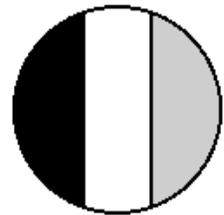


TRADOC COMBAT DEVELOPMENTS ENGINEERING

Failure Definition and Scoring Criteria (FDSC) for the Load Handling System (LHS) Modular Fuel Farm (LMFF)



6 May 2004



Prepared For
United States Army Combined Arms Support Command
Quartermaster Directorate of Combat Developments

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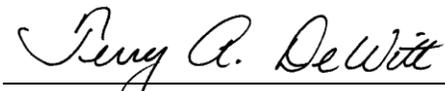
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Attachment 1 FAILURE DEFINITION AND SCORING CRITERIA

PURPOSE

This Failure Definition and Scoring Criteria (FDSC) defines what the user considers to be degraded and unacceptable performance of the Load Handling System Modular Fuel Farm (LMFF). It also outlines a specific process for categorizing all failure events that occur during testing.

CERTIFICATION



6 May 2004

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Date

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SYSTEM DESCRIPTION

The Load Handling System (LHS) Modular Fuel Farm (LMFF) is a bulk fuel storage and distribution system that can also perform retail operations. The LMFF consists of two types of modules, a tankrack storage module and a flatrack based pump filtration module. A storage module consists of a 2500 gallon tank mounted on an LHS compatible flatrack, manual emergency pump, and storage tubes for the non-collapsible hose used to interconnect the modules. The pump filtration module includes a diesel engine driven centrifugal pump, 400 gpm filter separator, valves, fittings, hoses, and refueling nozzles. Storage is provided on the module for all of the equipment required to set up a retail fuel storage and distribution system. This includes all of the discharge hoses, ground rods, water cans, fire extinguishers, and limited quantities of suction hose. The pump module includes an evacuation capability that allows all of the hose in the system to be purged of fuel prior to recovery. One pump filtration module can support up to 14 storage modules.

FAILURE DEFINITION

Essential Functions. Essential functions are the minimum operational tasks that the LMFF must be capable of performing to successfully complete its mission. The loss of an essential function, regardless of when it occurs, will be scored as an essential function failure (EFF).

Receive fuel: The valves and manifolding must allow the tankrack to safely be loaded with fuel.

Store fuel: Tankrack must provide for safe and leak free storage of fuel up to the tank's rated capacity

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Issue fuel: The pump filtration module and storage modules must allow for retail fuel distribution at throughput rates consistent with pump/filter separator ratings and receiving entities fuel acceptance rates.

Formal Failure Definition. Any event that causes the inability of the LMFF to perform its receive fuel, store fuel, or issue fuel functions will be scored as an essential function failure (EFF). Also, any event that causes the use of the system to be discontinued, to include those events posing threat of serious injury to personnel or equipment, will also be considered an EFF. Any fuel leak that cannot be immediately corrected by the operator (within 5 minutes) will be considered an EFF. Any malfunction of the flatrack modules that prevents the LHS from loading/unloading or moving the module will be considered an EFF. Minor events corrected by the operator/crew will be scored as non-failure events if the repair procedure is identified in the operator's manual as being a routine operating procedure and is performed using on-board tools and repair or spare parts.

SCORING CRITERIA

Classification of an event is based upon the event's impact on system operational performance. Primary classification categories are: No Test, Non-Failure and Failure. Failure categories include Essential Function Failure (EFF), Non-Essential Function Failure (NEFF), and Dependent Event (DE). Once an event has been classified as a failure, chargeability (paragraph 5) is assigned. Actual maintenance need not be performed in order to assign chargeability. Figure 1 depicts the scoring process.

