPROVED ROADS DURING MISSION OPERATIONS (TYPICAL "IN THEATER" CONVOY SPEED)	X			In this example, maintaining convoy operations was a critical factor. Some degradation may be acceptable based on the distance needed to be traveled, the other capabilities performed by the system when it arrives at its destination, the terrain on which it is traveling, and the overall mission. Criteria may be based on average speeds over certain terrains. Instead of a specific speed, a percent degradation is often utilized.
• VEHICLE UNABLE TO SUSTAIN OPERATIONALLY ADEQUATE FORWARD SPEED ON TRAILS TRAVELED DURING TYPICAL "IN THEATER" MISSION OPERATIONS •• SUSTAINED FORWARD SPEED LESS THAN 15 KPH	X			
•• SUSTAINED FORWARD SPEED IS LESS THAN 30 KPH BUT GREATER THAN 15 KPH		X		

INCIDENT DESCRIPTION (FUNCTIONAL DEGRADATION) RELATED TO THE MISSION ESSENTIAL FUNCTION (MEF) INDICATED	INCIDENT CLASSIFICATION			CONSIDERATIONS
	Level 1	Level 2	Level 3	
• VEHICLE UNABLE TO ADEQUATELY TRAVERSE CROSS-COUNTRY TERRAIN (AT AN OPERATIONALLY SUITABLE RATE) WHEN ENCOUNTERED DURING MISSION OPERATIONS	X			This function could be impacted by many factors: engine power, suspension, crew comfort, ability to secure cargo, etc. This could be expanded to address specific concerns which may result in different scores
• VEHICLE ACCELERATION OBVIOUSLY DEGRADED DURING MISSION OPERATIONS (BUT VEHICLE CAN STILL ATTAIN AND SUSTAIN SPEEDS OF AT LEAST 15 KPH ON TRAILS AND 45 KPH ON IMPROVED ROADS)		X		Vague terms like "obvious degradation" are sometimes necessary but are disliked by contractors.
• VEHICLE LOSES POWER DURING FORDING OPERATIONS ("DROWNS OUT") •• CREW ABLE TO RESTART ENGINE AND RESUME OPERATION WITHIN 30 MINUTE CCMA TIME LIMIT			X	Careful when considering this a reliability problem. Unless this is due to a malfunction (e.g., loose fitting that allows water inside), the ability to ford is a performance issue.
•• CREW UNABLE TO CORRECT PROBLEM AND RESTART ENGINE WITHIN 30 MINUTES	X			
• VEHICLE POWER REDUCED DUE TO DIRTY ENGINE AIR FILTER (CREW CLEANING ACTION REQUIRED)			X	Ordinarily these considerations get added as classification conventions as they come up in testing. This could also be an on-condition maintenance action.
• VEHICLE CRUISING RANGE REDUCED TO LESS THAN 1½ TIMES THE DISTANCE TO THE OBJECTIVE (E.G., DUE TO FUEL LEAKAGE); VALUE OF 1½ REPRESENTS A SAFETY FACTOR TO ENSURE SUFFICIENT FUEL TO ACCOUNT FOR UNEXPECTED EVENTS	X			Usually a fuel leak large enough to have a noticeable effect on range would be considered a safety issue and be a system abort under safety criteria.
• SELF-RECOVERY WINCH (OR SNATCH BLOCK, AS/IF SO EQUIPPED) INOPERABLE		X		Failure of more infrequently utilized functions are often classified with lower criticality
• VEHICLE UNABLE TO FLAT-TOW "LIKE" VEHICLE •• BRAKE SYSTEM UNABLE TO MATE WITH TOWED VEHICLE (PROBLEM ATTRIBUTED TO TOWING VEHICLE AND NOT THE TOWED VEHICLE	X			Towing a like vehicle is an essential function, and the inability to tow does not impact the towing vehicle. There may be acceptable alternatives which do not prevent mission accomplishment. It is unlikely that this function will be fully evaluated during a normal RAM test event.
•• TOWING VEHICLE'S PROVISIONS TO ACCOMMODATE TOW BAR ARE DAMAGED AND UNSERVICEABLE				
•• TOWING VEHICLE POWER OUTPUT DEGRADED/REDUCED TO INADEQUATE LEVEL				

