**Draft Failure Definitions and Scoring Criteria**

**for the Gun Safety Technology Challenge**

**National Institute of Justice**

**June 2016**

**Introduction**

This document has been developed for the National Institute of Justice (NIJ) Gun Safety Technology Challenge. It describes the failure definition (FD) and scoring criteria (SC) that will be used to “score” test events that occur during the testing of handguns, such as pistols and revolvers, in the Challenge. These firearms or firearms accessories can be understood to use integrated components that exclusively permit an authorized user or set of users to operate or fire the gun and automatically deactivate it under a set of specific circumstances, reducing the chances of accidental or purposeful use by an unauthorized user. The integrated gun safety technology may include different authentication technologies such as radio frequency identification and fingerprint sensors.

This document follows the testing methodology published in *Draft Test Procedures for the Gun Safety Technology Challenge* to provide meaningful comparison between similar firearms in order to determine whether the reliability of the tested firearms differs significantly based on performance. Testing and evaluation is designed to prioritize the collection and use of data that can substantiate conclusions about the relative performance of firearms such that firearms with and without advanced gun safety technology that are similar with respect to type, form factor, caliber, and other physical characteristics are tested and evaluated using a common methodology and equivalent ammunition. Testing and evaluation is not designed to provide comparison of test results against absolute performance requirements or safety criteria, but rather to provide a meaningful comparison of test results of one firearm against another, similar firearm, or a firearm with and without a relevant safety accessory. The end result of the scoring process is to provide “scored” data points in order to form a basis to determine whether the addition of a smart gun technology does or does not significantly reduce the reliability of the firearm system compared to existing firearms.

Together, the FD and SC serve as a tool for guiding a reliability scoring panel through the test event scoring process, with the intent of eliminating as much subjectivity from the process as possible. The purpose of the FD is to define degraded handgun performance or functionality which is considered a failure when evidenced by a malfunction. The purpose of the SC is to define a specific and agreed upon process for scoring test events which occur during firearm testing. The scoring process involves the characterization of each test event into the proper category based upon its impact on the firearm’s operational performance or functionality, followed by attributing the cause of the test event to a particular cause. The content of this FDSC follows U.S. Army guidance, such as *Guidelines for Developing Reliability Failure Definition and Scoring Criteria,* to characterize the impact of malfunctions on the handguns tested in the Challenge, consistent with the failure definitions that have traditionally been applied to small arms.

Please direct any feedback on this document by email to [gunsafetytechnology@usdoj.gov](mailto:gunsafetytechnology@usdoj.gov).

**1 Scope**

**1.1** This document describes the failure definition (FD) and scoring criteria (SC) that will be used to “score” test events that occur during the testing of handguns, such as pistols and revolvers, in the Challenge.

**1.2** This document follows the testing methodology published in *Draft Test Procedures for the Gun Safety Technology Challenge* to provide meaningful comparison between similar firearms in order to determine whether the reliability of the tested firearms differs significantly based on performance.

**1.3** Testing and evaluation is designed to determine whether the addition of a smart gun technology does or does not significantly reduce the reliability of the firearm system, as compared to existing firearms.

**1.4** Reliability shall be assessed by a panel of qualified experts familiar with testing and evaluation of firearms using the FDSC in this document.

**1.5** Inherent hardware failures shall be recorded and appropriately scored according to the FDSC.

**1.6** Induced failures attributable to the operator, technical documentation, maintenance, training, and applicable support equipment shall be recorded and appropriately scored according to the FDSC. Induced failures are included in the overall evaluation to capture and convey the impact of deficiencies which are rooted in sources other than hardware, but which ultimately manifest themselves in the form of equipment malfunctions, in order to provide a more complete picture of performance to the end user.

**1.7** Malfunctions of the firearms induced by ammunition failure shall be recorded and appropriately scored according to the FD, however further separate assessment of ammunition reliability is outside the scope of this document.

**2 References**

*Draft Test Procedures for the Gun Safety Technology Challenge*, National Institute of Justice, Washington, DC, April 2016, <http://www.nij.gov/funding/pages/fy16-gun-safety-challenge.aspx>.

