CHAPTER 6

DATA ANALYSIS AND REPORTING REQUIREMENTS FOR THE OBJECTIVE TEST METHODOLOGY

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6 DATA ANALYSIS AND REPORTING REQUIREMENTS FOR THE OBJECTIVE TEST METHODOLOGY

6.1 Introduction

A set of objective test procedures was proposed in Chapter 5 to evaluate the compliance of a Forward Collision Warning (FCW) system with the minimum functional requirements from Chapter 4. The vehicle-level test procedures include a detailed description of data collection requirements to support this testing. In this chapter, a set of requirements for data analysis is presented to support the test procedures. This analysis results in a pass/fail outcome for the FCW system.

6.2 Approach to Evaluating Countermeasure Performance

Section 6.2.1 summarizes key FCW system functional requirements in the context of evaluating test data. Section 6.2.2 describes the approach to using the outcomes of individual test trials to assess whether the countermeasure passes or fails the testing.

6.2.1 Minimal Functional Requirements

A set of minimum functional requirements for forward collision warning (FCW) systems are developed in Chapter 4. These requirements and corresponding tests may be partitioned into four groups:

- Driver-vehicle interface issues (How and when should an alert be presented to a driver?)
- Required crash alerts (When must an alert occur?)
- Out-of-path nuisance alerts (Alerts should not be triggered by objects outside the vehicle's path)
- In-path nuisance alerts (Alerts should not be triggered by vehicles in the Alert Zone unless the relative longitudinal motion would be considered alarming by drivers)

Driver-vehicle interface requirements include alert onset timing, alert modality, and other driver interface issues. The alert onset timing requirements are tested in the crash alert tests. Other driver-vehicle interface issues are not part of the test procedures. See Chapter 5, Section 2 for further discussion of the rationale for this approach.

The remainder of this section reviews the FCW system requirements associated with crash alerts, out-of-path nuisances, and in-path nuisances, from the perspective of using test measurements to assess a countermeasure's compliance with the functional requirements.

6.2.2 Evaluating Countermeasure Performance Using Test Results

A countermeasure passes the entire set of objective tests only if it passes each of three evaluation segments – crash alert tests, out-of-path nuisance alert tests, and in-path nuisance alert tests. If the results of one or more of these segments are not satisfactory, the countermeasure fails the entire set of tests.

Testing consists of executing several trials of each test scenario. For each individual test trial, the result is a pass/fail for one or more of the three evaluation segments. For crash alert test trials, the results are pass/fail for crash alerts (not too late/ too late) and for in-path nuisance alerts (not too early/ too early). For out-of-path nuisance alert test trials, the result is pass/fail for out-of-path alerts.

The following subsections describe briefly how each of the three segments use results of individual test trials to determine pass/fail outcomes. Obtaining results for a single test trial is discussed later, in Section 6.3 (crash alert tests) and Section 6.4 (out-of-path nuisance alert tests), and is also covered in each test procedure description (Chapter 5).

6.2.2.1 Pass/Fail Criteria for Crash Alert Test Segment

The crash alert test portion of the test procedures presents the countermeasure with 17 situations that should produce alerts in accordance with minimum functional requirements.

Successful countermeasure performance in the crash alert test portion requires that, for each of the five trials performed for each of the seventeen test scenarios, the onset of the crash alert should never be late. If the crash alert onset is late for one trial, fifteen more trials of that test must be run with no incident of late crash alerts, or the countermeasure fails the entire crash alert segment of the testing. If the crash alert onset is late for two trials, thirty more trials are required with no late crash alerts, and so forth.

These requirements are proposed because it is assumed that drivers will expect the FCW system will provide them with adequate braking distance (for good traction conditions).

Data collected during crash alert testing is also used for in-path nuisance alert evaluation, which is discussed next.

6.2.2.2 Pass/Fail Criteria for In-Path Nuisance Alert Segment

The data from all crash alert test trials is used to evaluate compliance with the in-path nuisance alert requirements.

In-path nuisance alerts are crash alerts that are triggered by vehicles inside the Alert Zone and that occur in situations drivers do not consider alarming. A suggested requirement from Chapter 4 on the frequency of in-path nuisance alerts is: less than one in-path nuisance alert per “week.” (That is, for a driving duration and exposure to traffic patterns representative of an “average” U.S. driver during a week).