INCIDENT DESCRIPTION (FUNCTIONAL DEGRADATION) RELATED TO THE MISSION ESSENTIAL FUNCTION (MEF) INDICATED	INCIDENT CLASSIFICATION			CONSIDERATIONS
	Level 1	Level 2	Level 3	
• ONE OR MORE TIRES IN RUN-FLAT CONDITION •• TIRES FAIL PREMATURELY IN RUN-FLAT CONDITION	X			Although a required speed has been specified above, this separate sub-category recognizes the ability to continue with a run-flat. Good to address known redundancies when they exist within the system.
•• VEHICLE UNABLE TO TRAVEL TO OBJECTIVE DUE TO DISTANCE IN EXCESS OF RUN-FLAT CAPABILITY OR DUE TO MOVEMENT SPEEDS LESS THAN MISSION OPERATIONS DICTATE				
• ONE/TWO TIRES PUNCTURED BUT VEHICLE HAS TRAVELED TO THE OBJECTIVE IN RUN-FLAT CONDITION WITH NO CRITICAL ADVERSE IMPACT ON MISSION OPERATIONS (RUN-FLAT SPEED NOT A MAJOR DETRIMENT)		X		
• STEERING CAPABILITY LOST (CRITICAL COMPONENT IN STEERING LINKAGE FRACTURED/UNSERVICEABLE)	X			This SA criterion seems very obvious and is not necessary. It would be like stating "engine failure which prevents movement". But because detailed criteria were added for degraded steering it was included for completeness.
• STEERING ERRATIC / DIFFICULT (BUT CONTROLLABLE) •• WANDERING IN EITHER DIRECTION •• BINDING/EXCESSIVE "PLAY" IN STEERING LINKAGE •• STEERING COLUMN ASSEMBLY BENT RESULTING IN STEERING DIFFICULTY •• FAILURE OF ASSISTED (POWER) STEERING PUMP OR ASSOCIATED DRIVE BELT (INCIDENT CONSTITUTES AN EFF IF RESIDUAL STEERING CAPABILITY IS OPERATIONALLY ADEQUATE AND SAFELY CONTROLLABLE (IF NOT, AN SA WILL BE THE RESULT))		X		
• MINOR DEGRADATION OF STEERING CAPABILITY			X	
• PRIMARY BRAKING SYSTEM (SERVICE BRAKES) NOT SERVICEABLE (I.E., ARE INOPERATIVE OR SEVERELY DEGRADED)	X			Safety implications may already dictate classification SA for loss of service brakes but if backup systems exist it is worthwhile to mention
• MINOR BRAKE SYSTEM AIR LEAK NOT AFFECTING BRAKE FUNCTION (MAY QUALIFY AS AN NEFF, BUT DUE TO IMPENDING SAFETY CONCERNS, WOULD LIKELY REQUIRE PROMPT CORRECTIVE MAINTENANCE, THUS WOULD CONSTITUTE AN EFF)		X		
• ANTILOCK BRAKING SYSTEM INOPERABLE / NOT SERVICEABLE (INCIDENT CONSTITUTES AN EFF IF SYSTEM REVERTS TO MANUALLY CONTROLLED BRAKING CAPABILITY)		X		
• EMERGENCY BRAKES INOPERABLE (E.G., FAIL TO APPLY AUTOMATICALLY IN THE EVENT OF BRAKE SYSTEM AIR LOSS)	X			

INCIDENT DESCRIPTION (FUNCTIONAL DEGRADATION) RELATED TO THE MISSION ESSENTIAL FUNCTION (MEF) INDICATED	INCIDENT CLASSIFICATION Level 1	Level 2	Level 3	CONSIDERATIONS
• PARKING BRAKE INOPERABLE (CAN USE WHEEL CHOCK BLOCKS OR KEEP DRIVER IN VEHICLE IF THE NEED TO PARK ON AN INCLINE/DECLINE EXISTS)		X		
• VEHICLE HEADLIGHTS INOPERABLE		X		These types of failures may be scored differently in wartime conditions than in peacetime. Loss of headlights may be reason for declaring a vehicle non-mission capable in peacetime. Usually an FDSC reflects combat wartime conditions
• EXTERNAL BLACKOUT LIGHTS INOPERABLE		X		
• INFRARED DRIVING LIGHTS INOPERABLE		X		
• BRAKE LIGHTS / TURN SIGNALS / SIDE MARKER LAMPS / EMERGENCY FLASHERS INOPERABLE			X	
• VEHICLE SPOTLIGHT INOPERABLE		X		
• EXTERIOR DROPLIGHT INOPERABLE			X	
• CAB OVERHEAD DOME LIGHT INOPERABLE •• NO WHITE LIGHT •• NO NIGHT VISION DEVICE COMPATIBLE LIGHTING			X	
• DRIVER'S VISION ENHANCER INOPERABLE OR SEVERELY DEGRADED (DRIVER CAN USE NIGHT VISION DEVICE AS AN ALTERNATIVE)		X		
• VEHICLE WINDSHIELD ABRADED •• SEVERE ABRASION DEGRADING VISUAL RESOLUTION/ACUITY		X		Loss of visibility also affects mobility and should be considered when developing failure criteria. Loss of windshield wipers could impact speed, safety and could be cause for a system abort.
•• MINOR ABRASION (WINDSHIELD REPLACEMENT DEFERRABLE FOR AN EXTENDED PERIOD OF TIME)			X	
• VEHICLE WINDSHIELD WIPERS INOPERABLE (SERIOUS ISSUE DURING "IN THEATER" RAINY SEASON)		X		
• VEHICLE GAUGES/INDICATORS INOPERABLE/MALFUNCTIONING •• VOLTMETER, FUEL GAUGE, ENGINE OIL PRESSURE GAUGE / WARNING LIGHT, COOLANT TEMPERATURE GAUGE / WARNING LIGHT, AIR RESTRICTION GAUGE, AND TRANSMISSION TEMPERATURE WARNING DEVICE (AS EQUIPPED)		X		
•• SPEEDOMETER, ENGINE HOUR METER, ODOMETER (AND TRIP METER)			X	
• TRACKED VEHICLE SUSPENSION •• TRACK PADS			X	Tracked platforms are complicated and it is recommended that a set of criteria be prepared for common failures based on
•• END CONNECTOR			X	