*Guidelines for Developing Reliability Failure Definition and Scoring Criteria*, 3rd ed., U.S. Army Training and Doctrine Command, Army Capabilities Integration Center, April 2012.

Charles E. Ebeling, *An Introduction to Reliability and Maintainability Engineering*, 2nd ed., (Long Grove, IL: Waveland Press), 2010.

Siegmund Halpern, *The Assurance Sciences: An Introduction to Quality Control*

*and Reliability* (Englewood Cliffs, NJ: Prentice-Hall), 1978.

**3 Terms and definitions**

**Reliability**

The probability that a device will perform its intended function for a specified period of time under stated conditions.[[1]](#footnote-1)

**Maintainability**

The probability that a failed component or system will be restored or repaired to a specified condition within a period of time when maintenance is performed in accordance with prescribed procedures.[[2]](#footnote-2)

**Malfunction**

A test event where the firearm does not perform its intended function properly.

**Test event**

Any occurrence during testing, whether expected or unexpected, that requires the operator to make an adjustment or take corrective action.

**Operator**

Individual person using the firearm.

**4 Failure definition**

The failure definition formally defines what constitutes a failure as it relates to testing the firearm’s essential functions.

**4.1 General considerations**

**4.1.1** Observed test events are divided into three general categories:

* “Failure” events related to reliability;
* “Non-failure” events related to maintainability; and
* Events or failures not related to reliability or maintainability.

**4.1.2** A failure related to reliability is characterized by a malfunction in which the firearm fails to perform its intended function properly.

**4.1.3** Any test event that involves a malfunction of the firearm shall be scored as a “failure” for the purpose of evaluating reliability.

**4.1.4** The cause shall be assigned after the failure has been scored by referencing the established event chargeability categories.

**4.1.5**  As failures generate maintenance demands, a test event should still be classified as a failure even if “corrective” action to address the malfunction may be deferred until testing has been completed.

**4.1.6** Any observed problem that does not require immediate corrective action and which can be remedied through the execution of a routine operating procedure, such as an adjustment, prescribed in the firearm’s instructional materials should not be scored as a failure.

**4.1.7** Any expected test events that can be considered exceptions to exclude from scoring as a failure shall be documented in writing prior to testing.

**4.1.8** Any test methods that may not conform to, may deviate significantly from, or may be obviously in conflict with the acceptable range of test firearm use shall be identified and documented in writing prior to testing.

**4.1.9** In order for a deficiency of the firearm to be included in the evaluation of reliability, the firearm must first be capable of performing the function to which the deficiency pertains.

**4.1.10** If the firearm is incapable of performing a particular function, then a malfunction related to that function cannot have occurred.

**4.1.11** Performance limitations caused by design deficiencies where no malfunction has occurred shall not be scored as failures related to reliability, and should be evaluated as a performance limitation.

**4.1.12** Failure to observe this protocol will result in the firearm being penalized twice for the same test event by *improperly* charging the firearm with a reliability-related failure in addition to a performance-type failure event.

**4.2 Failure events related to reliability**

**4.2.1** A test event meeting the definition of a “failure” related to reliability shall be scored in accordance with the failure categories in this section.

**4.2.2** Failures related to reliability are divided into three general categories:

* Essential function failures (EFF);
* Non-essential function failures (NEFF); and
* Dependent malfunctions (DM).

**4.2.3 Essential function failure (EFF)**

An EFF is a failure that renders the firearm incapable of performing one or more essential functions, or which degrades the ability to properly perform an essential function to the point where the residual utility of the function is deemed “operationally” inadequate.

Essential function failures are further characterized into three subcategories by level of criticality in accordance with the following historical small arms failure definitions:

* A Class I EFF is an immediately clearable failure or stoppage of the firearm adversely impacting one or more essential functions that the operator can correct in approximately 10 seconds or less through the execution of immediate action procedures, such as removal and reinstallation of the magazine or manually removing an ammunition round or empty casing;
* A Class II EFF is an operator clearable failure or stoppage of the firearm adversely impacting one or more essential functions which requires the operator to take more than 10 seconds to correct through execution of prescribed operator level troubleshooting and corrective action procedures, either with or without the use of common tools or cleaning kit components; and
* A Class III EFF is a severe failure or stoppage of the firearm that the operator is unable to correct through execution of prescribed operator level troubleshooting and corrective action procedures, either because the malfunction requires higher level maintenance that is non-deferrable, or the need for tools, equipment, or parts go beyond common tools or cleaning kit components.