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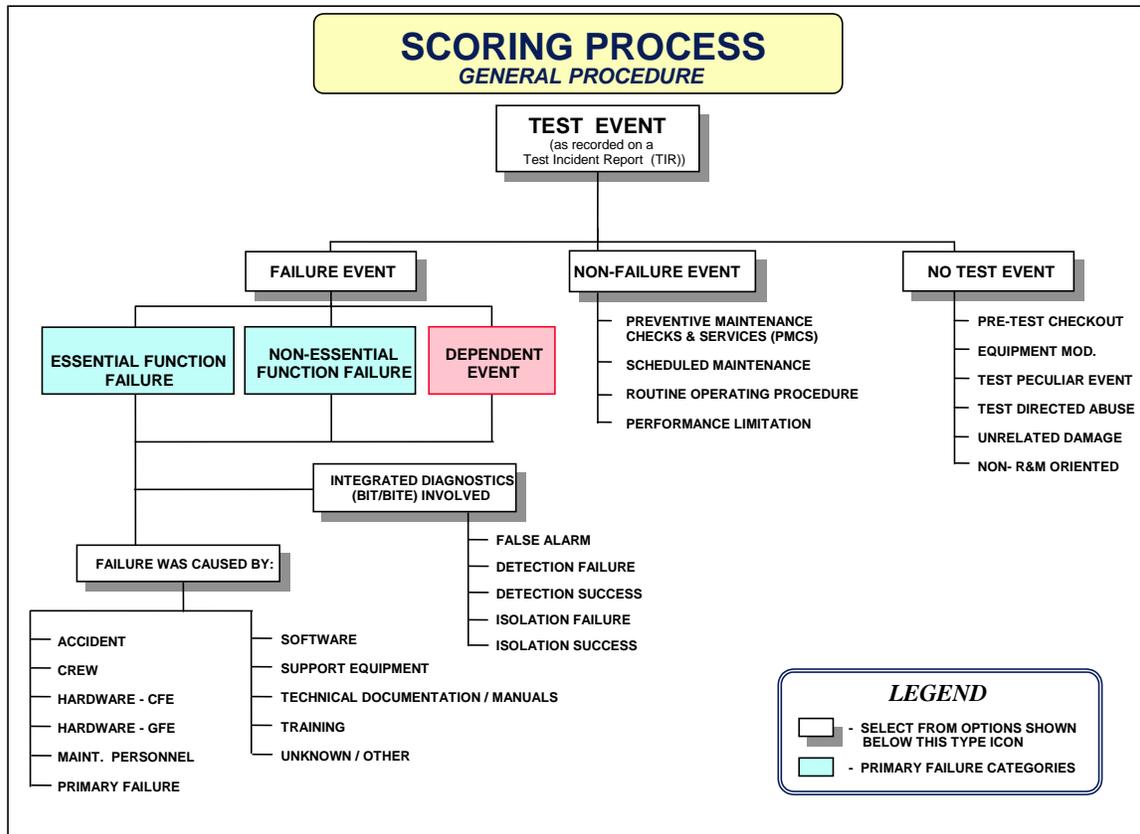


Figure 1 - Scoring Process Diagram

Scoring Procedure

1. Select appropriate category below and proceed as directed:
 - a. Event is "Failure." Proceed to #2.
 - b. Event is "Non-Failure." Proceed to #3.
 - c. Event is "No Test." Proceed to #4.

2. Assign event to one or more of the following failure categories and proceed to #5:
 - a. EFF
 - b. Non-EFF
 - c. Dependent Event

3. Identify the event as one of the following and proceed to next event:
 - a. Preventive maintenance, checks & services (PMCS).

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- b. Scheduled maintenance.
 - c. Routine operating procedures performed by operator & prescribed in user manual.
 - d. Performance limitation.
4. Assign event to appropriate category, then proceed to next event:
- a. Pre-test Checkout.
 - b. Equipment Modification.
 - c. Test Peculiar.
 - d. Test-directed Abuse.
 - e. Unrelated Damage.
 - f. Non-R&M Oriented.
5. Identify the cause of the event from the following list:
- a. Accident.
 - b. Crew/Operator.
 - c. Hardware (CFE/GFE).
 - d. Maintenance Personnel.
 - e. Primary Failure.
 - f. Software.
 - g. Support Equipment.
 - h. Technical Documentation/ Manuals.
 - i. Training.
 - j. Unknown.
6. Assign to appropriate BIT/BITE category below:
- a. False Alarm.
 - b. Detection Failure.
 - c. Detection Success.
 - d. Isolation Failure.
 - e. Isolation Success.