INCIDENT DESCRIPTION (FUNCTIONAL DEGRADATION) RELATED TO THE MISSION ESSENTIAL FUNCTION (MEF) INDICATED	INCIDENT CLASSIFICATION			CONSIDERATIONS
	Level 1	Level 2	Level 3	
•• IDLER WHEEL RUBBER			X	general expectation of the failure effects, which may be based on testing. This alleviates the burden of trying to assess the effect of failure each time something happens, and provides for more consistent classification.
•• LOSS OF MORE THAN FOUR SHOCK ABSORBERS	X			
•• LOSS OF THREE OR FOUR SHOCK ABSORBERS		X		
•• LOSS OF ONE OR TWO SHOCK ABSORBERS			X	
•• LINK FAILURE RESULTING IN LOSS OF TRACK	X			
•• LOSS OF TRACK TENSION	X			
•• THROWN TRACK	X			

INCIDENT DESCRIPTION (FUNCTIONAL DEGRADATON) RELATIVE TO THE MISSION ESSENTIAL FUNCTION (MEF) INDICATED	INCIDENT CLASSIFICATION			CONSIDERATIONS
	Level 1	Level 2	Level 3	
MEF (2) – Shoot				
TARGET DETECTION, ACQUISITION, AND AIMING • MALFUNCTIONS CAUSING FUNCTIONAL LOSS OR SEVERE DEGRADATION OF THE ATTACHED WEAPON SIGHT; NIGHTTIME AND DAYTIME TARGET DETECTION/ACQUISITION/AIMING CAPABILITY SUBSTANTIALLY REDUCED (BACKUP/ALTERNATIVE CAPABILITIES MUST BE UTILIZED) •• INABILITY TO MOUNT AND SECURE SIGHT UNIT TO HOST WEAPON •• SIGHT UNIT UNABLE TO BE BORESIGHTED TO HOST WEAPON •• INABILITY OF SIGHT UNIT TO RETAIN OPERATIONALLY ADEQUATE BORESIGHT ALIGNMENT (WHEN DUE TO A MALFUNCTION OR EQUIPMENT DAMAGE) •• IMAGERY INADEQUATE (DISTORTED OR OF INSUFFICIENT RESOLUTION) TO PERMIT USER TO SEARCH FOR TARGETS, ACQUIRE/OBSERVE TARGETS, AND DIRECT/PLACE FIRE •• INABILITY TO SELECT THE NARROW FIELD OF VIEW, AS APPLICABLE		X		It is important to distinguish between malfunctions and their impact on detecting, acquiring and aiming; and the inability to hit a target. Even if there is no malfunction, there is no guarantee of hitting a target. The performance of the weapon should be assessed separately.
• INTEGRAL IRON SIGHTS DAMAGED (NOT FUNCTIONAL), CAUSING THE LOSS OF ZERO RETENTION AND AIMING PROVISIONS WHEN/WHILE USED AS THE PRIMARY SIGHTING MECHANISM (E.G., IN SITUATIONS WHERE THE ACCESSORY WEAPON SIGHT UNIT IS INOPERABLE)	X			
• IRON SIGHTS DAMAGED (BUT PRIMARY WEAPON SIGHT CAN BE REMOUNTED TO THE WEAPON AND UTILIZED TO ENGAGE TARGETS)		X		
TARGET ENGAGEMENT (WEAPON FIRING) • FAILURES OF WEAPON TO FEED AND CHAMBER AMMUNITION CARTRIDGES; CLEAR EMPTY LINKS; FIRE ROUNDS; AND EXTRACT & EJECT EMPTY CASINGS •• IMMEDIATELY OPERATOR CLEARABLE INCIDENTS/STOPPAGES (CLEARABLE W/IN APPROXIMATELY 10 SECONDS)			X	Each weapon system will have certain characteristics and components for which the loss of that component will have a known or predicted effect on the successful firing of the weapon. As much detail as possible should be added.
•• INCIDENTS THAT ARE NOT IMMEDIATELY CLEARABLE BUT WHICH CAN BE CLEAR/REMEDIED BY THE OPERATOR WITHIN 5 MINUTES		X		
•• INCIDENTS NOT CLEARABLE/CORRECTABLE WITHIN 5 MINUTES	X			
• WEAPON UNABLE TO BE "SAFED" (REMOVAL OF AMMUNITION REQUIRED TO "SAFE" WEAPON)		X		