**4.2.4 Non-essential function failure (NEFF)**

A NEFF is a failure that renders the firearm incapable of performing one or more non-essential functions, but which *does not* adversely or significantly impact the ability of the firearm to perform an essential function.

A NEFF may be assigned to a group of recurring operator actions of a particular type that, while they may fit in the category of *routine operating procedures* [in section 4.x], have become so frequent that the constant interruption becomes a significant problem.

**4.2.5 Dependent malfunction (DM)**

A DM is a failure caused by or directly attributable to another “primary” test event, such as a preceding or prior malfunction of the firearm. To characterize a malfunction as a DM, analysis of the failure shall positively confirm that it occurred as the direct result of a specified primary event.

The score ultimately assigned to the primary event shall be based on the overall impact or severity of both test events on system functionality. If the impact of the dependent malfunction was greater than that of the primary event, then the score assigned to the primary event should reflect that level of severity, based on the secondary failure’s functional impact.

**4.2.6 Reliability-related failure event chargeability categories**

**Primary failure**

This category is used to identify the cause of failure events that are classified as DM. The chargeability for each confirmed DM should be assigned to the *primary failure* category.

**Quality control**

This category is used to address failure events that are attributable to inadequate quality control in the equipment manufacturing, production, or assembly process.

**Manufacturer furnished hardware**

This category is used for malfunctioning hardware developed or furnished by the equipment manufacturer and operator-related test events attributable to the hardware design that may lead to malfunctions. This is distinct from a performance limitation described in 4.3.7, in that the hardware is the cause of a malfunction.

**Operator**

This category is used for failure events induced by the operator that are not rooted in hardware design problems, inadequate training, deficiencies or errors in the technical documentation, or the result of abuse.

**Technical documentation**

This category is used for failure events attributable to misleading, incorrect, or nonexistent information in technical documentation provided with the firearm. Inadequate instructional materials may cause operator or maintenance errors, and in such cases the failure event should be charged to the technical documentation.

**Maintenance personnel**

This category is used for failure events attributable to errors caused by maintenance personnel, such as not adhering to the established repair procedures.

**Training**

This category is used for failure events that can be directly attributed to inadequacies in training due to omitted or incorrect training procedures, inappropriate training material, or inadequate or insufficient training time.

**Manufacturer furnished support equipment**

This category is used for failure events directly attributable to tools and external test, measurement, and diagnostic equipment furnished by the manufacturer.

**Laboratory furnished support equipment**

This category is used for failure events directly attributable to tools and external tests, measurements, and diagnostic equipment furnished by the laboratory.

**Accident**

This category is used only for those failure events resulting from accidents which are not attributed to the design of the firearm. However, accidents due to inadequate training, inadequate warnings in the technical documentation, careless operation, or failure to perform preventative maintenance should not be charged as an “accident” but rather to the appropriate *root* cause of the accident.

**Unknown**

This category is used only for those failure events for which the cause or source cannot be determined.

**4.3 “Non-failure” events related to maintainability**

This includes test events leading to maintenance actions that are performed for reasons *other than* to correct failures or malfunctions related to reliability.

Maintenance type actions in this category include:

* Preventive maintenance;
* Scheduled maintenance;
* On-condition maintenance;
* Cosmetic maintenance;
* Routine operating procedures;
* Malfunctions or maintenance induced by the ammunition; and
* Performance limitation.

**4.3.1 Preventive maintenance**

Actions that the operator is required to perform which are necessary to maintain the system in proper working condition in accordance with procedures defined as preventative maintenance in the applicable technical documentation. This does not include corrective type maintenance that is performed to correct firearm deficiencies *detected* during preventative maintenance, as such actions are required either to remedy a “failure” or execute a routine operating procedure.