BIT/BITE

The LMFF may have Built-In-Test (BIT), Built-In Test Equipment (BITE) or Prognostics capabilities. Events involving BIT/BITE/Prognostics should be scored as follows:

A false alarm is any indication of a non-existent failure. A detection failure occurs when BIT/BITE/Prognostics fail to detect an actual event (true alarm). The opposite is a detection success. An isolation failure occurs when BIT/BITE does not isolate a failure

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to the faulty subsystem, component or Line Replaceable Unit (LRU) in accordance with the approved maintenance concept. Its opposite is an isolation success.

Instructions for Test Data Collection

Accurate collection of certain data and information is critical to successful evaluation of a system's R&M performance. Some of this information and data is used by scoring personnel to make final determinations regarding categorization of reliability failures. Maintenance and supply demand categories, defined later in Definitions and Explanations, are determined based on the failure category assigned or by definition. Following is a list of data and information that should be collected:

- Cumulative test time/miles for each individual test item
- Maintenance level
- Maintenance man-hours
- Maintenance clock-hours
- Identify MOS
- Spare parts or LRUs used
- Repair parts used
- POL quantity used
- Crew Correctable Maintenance Demand (CCMD)
- Scheduled Maintenance Demand (SMD)
- Non-Essential Unscheduled Maintenance Demand (NUMD)
- Essential Unscheduled Maintenance Demand (EUMD)
- Essential Logistics Demand (ELD)
- Non-Essential Logistics Demand (NELD)

Definitions and Explanations

The following terms with definitions or explanations pertain to this FDSC.

Failure Event. A failure is an event, or inoperable state, in which an item or part of an item does not perform as specified. Any test incident that is a malfunction of the system in any way will be scored as a failure. Scoring an incident as a failure does not attempt to discriminate or assess the cause of the failure. Any incident scored as a failure will be further evaluated to determine the severity and/or effect of the failure. This determination of severity/effect will be made using the Essential Function definitions. The categories into which failures are sub-divided are delineated below.

Essential Function Failure (EFF). An event that causes a loss of, or degradation in performance of, an essential function to the extent that there is an obvious indication and/or maintenance is required to remedy the failure (an EFF may result in a "Partial Mission Capable" status under wartime conditions or reduce

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the system's utility in certain operations on the battlefield). See Formal Failure Definition paragraph on page 3.

Non-Essential Function Failure (NEFF). An event that does not result in the degradation or loss of an essential function but has an obvious indication and/or maintenance is required to remedy the failure. A NEFF generates an NUMD and, if corrected and authorized by the crew/operator, a CCMD.

Dependent Event. A failure event caused by another related event and which occurs simultaneous to the related causing event. In some cases, it may be necessary to present engineering evidence to link the dependent event to the causing event.

Non-Failure Event. An event will be scored as a non-failure when no actual failure has occurred. A non-failure may consist of, but is not limited to, any of the following events.

Preventive Maintenance Checks and Services (PMCS). This includes those procedures defined as PMCS in the system's technical documentation. It does not include those incidents where a part is required (requirement of a replacement part infers that a component has failed or worn out which qualifies as a "failure" and requires corrective maintenance). A part requirement does not include replenishment of fluids that may be consumed during normal operation. Crew preventive maintenance checks and services (PMCS) should be separately recorded as PMCS, and associated times will **not** be included in maintenance ratio calculations.

Scheduled Maintenance. This includes those procedures defined in the system's technical documentation as a regularly scheduled service, as well as "on-condition" maintenance based on documented replacement criteria. The associated maintenance times will be included in maintenance ratio calculations.

Routine Operating Procedures. Routine operating procedures are performed by an operator and prescribed in user manual and are accomplished with on board tools/Basic Issue Items (BII). The intent is to not penalize a system for needing a minor, quick remedy, using only on-board tools, that is considered a normal, routine operating procedure in the operator's manual. These procedures should be based on how quickly and easily the crew or operator can do the task without impact on mission accomplishment, crew safety, etc. If frequency of occurrence is an issue, the scoring conference members should address unacceptable recurrence and establish constraints on routine operating procedures. If the constraint is exceeded, the events will be recorded on their own merits.

Performance Limitation. These include those incidents that report the system's consistent inability to meet performance specifications even though no actual

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malfunction has occurred. This category also includes those events where the system does not meet performance specifications because of inadequate component design or inadequate quality controls during manufacture/production.