The results of testing must be mapped to the requirement “fewer than one alert per week” in some manner. If the expected exposure to each test scenario during the theoretical representative driving week was known, then the number of in-path nuisances observed during testing could be scaled to give an expected in-path nuisance rate. This could then be compared to the requirement of less than one alert per week.

Unfortunately, the expected exposure to crash alert test scenarios is presently unknown. Instead, an estimate of the proper scaling and threshold parameters is shown later (Section 6.3.1.2). The result has the same form as the ideal method of mapping -- the occurrences of in-path nuisances are weighted by test scenarios and summed together. If the sum is less than a threshold, the system passes the in-path nuisance segment of testing. If not, it fails the in-path nuisance evaluation, and hence, the entire set of tests.

6.2.2.3 Pass/Fail Criteria for Out-of-Path Nuisance Alert Testing Segment

The out-of-path nuisance alert test procedures present the countermeasure with a set of situations representative of commonly occurring driving experiences in which objects or vehicles outside the Alert Zone may trigger out-of-path nuisance alerts.

Chapter 4 states that a very small number of out-of-path nuisance alerts are allowed. The requirement in the chapter is: less than one out-of-path nuisance alert per “week” (that is, for a driving pattern and duration equal to the average driving of a U.S. driver during a week), under representative conditions. Horowitz (1986) estimates the average U.S. driver covers 201 miles per week.

Mapping of the out-of-path nuisance alert test trial, results to the requirement “fewer than one alert per week” is done. Compared with the in-path nuisance evaluation, however, two steps toward better mapping have been made. First, the number of repetitions necessary to establish confidence has been estimated based on a pilot experimental study by CAMP (Appendix E). Second, the out-of-path objects are placed at various lateral distances from the Alert Zone to create a distribution of events. These distributions are described in Section 6.4.1.3 (also see Chapter 5).

With this mapping approach, a confidence of satisfactory performance for out-of-path nuisance alerts requires the system to produce no more than three crash alerts when the FCW equipped vehicle is exposed to three times the number of exposures expected in a week.

6.3 Crash Alert Tests – Data Analysis and Reporting

Chapter 5 describes 17 crash alert test scenarios. These are each repeated five times, and possibly more (see Chapter 5, Crash alert test repetition requirements).

This section describes general data reporting and analysis requirements, such as calibration issues and data processing issues that apply across most (if not all) crash alert tests. Next, each of the crash alert tests is addressed and any additional data reporting or analysis requirements are given.

6.3.1 Data Analysis and Reporting – General Requirements

Some data reporting and analysis requirements apply across many crash alert tests. This includes generic issues such as calibration requirements as well as detailed requirements on data reporting and analyses that apply across tests. Section 6.3.1.1 below describes general requirements for documenting "test validity," that is, reporting data and calculations to show test trials meet the specifications given in the procedures of Chapter 5. That section also levies requirements for documenting test execution. The third subsection below, Section 6.3.1.2, describes general requirements for reporting countermeasure performance metrics for individual crash alert test trials.

For each crash alert test, additional requirements appear later in Section 6.3.2.

6.3.1.1 Test Validity Analysis

Test validity analysis refers to the measurements and computations necessary to show that a test trial is valid, i.e., meets the requirements described in Chapter 5.

Calibration Documentation

Users of the test procedures should document compliance with all accuracy requirements given in the detailed test procedures of Chapter 5. Those requirements address the accuracy values of significant measurements, estimates, and controlled variables. The documentation of test results should describe calibrations and computations needed to show that the requirements are satisfied.

The list of uncertainties that need to be quantified will depend on the specific implementation of the test procedures.

Environmental Conditions Documentation

For each crash alert test, Chapter 5 specifies allowable values of various parameters describing ambient conditions. The user of the test procedures is responsible for gathering necessary measurements to verify that these conditions are met during the running of each trial. Documentation of these conditions for each test trial is required.

Vehicles, Props, and Test Site Documentation

Information on the vehicles and props involved in testing, as well as information on the test site itself, should be documented for each test design. Here some necessary information is listed and described.