**4.3.2 Scheduled maintenance**

This includes any periodic preventive maintenance defined in the firearm’s technical documentation that is to be performed at prescribed intervals by dedicated maintenance personnel in order to keep the firearm in proper operational condition, and that are considered to be scheduled maintenance. To qualify as scheduled maintenance, an event must be consistent with the prescribed service interval, such as rounds fired, operating hours, or calendar time.

This does not include corrective type maintenance that is performed to correct firearm deficiencies *detected* during scheduled maintenance, as such actions are required to either remedy a “failure” or execute a routine operating procedure. This category does not include corrective maintenance that is performed during the scheduled maintenance period to fix known deficiencies.

**4.3.3 On-condition maintenance**

This includes maintenance not related to a failure executed in order to replace worn parts or components which have met their expected service life. For such actions to be characterized as on-condition maintenance, the part or component must have been functioning at the time of its replacement.

A test event in which a part or component physically fails almost immediately after its expected service life may not be characterized as a “non-failure” depending on a number of factors, including monitoring accuracy of the part or component by cognizant personnel, shortcomings in the technical documentation, or periodic maintenance schedules.

Parts or components that continue to exhibit gradual degradation after meeting their expected service life that do not experience sudden or catastrophic physical failure should not be scored as a reliability-related failure, if they continue to be used for an extended period of time prior to replacement, and consequently show excessive wear at the time of replacement.

Parts or components that experience sudden or catastrophic physical failure if they continue to be used for an extended period of time after meeting their expected service life should not be scored as a reliability-related failure, but attributed to another cause, such as abuse due to excessive use.

**4.3.4 Cosmetic maintenance**

This includes anymaintenance not related to a malfunction that is undertaken to correct a cosmetic deficiency or anomaly, such as deburring a rough external surface or sharp edge to prevent personal injury, rather than for the purpose of restoring lost or degraded functions.

**4.3.5 Routine operating procedures**

This includes tasks that can be performed quickly and readily, such as those prescribed in firearm instructional materials, which are not considered immediate corrective action. This is to prevent the system from being penalized for needing a minor operator action that is considered a normal, routine operating procedure, such as an adjustment. A task to correct a malfunction does not constitute a routine operating procedure nor should an immediate action such as clearing a stoppage be considered routine.

**4.3.6 Malfunction or maintenance induced by the ammunition**

This includes malfunctions or stoppages caused by the ammunition. These test events could be due to improper physical dimensions of the cartridge which prevents it from being properly fed or chambered, failure of the ammunition to fire when adequately struck by the firing pin, or an improper powder charge causing inadequate gas pressure or recoil force that may lead to an extraction or ejection failure. Should a malfunction be due to excessive carbon build-up in the firearm, the failure may be attributed to inadequate preventative maintenance.

**4.3.7 Performance limitation**

The inability of a firearm to meet a specified performance criterion where no malfunction has occurred should be considered a performance limitation attributable to a design deficiency, rather than a failure related to reliability. A design deficiency generally cannot be eliminated through typical maintenance or repair actions. Instead, some form of equipment redesign or modification will be required to remedy the problem that is causing the limitation in performance.

An indicator of a design deficiency would be the inability of the firearm to perform a particular function at any time where no maintenance action can be performed to correct the problem. In order for a design deficiency to be scored as a performance limitation instead of a failure related to reliability, a definitive numeric performance criterion shall exist with regard to the affected area of performance.

**4.4 Test events not applicable to reliability or maintainability**

This includes test events that are not related to and have no impact on the reliability or maintainability of the firearm. The assignment of events to this category should in no way be construed to imply that they are invalid or insignificant, as they can impact on other functional areas of system evaluation. This category includes:

* Pretest inspection;
* Equipment modifications;
* Test-peculiar events;
* Abuse;
* Unrelated damage; and
* Other test events not applicable to reliability or maintainability.

**4.4.1 Pretest inspection**

This includes test events observed or detected during pretest inspection or other designated pretest activities. Pretest events are not scored against the reliability or maintainability of system as they have occurred outside of the actual testing “phase,” however all events detected after the pretest period will be scored on their own merit.