INCIDENT DESCRIPTION (FUNCTIONAL DEGRADATON) RELATIVE TO THE MISSION ESSENTIAL FUNCTION (MEF) INDICATED	INCIDENT CLASSIFICATION			CONSIDERATIONS
	Level 1	Level 2	Level 3	
• SIGNIFICANT REDUCTION IN RATE OF FIRE		X		
Mounted Missile System				
WEAPON POSITIONING • MECHANICAL FAILURE/DAMAGE/MALFUNCTION OF MOUNT ASSEMBLY / TRAVERSING UNIT RESULTING IN REDUCED CAPABILITY TO POSITION THE WEAPON FOR TARGET ENGAGEMENT AND MISSILE TRACKING •• UNABLE TO ELEVATE, DEPRESS, AND TRAVERSE WEAPON OVER RANGES OF MOTION NECESSARY AND ADEQUATE FOR THE CONDUCT OF MISSION OPERATIONS	X			It is important to distinguish between malfunctions and their impact on detecting, acquiring and aiming; and the inability to hit a target. Even if there is no malfunction, there is no guarantee of hitting a target. The performance of the weapon should be assessed separately.
•• RANGE OF MOTION IS SIGNIFICANTLY REDUCED, BUT OPERATIONALLY ADEQUATE		X		
TARGET DETECTION, ACQUISITION, SIGHTING, AND TARGET TRACKING • MALFUNCTIONS CAUSING FUNCTIONAL LOSS OR SEVERE DEGRADATION OF THE SYSTEM; NIGHTTIME AND DAYTIME TARGET DETECTION/ACQUISITION/SIGHTING AND TARGET TRACKING CAPABILITY SUBSTANTIALLY REDUCED •• SYSTEM REPEATEDLY FAILS TO RETAIN OPERATIONALLY ADEQUATE BORESIGHT ALIGNMENT (WHEN DUE TO A MALFUNCTION OR EQUIPMENT DAMAGE) •• GUNNER'S DISPLAY INOPERABLE	X			Each weapon system will have certain characteristics and components for which the loss of that component will have a known or predicted effect on the successful firing of the weapon. As much detail as possible should be added.
• INABILITY TO GUIDE MISSILE TO TARGET (ALL MISSILE GUIDANCE CAPABILITY LOST) •• MISSILE FLIGHT TRACKER (TRACKING MECHANISM(S) INOPERATIVE) •• FLIGHT TRAJECTORY CORRECTIONS UNABLE TO BE PROVIDED TO MISSILES	X			
• MALFUNCTIONS CAUSING FUNCTIONAL DEGRADATION WHICH DOES NOT RESULT IN THE LOSS OF AN EF •• ELECTRONIC RETICLES INOPERATIVE IN HIGH MAGNIFICATION (CAN USE AUTOTRACKER TO LOCK-ON AND ENGAGE TARGETS) •• FAILURE OF DAY CAMERA (FLIR/THERMAL SIGHT AVAILABLE) OR SIGNIFICANT DEGRADATION OF DAY CAMERA RESOLUTION •• LOSS OF AUTOMATIC TRACKING CAPABILITY (PROVIDED THAT MANUAL TRACKING FUNCTION IS AVAILABLE/OPERATIONAL)		X		

INCIDENT DESCRIPTION (FUNCTIONAL DEGRADATON) RELATIVE TO THE MISSION ESSENTIAL FUNCTION (MEF) INDICATED	INCIDENT CLASSIFICATION			CONSIDERATIONS
	Level 1	Level 2	Level 3	
• LASER RANGEFINDER INOPERABLE		X		
• SYSTEM CAPABLE OF CAPTURING, TRACKING, AND GUIDING MISSILES FIRED ONLY TO SLOW MOVING OR STATIONARY TARGETS		X		
• MALFUNCTIONS NOT CAUSING OPERATIONALLY SIGNIFICANT ADVERSE IMPACT •• MINOR DEGRADATION OF RETICLE BRIGHTNESS OR VIDEO SYMBOLOGY BRIGHTNESS CONTROL •• REVERSE CONTRAST POLARITY NOT AVAILABLE (FUNCTIONALLY INOPERATIVE) •• LOSS OF INDICATOR SYMBOLOGY ON THE THERMAL SIGHT / DAY CAMERA DISPLAYS (NOTE: AN EFF OR EVEN AN SA WILL BE SCORED IF/WHEN CRITICAL FUNCTIONS CANNOT BE PERFORMED BECAUSE OF THE INABILITY TO VIEW MENU DRIVEN MODE SELECT FUNCTIONS)			X	
<u>TARGET ENGAGEMENT (MISSILE FIRING)</u> • INABILITY TO FULLY ARM MISSILE	X			
• INABILITY TO INITIATE MISSILE LAUNCH	X			
• WIRE-CUT FUNCTION CANNOT BE PERFORMED AUTOMATICALLY, BUT CAN BE ACCOMPLISHED BY USING THE MISSILE ABORT SWITCH			X	