Test Site – Requirements for the test site are given for each test in Chapter 5. The requirements are given in terms of a set of independent variables, which are defined in the Definitions section of that chapter. To show that the testing sites comply with these requirements, the user should describe the methods of measuring or determining the values of appropriate test site parameters. The user should also show that the resulting accuracy values support the determination that the test site characteristics are acceptable.

The following variables should be reported for each test site. The detailed procedures in Chapter 5 provide requirements for the ranges for each variable.

- Test site location
- Horizontal curvature
- Vertical curvature
- Descriptions of the type of lane markings present at the test site and the quality of the lane markings
- Lane width and lane width variation
- Roadway unevenness and superelevation parameters

Test Execution Documentation

Parameters Describing Vehicle Motions – Crash alert tests involve scripted maneuvers that are designed to trigger crash alerts in SVs equipped with countermeasure systems that satisfy the minimal functional requirements. For each crash alert test, Chapter 5 defines the maneuver, in part by describing allowable bounds on significant kinematics quantities, such as speeds, range, lateral position, and so forth. The required documentation associated with these specified motions is now described.

For any variable describing SV and/or POV motion for which Chapter 5 provides allowable bounds, there should be documentation that the measurements indicate that the bounds are satisfied. For each variable, three items should be included:

- The maximum deviation of the variable from the specification,
- The uncertainty associated with the measurement and/or estimation of the variable.
- Analysis that shows the variable was kept within the bounds given in Chapter 5 with a 95% confidence level.

For instance, if the SV speed is specified to be a constant 26.8 m/sec, with an allowable tolerance on either side of 0.67 m/sec, the documentation should report the maximum deviation from 26.8 m/sec, the estimated uncertainty in measuring SV speed (with justification), and a demonstration that the maximum deviation was less than 0.67 m/sec, with 95% probability.

Braking or Evasive Maneuvers – For each test run, one of the following questions must be answered in the positive, and documented, in order for the trial to apply:

- Does the required crash alert occur before the brake switch is triggered on the SV? or
- Does the range from the SV to the primary POV fall to less than 90% of the minimum range allowed for the onset of the crash alert before the brake switch is triggered on the SV (and before any other evasive action is taken by the driver of the SV)?

It is important to continue the driving maneuvers until one of the two situations above are attained, since countermeasures may use a variety of clues to help infer driver intentions.

6.3.1.2 Countermeasure Performance Analysis

Metrics to Report for Crash Alert Tests

For individual crash alert trials, the following items should be reported. In each case, the method of measurement and estimation should be documented.

- Estimated range from the SV to the POV at the time of alert onset.
- Estimated minimum required range at onset of alert. (See Chapter 4, Section 2 or Appendix B for instructions on computing this variable.)
- Difference between the range at alert onset and the minimum required warning range.
- Uncertainty in this difference.
- Estimated maximum allowed range at alert onset (to evaluate in-path nuisance alert events). See Chapter 4, Section 2 or Appendix B for discussion of this variable.
- Difference between the maximum allowed warning range and the actual range at onset of alert.
- Uncertainty in this difference.

It is also important to know the lateral position of the POV when the crash alerts are first presented to the driver, so that the compliance of the alerts with requirements can be determined. The following items should be reported:

- Estimated lateral distance between the nearest points on the POV and the SV, when the alert begins. Lateral distance is the difference in lateral positions, and lateral positions are measured with respect to the travel lane. Along with the quantities in the previous subsection, the lateral distance helps to determine whether an alert is required, allowed, or not allowed (Chapter 4, Section 3).
- Uncertainty in the above value (including effects of possible errors in knowing when the alert occurred, etc.).

Pass/Fail for Individual Crash Alert Test Trials

The metrics above should be used to locate the POV at the time of alert onset, and therefore allow the user to determine whether the crash alert onset met the requirements of Chapter 4. (The figure in Chapter 4, Section 3 illustrate a method of classifying a crash alert based on the POV location at the time of alert onset.) If the alert begins while the POV is in the “allowed” region of the figure in Chapter 4 (Region 4), the countermeasure passes the test trial. For all other results, the countermeasure fails the test trial.