No Test Event. Events scored “No Test” will not have chargeability assigned and will not be included in the overall reliability and maintainability evaluations of the system. These events may include pre-test inspections, equipment modifications, test-peculiar events, test-directed abuse, unrelated damage, and other non-R&M related events. Other non-R&M related events include suggested improvements, inadequate test procedures, reports on unacceptable replacement parts (provided they are discovered prior to or during installation), inability to meet performance specifications when no failure or malfunction has occurred, test schedule delays, etc. This includes post test events, events that occurred after completion of the test. This does not include events that occurred during test whose resulting maintenance demands were not performed during test; these will be scored on their own merits with associated maintenance times estimated based on previous or similar maintenance actions.

Pretest Checkout. Events observed during burn-in, pre-test inspection, or other pre-test activities are classified as “NO TEST”. The test plan must specify the number of hours for the pretest burn-in to permit a determination of when the pre-test period has ended. All events detected after the pre-test period will be scored on their own merits under succeeding steps.

Equipment Modification. This includes all maintenance actions involved in the installation of hardware kits or incorporation of redesigned components. If the replaced component was not functioning at the time of its replacement with the modification, the event will be scored on its own merit. The maintenance time will be estimated based on the time to restore the system to its original condition. Subsequent malfunctions of the modification will be scored on their own merit.

Test Peculiar. Malfunctions caused by equipment that is not part of the system being tested or people not acting as test players (crew or maintenance personnel) are scored as "NO TEST". Engineering evaluations to analyze the cause of the malfunctions, as well as any malfunctions and/or maintenance efforts caused by the engineering evaluation are scored as "NO TEST". This also includes maintenance evaluations conducted as a part of the test plan and malfunctions to or caused by test peculiar instrumentation. Events related to test peculiar diagnostic equipment used in lieu of the diagnostic equipment that will be fielded are scored on their own merits under succeeding steps.

Test Directed Abuse. Events in which the tester directs the deliberate abuse of the system (e.g., a test to over-stress the performance limit of the system), whether called for by the test plan or not, are classified as "NO TEST."

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Unrelated Damage. This includes damage caused by natural phenomena (e.g. lightning, earthquakes, etc.) and other influences that are beyond the control of the operational elements of the system.

Non-R&M Oriented. This step includes those events for which a test incident report might be initiated by the test activity, but which are not events used in R&M computations. Examples include suggested improvements, reports on inadequate test procedure, unusable or unacceptable replacement parts which were discovered prior to or during installation, test schedule delays, and suggested human factors improvements. Recommended changes to the system support package not related to a specific test event are also covered by this step.

Cause of Failure. Any event that is scored as a failure will have a cause of failure identified. Cause of failure will be assigned to one of the following categories.

Accident. Chargeability category including only those accidents that are not caused by the design of the system. That is, accidents that are due to inadequate training, inadequate warning in the manuals, and careless operation would not be charged to the "Accident" category; they would be charged to the appropriate root cause of the accident.

Crew/Operator. Chargeability category including all events attributable to crew/operator error that were not rooted in hardware/software design problems, inadequate training, or poorly written manuals.

Hardware. Chargeability category that includes malfunctioning hardware and personnel-related events attributable to the hardware's design. For example, if the device has an exposed ON/OFF switch that is easy to trip inadvertently, the unintended power disruption may be charged to hardware, and not to crew. This category may be further broken down into sub-categories for government furnished and contractor furnished hardware.

Maintenance Personnel. Chargeability category which includes all events attributable to maintenance personnel errors that were not rooted in hardware/software design problems, inadequate training, or poorly written manuals.

Primary Failure. Chargeability category which includes all events directly attributable to another (primary) failure or event.

Software. Chargeability category that includes all events attributable to the software of the system. As with hardware, personnel-related events that are rooted in the software's design should again be charged to software and not crew.

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Care should be taken to distinguish between genuine software reliability problems and simply improperly designed software incapable at any time of executing a given task. Consideration is also needed in distinguishing between software that is part of the system under test and "peripheral" software, that is not actually part of the system under test.

Support Equipment. Chargeability category which includes any event caused by special tools, common tools, Test Measurement and Diagnostic Equipment (TMDE), spares, repair parts, associated software, and sometimes power sources, not part of the operational system.