INCIDENT DESCRIPTION (FUNCTIONAL DEGRADATON) RELATIVE TO THE MISSION ESSENTIAL FUNCTION (MEF) INDICATED	INCIDENT CLASSIFICATION			CONSIDERATIONS
	Level 1	Level 2	Level 3	
MEF (3) – Communicate and Maintain Situational Awareness				
EXTERNAL VEHICLE COMMUNICATION • ALL ON-BOARD VEHICLE RADIOS INOPERABLE (E.G., RADIO POWER HARNESS FAILURE)	X			Some vehicles may operate in a situation (e.g., convoy) such that external communication is not critical to mission accomplishment
• INABILITY TO TRANSMIT OR RECEIVE ON ALL ON-BOARD RADIOS	X			
• FUNCTIONAL LOSS OF ABILITY TO TRANSMIT/RECEIVE ON SECURE NET		X		
• FUNCTIONAL LOSS OF DIGITAL DATA TRANSMISSION/RECEPTION CAPABILITY (WHERE VOICE RECEIVE/TRANSMIT CAPABILITY REMAINS FUNCTIONAL/ OPERATIONAL)		X		
• RADIO OPERATION (COMMUNICATION) AT REDUCED SIGNAL LEVELS			X	
INTERNAL VEHICLE COMMUNICATION • LOSS OR DEGRADATION OF INTERNAL VEHICLE COMMUNICATION AT ANY CREW STATION OR EMBARKED/MOUNTED PERSONNEL LOCATION (PERSON-TO-PERSON VOICE COMMUNICATION IS OPERATIONALLY ADEQUATE)			X	Relative position of crew members should be taken into consideration as well as their criticality to the mission
SITUATIONAL AWARENESS • SURVEILLANCE SYSTEM INOPERABLE OR SUBSTANTIALLY DEGRADED •• FUNCTIONAL LOSS OF DAY AND THERMAL CAPABILITY	X			
•• DISPLAY INOPERATIVE (FAILS TO POWER-UP OR DISPLAY GOES BLANK AND DOES NOT REINITIATE)	X			
•• FUNCTIONAL LOSS OF DAY OPTICS (WHERE THERMAL IMAGER REMAINS FUNCTIONAL)		X		
•• COMPLETE FUNCTIONAL LOSS OF THERMAL IMAGER (WHERE DAY OPTICS REMAIN FUNCTIONAL)		X		
•• FUNCTIONAL LOSS OF RETICLE (DAY OR NIGHT)		X		
•• INABILITY TO ELEVATE, DEPRESS, OR TRAVERSE OVER THE FULL RANGE OF MOTION (WHERE RESIDUAL CAPABILITY IS OPERATIONALLY ADEQUATE)		X		
•• LOSS OF HIGH OR LOW MAGNIFICATION VIEWING		X		

INCIDENT DESCRIPTION (FUNCTIONAL DEGRADATON) RELATIVE TO THE MISSION ESSENTIAL FUNCTION (MEF) INDICATED	INCIDENT CLASSIFICATION			CONSIDERATIONS
	Level 1	Level 2	Level 3	
•• LASER RANGEFINDER INOPERATIVE (OR INCORRECT RANGE CALCULATIONS CONTINUOUSLY PROVIDED)		X		
• MINOR DEGRADATION •• SCRATCHED OPTICS (MINOR ABRASION)			X	
•• THERMAL IMAGER STANDBY MODE NOT ACCESSIBLE			X	
•• INTERMITTENT BIT ERRORS/INDICATIONS			X	
• ON-BOARD POSITIONING SYSTEM (GLOBAL POSITIONING SYSTEM RECEIVER) INOPERABLE OR SUBSTANTIALLY DEGRADED •• VEHICLE POSITION/LOCATION UPDATES/FIXES UNABLE TO BE OBTAINED •• CONFIRMED MALFUNCTIONS RESULTING IN OBVIOUSLY ERRANT/ERRONEOUS POSITION/LOCATION DATA (DATA FROM ACCOMPANYING VEHICLE OR MAPS AND GROUND REFERENCES CAN BE USED AS THE ALTERNATIVE) •• UNREADABLE OR DEGRADED DISPLAY SCREEN IMAGERY		X		
• ONE OR MORE VEHICLE MIRRORS DAMAGED (INCIDENTS OF THIS TYPE CONSTITUTE AN EFF, AS THE MIRRORS ARE A MAJOR ASSET FOR MAINTAINING SITUATIONAL AWARENESS IMMEDIATELY AROUND THE VEHICLE, DUE TO THE VEHICLE PLATFORM'S SIZE/HEIGHT AND RELATED BLIND SPOTS)		X		