Crash Alert Test C-11 may be passed another way. The test involves a SV approaching a stopped POV in poor visibility conditions. As described, a countermeasure passes this test if either the alert occurs at appropriate ranges or the countermeasure indicates to the driver that it cannot operate to its full function in the visibility conditions.

Pass/Fail Criteria for Individual In-Path Nuisance Alert Trials

Crash alert test trial results are examined, using the metrics above, to locate the POV at the time of alert onset and determine whether a crash alert onset is considered to be "too early," that is, a in-path nuisance alert. The "too early" cutoff is described in Chapter 4, Section 2. Appendix B gives detailed instructions to compute the cutoff. If the alert is an in-path nuisance alert, this is included in a weighted sum of such instances, as described in the following subsection. If the weighted sum exceeds a threshold value, the FCW system fails the in-path nuisance alert segment of testing, and therefore fails overall.

The following subsection develops the weights and thresholds used to combine results of individual test trials to decide whether the FCW system passes this segment of testing evaluation.

Pass/Fail for the In-Path Nuisance Alert Segment Using Individual Test Trial Results

This section describes the details of combining results of in-path nuisance alert occurrences seen during testing to determine whether the countermeasure passes or fails the in-path nuisance segment. Section 6.2.2.2 explains that the approach described here uses a preliminary estimate of the exposure to situations similar to the crash alert test. Thus in-path nuisance alerts seen during testing can be "mapped" to expected rates during a hypothetical average drive.

There are 17 crash alert tests described in Chapter 5. For each trial, there is no distinction made between alerts that are very early and alerts that are slightly early. For the ith crash alert test, let p_i denote the proportion of trials in which the crash alert is considered to be an in-path nuisance. Let w_i be a scalar weighting associated with the ith test. Let the weighted sum of in-path nuisance occurrences in all tests be a metric of the countermeasure's performance in the in-path nuisance segment of the tests. The countermeasure is considered to pass if the weighted sum does not exceed a threshold T_{IPNA}:

$$\text{If } \sum_i w_i p_i \le T_{IPNA}\text{, the countermeasure passes in-path nuisance segment.}$$

The choices of weights and threshold are now described. Ideally, weights assigned to the crash alert tests would be based on the relative exposure of drivers to the different test situations. In the absence of comprehensive data on driver braking behavior, weights are chosen by estimating the relative exposures of drivers to the testing situations. This is done using engineering judgment and the logic that follows. Weights are assigned to the crash alert tests based on (1) initial closing speeds, (2) POV braking severity, (3) presence or absence of lateral maneuvering. Weights do not consider roadway geometry and POV type since these parameters affect sensing and sensory interpretation performance, and in-path nuisance alerts involve alert timing.

To begin, a weight is assigned to each test based on the closing speed at the beginning of the test. Initial closing speeds vary from 0 to 100 kph. Weights are chosen to decrease as closing speeds increase; this is based on an assumption that the most common closing speed is zero, and as closing speeds increase, the probability that a driver is exposed to the closing speed decreases. The following table shows relative weights assigned to ranges of initial closing speeds.

Initial Closing Speed (kph)	Weight Assigned
0 – 25	100
26-50	50
51-75	20
76-100	10

Second, the weights are scaled by POV braking intensities, again based on an engineering sense of relative exposure to lead vehicle deceleration levels. The following scaling factors are used:

POV Braking Level	Scaling Factor
0.0 to –0.1g	1
-0.11g to –0.30g	0.30
-0.31g to –0.50g	0.05

Third, the weights are reduced for tests with lateral maneuvers, based on the simple assumption that crash alerts are more likely to happen when neither vehicle is changing lanes.

Lateral Maneuver Occurs?	Scaling Factor
No lateral maneuvers	1.0
SV lane change	0.3
POV cut-in	0.3

Table 6-1 shows the resulting weights to use for each test scenario.

Given the proportion of tests in which the crash alert tests produced an in-path nuisance alert, the system's performance is compared to a threshold, $T_{IPNA'}$ as described earlier. The threshold is chosen here as follows. Assume, based only on engineering judgment, that "representative driving" for the U.S. (201 miles, Horiwitz) involves 10 incidents per week in which a driver approaches a situation in which a crash alert may be triggered. The requirements of Chapter 4 propose that in-path nuisance alerts should not occur more than once per week, for the week of "representative driving." Thus, given the normalized weighting of the tests shown in the table below, only one tenth of these incidences can be allowed to produce an in-path nuisance alert. Therefore the threshold is chosen to be 1/10, or $T_{IPNA} = 0.10$.