**4.4.2 Equipment modifications**

This includes test events involving maintenance actions associated with the installation or incorporation of modified or upgraded firearm hardware. These events have no applicability to reliability or maintainability unless the original hardware item was nonfunctional, or was malfunctioning prior to being upgraded or replaced as part of the modification. In those cases where there is applicability to reliability or maintainability, the event of removing and replacing a faulty item will be scored on its own merit.

**4.4.3 Test-peculiar events**

This includes test events consisting of malfunctions and maintenance efforts caused by equipment that is not part of the system being tested, such as tools or instrumentation peculiar to the test, or by people who are not official test participants, such as people other than operators or maintenance personnel. Test-peculiar events are not attributable to the system being tested, and have no applicability to its reliability or maintainability.

**4.4.4 Abuse**

This includes test events in which official test participants, such as operators or maintenance personnel, cause damage to the system either willfully or through gross carelessness or negligence. This category also includes any events in which the test personnel directs the deliberate abuse of the system, such as a test excursion to over-stress or exceed the performance limits of the system for investigative purposes, whether called for by the test plan or not.

**4.4.5 Unrelated damage**

This includes test events in which damage is caused by natural phenomena or other influences that are beyond the control of official test participants. Because the source of these events is external to the system being tested, they should not be included in the evaluation of reliability and maintainability.

**4.4.6 Other test events not applicable to reliability or maintainability**

This includes test events which have no bearing on reliability and maintainability that do not fit into other categories. Examples may include suggested improvements, reports of inadequate test procedures, recommended improvements to technical manuals, unusable or unacceptable replacement parts discovered prior to or during installation, test delays, general information regarding the condition of equipment or components where no failure related to reliability has occurred, and suggested human factors improvements.

**5 Essential functions**

Essential functions represent the core operational functions that the firearms shall be capable of performing. Five essential functions are enumerated below and described more in 5.1 through 5.5:

* The operator shall be able to install a full load of rounds into the ammunition magazine and subsequently both insert the magazine into and remove it from the firearm;
* Safety mechanisms shall function properly and remain in the selected state until actuated by the operator;
* The firearm shall feed and properly chamber each individual round/cartridge without inducing a stoppage that requires corrective action;
* The firearm shall fire chambered rounds by properly striking the primer of each individual cartridge with sufficient impact to initiate firing in all firing modes available on the firearm without inducing a stoppage that requires corrective action; and
* The firearm shall extract and eject empty casings and unfired cartridges without inducing a stoppage that requires corrective action.

**5.1 Essential function 1**

The operator shall be able to install a full load of rounds into the ammunition magazine and subsequently insert the magazine into and remove it from the firearm.

**5.1.1 Essential function failure**

This function is considered seriously degraded and results in an EFF with regard to the scoring of firearm reliability when there is a significant reduction on the ability to install a full load of rounds into the ammunition magazine and subsequently insert the magazine into and remove it from the firearm.

**5.1.2 Non-essential function failure**

This function is not considered degraded and results in a NEFF with regard to the scoring of firearm reliability when there is at most a minimal reduction of the ability to install a full load of rounds into the ammunition magazine and subsequently insert the magazine into and remove it from the firearm.

**5.2 Essential function 2**

Safety mechanisms shall function properly and remain in the selected state until actuated by the operator.

**5.2.1 Essential function failure**

This function is considered seriously degraded and results in an EFF with regard to the scoring of firearm reliability when safety mechanisms fail to remain in the proper operator-selected state, including both mechanical safeties and integrated gun safety technology that may include different authentication technologies like radio frequency identification and fingerprint sensors. Examples may include the firearm discharging with the safety “on” or the operator not being able to toggle from “safe” to “fire” or vice versa.

**5.2.2 Non-essential function failure**

This function is not considered degraded and results in a NEFF with regard to the scoring of firearm reliability when there is at most a minimal impact on safety mechanisms remaining in the proper operator-selected state, such as when a mechanism is difficult to manipulate but the operator can actuate it to the desired state with no significant delay.

**5.3 Essential function 3**

The firearm shall feed and properly chamber each individual round/cartridge without inducing a stoppage that requires corrective action.

**5.3.1 Essential function failure**

This function is considered seriously degraded and results in an EFF with regard to the scoring of weapon reliability when there is a failure to feed or properly chamber a round, however a failure or stoppage due to bad ammunition shall not be considered an EFF of the firearm.