Technical Documentation/Manuals. This includes incidents that are attributable to misleading, incorrect, and/or nonexistent, but needed, information. This includes information on paper, plastic, in manuals, on equipment data tags, or stored in an electronically recoverable data format. Crew or maintenance personnel errors resulting from misleading, incorrect or poorly written manuals, should be charged to this category.

Training. Chargeability category which includes any event that can be directly attributed to inadequacies in training due to omitted or incorrect training procedures, or inappropriate training material.

Unknown/Other. These are incidents that do not have sufficient information/data to permit chargeability or the cause and source cannot be determined.

Integrated Diagnostics. The LMFF may have Built-In-Test (BIT), Built-In Test Equipment (BITE) or Prognostics capabilities. Events involving BIT/BITE/Prognostics should be scored as follows:

False Alarm. Any indication of a non-existent failure given by BIT/BITE/Prognostics.

Detection Failure. Failure of BIT/BITE/Prognostics to detect an actual event (true alarm).

Detection Success. Success of BIT/BITE/Prognostics in detecting an actual event (true alarm).

Isolation Failure. Failure of BIT/BITE/Prognostics to isolate a failure to the faulty subsystem, component or LRU in accordance with the approved maintenance concept.

Isolation Success. Correct determination of BIT/BITE/Prognostics in isolating the faulty subsystem, component or LRU in accordance with the approved maintenance concept.

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Maintenance and Supply Demands.

Crew Correctable Maintenance Demand (CCMD). The CCMD is used to capture events where the crew or operator corrected failures. These maintenance actions must be authorized at the crew/operator level in the TM or applicable documentation. Each failure event should be recorded based on its impact on system performance, regardless of who accomplishes the corrective action. An event scored on its own merits and fixed by the crew generates a CCMD. An EFF corrected and authorized by the crew/operator generates both an EUMD and a CCMD.

Scheduled Maintenance Demand (SMD). An SMD is recorded when a test incident report documents a regularly scheduled service, as well as "on-condition" maintenance (usage, wear, etc.) based on documented replacement criteria. Crew preventive maintenance checks and services (PMCS) are also considered scheduled maintenance, but should be separately recorded. To qualify as an SMD, an event must meet the necessary intervals, conditions, or durability requirements defined in applicable system technical documentation (i.e., technical manuals).

Non-Essential Unscheduled Maintenance Demand (NUMD). This category should be used to cover each event requiring unscheduled maintenance that can be deferred until the next scheduled maintenance service at the prescribed level of maintenance without impacting the system's essential function, causing danger to the crew, or causing potential damage to the system. This category is used to cover the remaining incidents that require unscheduled maintenance but did not qualify as EUMDs. Obviously, an NEFF that requires unscheduled maintenance to remedy results in an NUMD. Note that an NEFF that is corrected and authorized by the crew/operator generates both an NUMD and a CCMD.

Essential Unscheduled Maintenance Demand (EUMD). An EUMD is recorded for each event requiring unscheduled maintenance that cannot be deferred until the next scheduled maintenance point at the prescribed level of maintenance. The maintenance cannot be deferred if the system has lost the ability to perform the specified essential functions. Crew safety and potential damage to the system are other key considerations in determining what maintenance is non-deferrable. Fully redundant component failures, even though they do not cause the loss of an essential function, should be classified in this category since they are necessary for the system to be fully capable (a fully redundant component provides equal capability to the system and should not be confused with a "back-up" capability). Note that an EFF that is corrected and authorized by the crew/operator generates both an EUMD and a CCMD.

Essential Logistics Demand (ELD). Both essential unscheduled maintenance demands (EUMD) and all scheduled maintenance demands (SMD) place essential

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demands on the logistics system. Thus, both are recorded as ELDs. Each part (requested or consumed) and each corrective action is considered one logistics demand. It is possible to have more than one essential logistics demand per event. This category does not include operator or crew level preventive maintenance checks and services (PMCS); it may include items/parts consumed during conduct of the PMCS.

Non-Essential Logistics Demand (NELD). An NELD is recorded for all non-essential unscheduled maintenance demands (NUMD). Each part (requested or consumed) and each repair is considered one logistics demand. It is possible to have more than one logistics demand per event. This category does not include operator or crew level preventive maintenance checks and services (PMCS); it may include items/parts consumed during conduct of the PMCS.

NOTE: ELDs and NELDs are sums of maintenance and supply demands.