The choice of threshold, as well as the weightings, would be improved through the use of real-world data, such as that collected in the ICC Field Operational Tests (see References). The data might be used to better infer exposures to the scenarios represented by the crash alert tests, as well as provide a basis for a better estimate of how often drivers approach the "too early" bound of the crash alert onset requirements of Chapter 4.

Table 6-1 Weighting the Results Of Crash Alert Tests To Evaluate In-Path Nuisance Alerts

Test	Test Name	Scale Factor for Initial Closing Speed	Scale Factor for POV Braking	Scale Factor for Lateral Maneuvers	Total Test Weight	Normal-ized Weight
C-1	100 kph to POV stopped in travel lane	10	1	1	10	0.0266
C-2	80 kph to POV at 16 kph	20	1	1	20	0.0532
C-3	100 kph to POV braking moderately hard from 100 kph	100	0.05	1	5	0.0133
C-4	100 kph to POV stopped under overhead sign	10	1	1	10	0.0266
C-5	100 kph to slowed or stopped motorcycle	10	1	1	10	0.0266
C-6	SV to POV stopped in transition to curve	20	1	1	20	0.0532
C-7	SV to POV stopped in a curve	10	1	1	10	0.0266
C-8	SV to slower POV, in tight curve	50	1	1	50	0.1330
C-9	POV at 67 kph cuts in front of 100 kph SV	50	1	0.3	15	0.0399
C-10	SV at 72 kph changes lanes and encounters parked POV	20	1	0.3	6	0.0160
C-11	100 kph to stopped POV, with fog.	10	1	1	10	0.0266
C-12	POV brakes while SV tailgates at 100 kph.	100	0.3	1	30	0.0798
C-13	100 kph to 32 kph motorcycle between two trucks	20	1	1	20	0.0532
C-14	100 kph to 32 kph motorcycle behind a truck	20	1	1	20	0.0532
C-15	100 kph to 32 kph Truck	20	1	1	20	0.0532
C-16	SV to POV stopped in transition to curve (poor lane markings)	20	1	1	20	0.0532
C-17	24 kph SV to stopped POV	100	1	1	100	0.2660
				Sums:	376	1.00

6.3.2 Data Analysis and Reporting for Specific Crash Alert Tests

Unless otherwise specified, the quantities specified above in Section 6.3.1 should all be documented. Some tests require additional measurement and reporting; this section describes these unique requirements.

Refer to Chapter 5 for descriptions of the test procedures and objectives for these tests.

6.3.2.1 Test C-1: 100 kph to POV Stopped in Travel Lane

Additional Requirements to Demonstrate Test Validity

Stationary POV Location and Orientation – This test involves a stationary POV. The user is responsible for demonstrating that the POV location and orientation meets the requirement given in Chapter 5, under Crash Alert Test General Requirements.

Countermeasure Performance Evaluation

Only those requirements that apply to all crash alert tests (Section 6.3.1.2) are needed for this test.

6.3.2.2 Test C-2: 80 kph to POV at 16 kph

Additional Requirements to Demonstrate Test Validity

None.

Countermeasure Performance Evaluation

Only those requirements that apply to all crash alert tests (Section 6.3.1.2) are needed for this test.

6.3.2.3 Test C-3: 100 kph to POV Braking Moderately Hard From 100 kph

Additional Requirements to Demonstrate Test Validity

None.

Countermeasure Performance Evaluation

Only those requirements that apply to all crash alert tests (Section 6.3.1.2) are needed for this test.

6.3.2.4 Test C-4: 100 kph to POV Stopped Under Overhead Sign

Additional Requirements to Demonstrate Test Validity

Overhead Sign – The overhead sign should be constructed and hung as defined in Chapter 5 (see in the Nuisance Alert sections); documentation should provide support for a statement that the overhead sign meets specifications.