**5.3.2 Non-essential function failure**

This function is not considered degraded and results in a NEFF with regard to the scoring of firearm reliability when there is no adverse impact to feed or properly chamber a round, such as damaged or worn components that do not degrade essential functionality of the firearm to any appreciable degree.

**5.4 Essential function 4**

The firearm shall fire chambered rounds by properly striking the primer of each individual cartridge with sufficient impact to initiate firing in all firing modes available on the firearm without inducing a stoppage that requires corrective action.

**5.4.1 Essential function failure**

This function is considered seriously degraded and results in an EFF with regard to the scoring of weapon reliability when there is a failure to fire a properly chambered round, however a failure due to bad ammunition shall not be considered an EFF of the firearm.

**5.4.2 Non-essential function failure**

This function is not considered degraded and results in a NEFF with regard to the scoring of firearm reliability when there is at most a minimal impact to fire a properly chambered round, such as damaged or worn components that do not degrade essential functionality of the firearm to any appreciable degree.

**5.5 Essential function 5**

The firearm shall extract and eject empty casings and unfired cartridges without inducing a stoppage that requires corrective action.

**5.5.1 Essential function failure**

This function is considered seriously degraded and results in an EFF with regard to the scoring of weapon reliability when there is a failure to extract and eject the cartridge casing from any ammunition round, as well as when the firearm is unable to extract and eject an unfired cartridge, however a failure due to bad ammunition shall not be considered an EFF of the firearm.

**5.5.2 Non-essential function failure**

This function is not considered degraded and results in a NEFF with regard to the scoring of firearm reliability when there is at most a minimal impact to extract and eject the cartridge casing from any ammunition round, such as damaged or worn components that do not degrade essential functionality of the firearm to any appreciable degree.

**6 Scoring criteria**

The scoring criteria outlines the process that is to be used to classify test events into proper categories based upon their impact on firearm functionality, and to subsequently charge the cause of the test event to a particular source.

**6.1** The scoring panel should know and understand the definitions and explanations of scoring process terms before scoring is initiated.

**6.2** The scoring panel shall have access to all test results.

**6.3** All scoring decisions shall be recorded in electronic format.

**6.4** The scoring panel shall use the scoring procedure defined below by reading the applicable statements, choosing the appropriate option, and then executing the associated directives.

**6.4.1** The panel shall select the appropriate category below that applies to the test event being scored, then proceed as directed.

* If the test event is not applicable to reliability or maintainability in accordance with 4.4, the scoring panel shall proceed to 6.4.2.
* If the test event is a “non-failure” related to maintainability in accordance with 4.3, the scoring panel shall proceed to 6.4.3.
* If the test event is a failure related to reliability in accordance with 4.2, the scoring panel shall proceed to 6.4.4.

**6.4.2** The panel shall assign the test event to the appropriate category below, then proceed to the next test event.

* Pretest inspection;
* Equipment modifications;
* Test-peculiar events;
* Abuse;
* Unrelated damage; or
* Other test events not applicable to reliability or maintainability.

**6.4.3** The panel shall assign the test event to the appropriate category below, then proceed to the next test event.

* Preventive maintenance;
* Scheduled maintenance;
* On-condition maintenance;
* Cosmetic maintenance;
* Routine operating procedures;
* Malfunctions or maintenance induced by the ammunition; or
* Performance limitations.

**6.4.4** The panel shall assign the test event to the appropriate category below, then proceed to 6.4.5.

* Class I EFF;
* Class II EFF;
* Class II EFF;
* NEFF; or
* DM.

**6.4.5** The panel shall assign the test event to the appropriate category below, then proceed to the next test event.

* Primary failure;
* Quality control;
* Manufacturer furnished hardware;
* Operator;
* Technical documentation;
* Maintenance personnel;
* Training;
* Manufacturer furnished support equipment;
* Laboratory furnished support equipment;
* Accident; or
* Unknown.

1. Halpern, p. 7. Ebeling provides a similar definition on p. 5. [↑](#footnote-ref-1)
2. Ebeling, p. 6. [↑](#footnote-ref-2)