INCIDENT DESCRIPTION (FUNCTIONAL DEGRADATION) RELATIVE TO THE MISSION ESSENTIAL FUNCTION (MEF) INDICATED	INCIDENT CLASSIFICATION			CONSIDERATIONS
	Level 1	Level 2	Level 3	
MEF (4) –Protect.				
<u>BALLISTIC PROTECTION</u> • PROTECTIVE BALLISTIC PROVISIONS INTEGRAL TO VEHICLE CHASSIS/HULL/BODY COMPROMISED •• STRUCTURAL CRACK PRESENT AT CRITICAL JUNCTURE (E.G., A STRESS CRACK ALONG A WELD IN THE HULL) •• BOLT-ON ARMOR (AS APPLICABLE) NOT SECURELY/PROPERLY AFFIXED; CRITICAL QUANTITY OF BOLTS (OR BOLTS IN A CRITICAL LOCATION) ARE EXCESSIVELY LOOSE (AND CANNOT BE RETIGHTENED BY THE CREW) OR ARE BROKEN / SHEARED OFF	X			
• PROTECTIVE BALLISTIC PROVISIONS FOR MOUNTED WEAPON SYSTEM GUNNER COMPROMISED •• CRITICAL SEGMENTS OF ARMOR NOT RETAINED IN PROPER PROTECTIVE POSITION (AND CANNOT BE REAFFIXED BY THE CREW); E.G., BOLTS SECURING ONE OR MORE ARMOR SEGMENTS OF ARMOR HAVE VIBRATED LOOSE, OR ARMOR HAS CRACKED AROUND BOLT HOLES	X			
• ONE OR MORE DOORS/HATCHES UNABLE TO BE SECURELY LATCHED/LOCKED IN THE CLOSED POSITION	X			
• REMOTE CONTROL IMPROVISED EXPLOSIVE DEVICE (RCIED) JAMMER DEGRADED/INOPERATIVE (INCIDENT CONSTITUTES AN EFF, AS THE CREW CAN RELOCATE VEHICLE WITHIN THE PROTECTIVE ENVELOPE OF AN ACCOMPANYING VEHICLE HAVING A FUNCTIONAL JAMMER)		X		
• INCIDENTS NOT CAUSING SIGNIFICANT ADVERSE IMPACT ON BALLISTIC PROTECTION •• BOLT-ON ARMOR (AS APPLICABLE) REMAINS SECURELY/PROPERLY AFFIXED, WHEREIN AN OPERATIONALLY/STRUCTURALLY INSIGNIFICANT QUANTITY OF BOLTS ARE EXCESSIVELY LOOSE (AND CANNOT BE RETIGHTENED BY THE CREW)			X	

INCIDENT DESCRIPTION (FUNCTIONAL DEGRADATION) RELATIVE TO THE MISSION ESSENTIAL FUNCTION (MEF) INDICATED	INCIDENT CLASSIFICATION			CONSIDERATIONS
	Level 1	Level 2	Level 3	
<u>FIRE SUPPRESSION</u> <u>CREW/TROOP COMPARTMENT</u> • FUNCTIONAL LOSS OF ALL FIRE EXTINGUISHING/SUPPRESSION CAPABILITY INTERNAL TO VEHICLE CAB/TROOP COMPARTMENT •• AUTOMATED <u>AND</u> MANUAL CAPACITIES INOPERABLE OR DEGRADED TO AN OPERATIONALLY UNACCEPTABLE LEVEL, ON VEHICLES EQUIPPED W/BOTH •• AUTOMATED CAPACITY INOPERABLE OR DEGRADED TO AN OPERATIONALLY UNACCEPTABLE LEVEL ON VEHICLES EQUIPPED W/ONLY AN AUTOMATED SUPPRESSION SYSTEM (E.G., SYSTEM UNABLE TO PROVIDE FIRE SUPPRESSION AT "AT LEAST" 2 INGRESS/EGRESS POINTS LOCATED ON DIFFERENT SIDES OF VEHICLE (TOP/BACK/LEFT SIDE/RIGHT SIDE) •• MANUAL CAPACITY INOPERABLE OR DEGRADED TO AN OPERATIONALLY UNACCEPTABLE LEVEL ON VEHICLES NOT EQUIPPED W/AN AUTOMATED SUPPRESSION SYSTEM (E.G., NO ONE HAND-HELD FIRE EXTINGUISHER REMAINS FULLY CHARGED / FULLY FUNCTIONAL) •• INADVERTENT DISCHARGE OF CREW/TROOP COMPARTMENT FIRE BOTTLES (SAFETY ISSUE)	X			
• FIRE EXTINGUISHING/SUPPRESSION CAPABILITY INTERNAL TO VEHICLE CAB/TROOP COMPARTMENT DEGRADED, BUT NOT FUNCTIONALLY INOPERABLE/INADEQUATE •• FAILURE OF ANY AUTOMATED SUPPRESSION SYSTEM FIRE DETECTION SENSORS, ON VEHICLES SO EQUIPPED (WHERE SYSTEM CAN BE MANUALLY ACTIVATED OR "AT LEAST" ONE HAND-HELD FIRE EXTINGUISHER REMAINS FULLY CHARGED/FUNCTIONAL) •• CREW/TROOP COMPARTMENT FIRE EXTINGUISHER BOTTLE PRESSURE/STATUS INDICATOR(S) INOPERABLE OR OBVIOUSLY INACCURATE (WHERE "AT LEAST" ONE HAND-HELD FIRE EXTINGUISHER REMAINS FULLY CHARGED/FUNCTIONAL)		X		
• FIRE EXTINGUISHING/SUPPRESSION CAPABILITY INTERNAL TO VEHICLE CAB/TROOP COMPARTMENT NOT SUBSTANTIALLY DEGRADED/COMPROMISED			X	