Stationary POV Location and Orientation – This test involves a stationary POV. The user is responsible for demonstrating that the POV location and orientation meets the requirement given in Chapter 5, under Crash Alert Test General Requirements.

Countermeasure Performance Evaluation

Only those requirements that apply to all crash alert tests (Section 6.3.1.2) are needed for this test.

6.3.2.5 Test C-5: 100 kph to Slowed or Stopped Motorcycle

Additional Requirements to Demonstrate Test Validity

Motorcycle -- The motorcycle should be as defined in Chapter 5.

Stationary POV Location and Orientation – This test involves a stationary POV. The user is responsible for demonstrating that the POV location and orientation meets the requirement given in Chapter 5, under Crash Alert Test General Requirements.

Countermeasure Performance Evaluation

Only those requirements that apply to all crash alert tests (Section 6.3.1.2) are needed for this test.

6.3.2.6 Test C-6: SV to POV Parked in Transition to a Curve

Additional Requirements to Demonstrate Test Validity

Longitudinal Location of Vehicles – The longitudinal position of each vehicle should be recorded. Document the method used to locate the transition from the straight road segment to the curve.

Wet Pavement – Document whether the pavement is wet due to rain or artificial wetting of the road.

Countermeasure Performance Evaluation

Only those requirements that apply to all crash alert tests (Section 6.3.1.2) are needed for this test.

6.3.2.7 Test C-7: SV to POV Parked on a Curve, No Lane Markings

Additional Requirements to Demonstrate Test Validity

Stationary POV Location and Orientation – This test involves a stationary POV. The user is responsible for demonstrating that the POV location and orientation meets the requirement given in Chapter 5, under Crash Alert Test General Requirements.

No Lane Markings – The user should document that the test is executed on a roadway that meets the requirement of a site with “no lane markings.” (See Chapter 5, Definitions.)

Countermeasure Performance Evaluation

Only those requirements that apply to all crash alert tests (Section 6.3.1.2) are needed for this test.

6.3.2.8 Test C-8: SV to Slower-Moving POV, in Tight Curve

Additional Requirements to Demonstrate Test Validity

None.

Countermeasure Performance Evaluation

Only those requirements that apply to all crash alert tests (Section 6.3.1.2) are needed for this test.

6.3.2.9 Test C-9: POV at 67 kph Cuts in Front of 100 kph SV

Additional Requirements to Demonstrate Test Validity

None.

Countermeasure Performance Evaluation

Requirements that apply to all crash alert tests (Section 6.3.1.2) are needed for this test.

6.3.2.10 Test C-10: SV at 72 kph Changes Lanes and Encounters Parked POV

Additional Requirements to Demonstrate Test Validity

Stationary POV Location and Orientation – This test involves a stationary POV. The user is responsible for demonstrating that the POV location and orientation meets the requirement given in Chapter 5, under Crash alert Test General Requirements.

Countermeasure Performance Evaluation

Requirements that apply to all crash alert tests (Section 6.3.1.2) are needed for this test.

6.3.2.11 Test C-11: 100 kph to Stopped POV, With Fog

Additional Requirements to Demonstrate Test Validity

Stationary POV Location and Orientation – This test involves a stationary POV. The user is responsible for demonstrating that the POV location and orientation meets the requirement given in Chapter 5, under Crash Alert Test General Requirements.

Visibility – The user is responsible for demonstrating that the atmospheric visibility at the time of the tests meets the requirements given for this test in Chapter 5.

Countermeasure Performance Evaluation

Requirements that apply to all crash alert tests (Section 6.3.1.2) are needed for this test. In addition, the driver of the SV should observe whether the countermeasure indicates to the driver that the system cannot function at full functionality.

6.3.2.12 Test C-12: POV Brakes While SV Tailgates at 100 kph

Additional Requirements to Demonstrate Test Validity

None.

Countermeasure Performance Evaluation

Requirements that apply to all crash alert tests (Section 6.3.1.2) are needed for this test.

6.3.2.13 Test C-13: Greater Size and Equal Distance

Additional Requirements to Demonstrate Test Validity

Motorcycle – The motorcycle should satisfy the requirements levied on motorcycles used in testing, per Chapter 5. Evidence that the motorcycle meets specifications should be included in the test documentation.

Trucks – Both trucks must meet the specifications of trucks to be used in the testing, per Chapter 5. Evidence that the trucks meet specifications should be included in the documentation.

Vehicle Longitudinal Locations – For this test Chapter 5 requires that the distance along the direction of travel between the rear of the three POVs should not exceed a specified amount. The testing organization should document support for an argument that the actual distances fall within that bound.

Countermeasure Performance Evaluation

Requirements that apply to all crash alert tests (Section 6.3.1.2) are needed for this test.

6.3.2.14 Test C-14: Greater Size and Greater Distance

Additional Requirements to Demonstrate Test Validity

Motorcycle – The motorcycle should satisfy the requirements levied on motorcycles used in testing, per Chapter 5. Support that the motorcycle meets specifications should be included in the test documentation.

Trucks –Both trucks should meet the specifications of trucks to be used in the testing, per Chapter 5. Support that the trucks meet specifications should be included in the documentation.

Vehicle Longitudinal Locations – The maximum and minimum values for the estimated range between the motorcycle and the truck should be reported. Chapter 5 provides an allowable set of

values that range can take on. The testing organization should document support for an argument that the actual range falls within that bound.

Countermeasure Performance Evaluation

Requirements that apply to all crash alert tests (Section 6.3.1.2) are needed for this test.

6.3.2.15 Test C-15: 100 kph to 32 kph Truck

Additional Requirements to Demonstrate Test Validity

Truck – The truck should meet the specifications on trucks to be used in the testing, per Chapter 5. Support that the truck meets specifications should be included in test documentation.

Countermeasure Performance Evaluation

Requirements that apply to all crash alert tests (Section 6.3.1.2) are needed for this test.

6.3.2.16 Test C-16: SV to POV Parked in Transition to a Curve, Poor Quality Painted Lane Markings

Additional Requirements to Demonstrate Test Validity

Longitudinal Location of Vehicles – The longitudinal position of each vehicle should be recorded. Document the method used to locate the transition from the straight road segment to the curve.

Painted Lane Markings of Poor Quality – The user should document the method used to determine whether the test roadway meets the requirements of a roadway with poor quality lane markings. Appropriate measurements and computations should be recorded and documented.

Countermeasure Performance Evaluation

Requirements that apply to all crash alert tests (Section 6.3.1.2) are needed for this test.

6.3.2.17 Test C-17: 24 kph to Stopped POV

Additional Requirements to Demonstrate Test Validity

Stationary POV Location and Orientation – This test involves a stationary POV. The user is responsible for demonstrating that the POV location and orientation meets the requirement given in Chapter 5, under Crash Alert Test General Requirements.

Countermeasure Performance Evaluation

Requirements that apply to all crash alert tests (Section 6.3.1.2) are needed for this test.

6.4 Out-of-Path Nuisance Tests – Data Analysis and Reporting

Out-of-path nuisance-alert tests are used to evaluate the countermeasure's compliance to the limits on alerts caused by objects that are not in the Alert Zone. Chapter 5 described nine out-of-path nuisance-alert tests. The data analysis and reporting requirements described here include documentation to show that each test was run properly and documentation and analysis to demonstrate that the number of alerts were within the required limits. Some of the data analysis and reporting requirements apply to all of the tests while others are test specific. Section 6.4.1 covers the requirements that apply to all of the out-of-path nuisance-alert tests.

6.4.1 Data Analysis and Reporting – General Requirements

6.4.1.1 Test Validity Analysis

Calibration Documentation

Users of the test procedures must show that the quantities listed below meet the specifications given Chapter 5. Documentation should include the calibration procedures used, calibration results, and methods used to estimate the uncertainty for each of the following measurements:

- Uncertainty of lateral and longitudinal position of each stationary prop.
- Uncertainty of SV lateral position relative to each stationary prop as the SV drives through the test scene.
- Uncertainty of the SV speed as the SV drives through the test scene.
- Uncertainty of lateral position of moving POVs relative to the SV while the SV drives through the test scene.
- Uncertainty in the time of any alerts that are generated.

Principal Other Vehicles Documentation

Chapter 5 includes requirements for the types of vehicles that are used as the POVs. The make and model of each vehicle should be documented. Any options or configuration alternatives that could enhance or degrade the ability of a FCW system to sense the vehicles should be documented.