INCIDENT DESCRIPTION (FUNCTIONAL DEGRADATION) RELATIVE TO THE MISSION ESSENTIAL FUNCTION (MEF) INDICATED	INCIDENT CLASSIFICATION			CONSIDERATIONS
	Level 1	Level 2	Level 3	
ENGINE COMPARTMENT (NO THRESHOLD/OBJECTIVE REQUIREMENT) • ENGINE COMPARTMENT FIRE SUPPRESSION SYSTEM INOPERABLE/DEGRADED (FOR VEHICLES SO EQUIPPED); SUCH INCIDENTS REGARDED AS "NON-ESSENTIAL," SINCE NO THRESHOLD/OBJECTIVE REQUIREMENTS FOR THIS CAPABILITY EXISTS			X	

INCIDENT DESCRIPTION (FUNCTIONAL DEGRADATION) RELATIVE TO THE MISSION ESSENTIAL FUNCTION (MEF) INDICATED	INCIDENT CLASSIFICATION			CONSIDERATIONS
	Level 1	Level 2	Level 3	
MEF (5) - Carry				
Deliver transported Personnel in Mission Capable Condition				
• VEHICLE DRIVER'S SEATING PROVISIONS OPERATIONALLY INADEQUATE •• FUNCTIONAL LOSS/DAMAGE OF ESSENTIAL SEAT INSTALLATION HARDWARE RESULTING IN INADEQUATE DRIVER SEATING SUPPORT •• SEAT ADJUSTMENT PROVISIONS NOT FUNCTIONAL (AS APPLICABLE), RENDERING DRIVER UNABLE TO ADEQUATELY REACH/ACCESS ACCELERATOR/BRAKING/STEERING CONTROL MECHANISMS	X			
• SEATING PROVISIONS FOR VEHICLE COMMANDER OR ONE OR MORE MOUNTED NON-CASUALTY PERSONNEL DEGRADED (SUCH INCIDENTS SCORED AS AN EFF FOR EACH PASSENGER AFFECTED)		X		
• TROOP COMPARTMENT OVERHEAD DOME LIGHT INOPERABLE •• NO WHITE LIGHT •• NO RED/MILITARY BLACKOUT LIGHTING			X	
• MULTI-POINT RESTRAINING SYSTEM INOPERABLE OR IN A DAMAGED CONDITION •• ONE OR MORE SEATING/RESTRAINING HARNESSES UNABLE TO BE LATCHED OR PROPERLY ADJUSTED (SUCH INCIDENTS SCORED AS AN EFF FOR EACH PASSENGER AFFECTED; MAY CONSTITUTE AN SA FOR THE VEHICLE DRIVER, IF RIDE QUALITY DICTATES THE NECESSITY FOR DRIVER RESTRAINT IN ORDER TO PROPERLY/SAFELY OPERATE THE VEHICLE)		X		
•• ANY SEATING/RESTRAINING HARNESS NOT ABLE TO BE PROMPTLY UNLATCHED (SUCH INCIDENTS PRESENT A SERIOUS SAFETY ISSUE (EVEN IF/WHEN TOOLS ARE AVAILABLE TO CUT THE HARNESS LOOSE), PARTICULARLY IN THE EVENT OF A VEHICLE FIRE)	X			
Maintain Air/Environmental Quality				
• CAB AND/OR TROOP COMPARTMENT AIR CONDITIONING (COOLING) INOPERABLE OR DEGRADED TO AN OPERATIONALLY CRITICAL LEVEL (BECAUSE OF A MALFUNCTION, EQUIPMENT DAMAGE, OR EQUIPMENT WEAR)	X			

• CAB AND/OR TROOP COMPARTMENT AIR CONDITIONING (COOLING CAPABILITY) IS REDUCED (E.G., DUE TO A COOLANT LEAK) BUT REMAINS OPERATIONALLY ADEQUATE THROUGHOUT THE CONDUCT OF ONGOING MISSION OPERATIONS		**X**		
• CAB AND/OR TROOP COMPARTMENT HEATING INOPERABLE OR SIGNIFICANTLY DEGRADED •• MISSION EQUIPMENT NOT AFFECTED		**X**		
•• MISSION EQUIPMENT REQUIRES MINIMUM TEMPERATURE	**X**			
• CLIMATIC CONTROL SYSTEM DEGRADED AND UNABLE TO ADEQUATELY CIRCULATE AIR •• INADEQUATE FRESH AIR SUPPLIED/CIRCULATED •• INABILITY TO CIRCULATE WEAPON EXHAUST FUMES (GASES) OUTWARD AWAY FROM INTERNAL CAB/TROOP COMPARTMENT (SAFETY ISSUE)	**X**			
• NUCLEAR, BIOLOGICAL, AND CHEMICAL (NBC) OVERPRESSURE SYSTEM INOPERABLE (NBC THREAT NOT AN ISSUE IN CURRENT THEATERS OF OPERATION; ADDITIONALLY, CREW CAN DRIVE THE VEHICLE OUT OF A CONTAMINATED AREA TO AVOID ADVERSE IMPACTS) - ULTIMATELY, SUCH INCIDENTS ARE REGARDED AS “NON-ESSENTIAL,” SINCE NO THRESHOLD REQUIREMENT FOR THIS CAPABILITY EXISTS			**X**	
• NBC OVERPRESSURE SYSTEM STATUS GAUGE INOPERABLE/MALFUNCTIONING			**X**	
• DOORS/HATCHES NOT ENVIRONMENTALLY SEALING PROPERLY (E.G., LEAKING RAIN WATER (DURING “IN THEATER” RAINY SEASON) OR DUST); IMPACT OF SUCH INCIDENTS IS DEPENDENT ON THE MAGNITUDE OF THE PROBLEM, BUT IS ENVISIONED TO CONSTITUTE AN NEFF)			**X**	
• MALFUNCTIONS / EQUIPMENT DAMAGE CAUSING THE INABILITY TO SUPPLY AND MAINTAIN SUFFICIENT ELECTRICAL POWER FOR MISSION ESSENTIAL MEDICAL EQUIPMENT	**X**			
Transport Stowed Equipment/Payload				
• EQUIPMENT TIE DOWNS (OR VEHICLE ANCHOR POINTS FOR TIE DOWNS) BREAK/FAIL WHILE SECURING NON-ESSENTIAL EQUIPMENT (OR HARD TO DAMAGE EQUIPMENT THAT IS MISSION ESSENTIAL); INCIDENT SCORED AS AN NEFF PROVIDED THAT THE LOOSE EQUIPMENT DOES NOT PRESENT A HAZARD TO PERSONNEL OR OTHER TRANSPORTED ITEMS THAT ARE MISSION ESSENTIAL (IF A HAZARD DOES EXIST, THE INCIDENT WILL DEFAULT TO AN EFF)			**X**	

• EQUIPMENT TIE DOWNS (OR VEHICLE ANCHOR POINTS FOR TIE DOWNS) BREAK/FAIL WHILE SECURING SENSITIVE MISSION ESSENTIAL EQUIPMENT THAT IS EASILY SUSCEPTIBLE TO DAMAGE OR WHICH CAN PRESENT A SAFETY HAZARD IN AN UNSECURED CONDITION (E.G., AN UNSECURED OXYGEN BOTTLE); INCIDENT WILL BE SCORED AS AN EFF AT THE MINIMUM, AND IF A CRITICAL OR CATASTROPHIC SAFETY HAZARD CONDITION RESULTED FROM THE INCIDENT, AN SA CAN BE SCORED (AN SA MAY ALSO BE APPROPRIATE IF MISSION ESSENTIAL EQUIPMENT WAS DAMAGED)		X		
• EQUIPMENT STORAGE CONTAINER/COMPARTMENT COMPROMISED IN THE AREA OF STRUCTURAL INTEGRITY (E.G., CRACKED, OVERSTRESSED, LEAKS (IF EXTERNALLY MOUNTED), CONTAINER DOOR HINGE BROKEN, DOOR LATCH BROKEN AND UNABLE TO BE SECURED OR UNLOCKED, ETC.); DEPENDING ON THE EQUIPMENT STORED, THE INCIDENT (DAMAGE/MALFUNCTION) CAN BE SCORED AT THE LEVEL OF AN NEFF, BUT IF THE EQUIPMENT TYPICALLY STORED IS MISSION ESSENTIAL, THE INCIDENT WOULD CONSTITUTE AN EFF (ONLY IF MISSION ESSENTIAL EQUIPMENT WAS SERIOUSLY DAMAGED, INACCESSIBLE, OR PERSONNEL SAFETY WAS SEVERELY COMPROMISED WOULD THE SCORE OF "SA" BE APPROPRIATE)			X	
Provide Ingress/Egress Capability				
• FUNCTIONAL LOSS OF CAPABILITY TO UNLOCK/OPEN ANY HATCH OR DOOR ON THE VEHICLE	X			
• ROOF HATCHES DIFFICULT TO OPERATE •• MECHANICAL ASSIST FOR HATCH(ES) DAMAGED OR DEGRADED, AS APPLICABLE; PROBABLY EFF IF SUBSTANTIAL FORCE IS REQUIRED TO OPEN THE HATCH (TIME DELAY ISSUE ASSOCIATED WITH WEAPON FIRING AND PERSONNEL EGRESS)		X		
•• SPENT AMMUNITION CASING STUCK IN HINGE AREA OF WEAPON HATCH, REQUIRING CREW ACTION	X			
• ROOF HATCH(ES) FAIL(S) TO SECURELY LATCH/LOCK IN THE OPEN POSITION (PERSONNEL SAFETY ISSUE)	X			
• DOORS DIFFICULT TO UNLATCH/OPEN (TIME DELAY ISSUE ASSOCIATED WITH PERSONNEL EGRESS)		X		

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