Documentation of Props

Chapter 5 includes requirements for the props that are used during the testing. The make and model of each purchased prop shall be recorded. The materials and dimensions of each prop that is constructed shall be documented. The vertical and horizontal displacement of props relative to the lanes of travel, including their position relative to any required vertical or horizontal curves, shall be documented.

Test Site Documentation

Chapter 5 includes requirements for the road surface characteristics. The road surface material and its roughness should be documented. The presence, location, and quality of painted lane markers or lane marking retroreflectors should also be documented. The individual tests also have limits on horizontal curvature, vertical curvature, and superelevation of the test track. The methods of measuring these characteristics and their values should be documented.

Test Execution

Each of the out-of-path nuisance-alert tests involves a scripted maneuver that causes the FCW equipped vehicle to approach an object that could, potentially, cause a nuisance alert. For each test scenario, Chapter 5 includes bounds on several significant kinematic quantities, such as speed and lateral position. The data analysis must include an analysis of the kinematic data, including an estimate of the measurement error, to demonstrate with a 0.95 level of significance that the maneuver was performed within the specified bounds.

6.4.1.2 Countermeasure Performance Analysis

The requirements in Chapter 4 state that a FCW system should produce less than one out-of-path nuisance alert per week when subjected to an average distribution of driving conditions. Chapter 5 describes how to expose a FCW system to representative scenarios that could generate out-of-path nuisance alerts. Each scenario is run multiple times using a distribution of distances between the objects and the Alert Zone. A system passes the out-of-path nuisance alert test segment if the sum of the number of alerts produced during all the repetitions is below a threshold.

This and the following sections explain how the required number of test repetitions and the distance distributions were derived. The number of repetitions is based upon three factors:

- An estimate of the daily or weekly exposure of a FCW system to each out-of-path nuisance alert scenario.
- An estimate of the distribution of distances of each type of object from the path of the SV.
- A statistical analysis of the number of trial exposures needed to have adequate confidence that a FCW system satisfies the limits for out-of-path nuisance alerts.

Several sources have been used to support estimates for the distribution of exposure rates. The research by Horowitz (1986) was used for the average miles driven in a week (201) and the average number of trips (27).

The values for exposure per day are based upon the findings of a pilot study performed by CAMP in suburban Detroit. Details of the study methods and results are included in Appendix D. The results of the pilot study are considered to be very preliminary, and therefore, the values presented here are likely to change when additional data becomes available.

The distribution of distances was derived by considering standard construction practices and using engineering judgements to translate these construction practices into reasonable distance

distributions. The roadway configurations recommended by AASHTO were used to derive lane widths, roadway markings, as well as distances between the traveled roadway and guardrails or concrete barriers. The MUTCD was used for requirements on the locations of signs, raised retroreflectors, and portable construction barriers.

The statistical analysis for the required number of trials is presented in Section 6.4.1.3. Briefly, demonstration of satisfactory performance for alerts requires the system produce no more than three crash alerts when the FCW equipped vehicle is exposed to three times the number of exposures expected in a week.

$$3 \geq I \equiv \sum_{k=1}^{9} I_k \quad : \mathrm{k} = \mathrm{N1} \quad \ldots \quad \mathrm{N9}$$ **Equation 6-1**

where:

I_k is the number of crash alerts generated during the kth test,

I is the total number of alerts generated during the tests

6.4.1.3 Repetitions Needed for Out-of-Path Nuisance Alert Tests

The following analysis derives the requirements for the number of repetitions for each of the out-of-path nuisance alert tests.

The analysis is based upon the following considerations. First, it is assumed to be important that the number of trials is not excessive, so that the tests are feasible to execute. The introduction to Chapter 5 suggested that four weeks (for all tests) is a practical testing period, therefore two-weeks is assumed to be a practical duration for out-of-path nuisance alert testing.

Second, it is assumed that alerts are independent events. That is, whether an alert occurs in an encounter with one type of object is independent of the time since the last alert occurred or the presence of other objects.

Third, the SV is presented with essentially the same set of conditions several times. The trial repetitions provide the data required to estimate the likelihood that an alert will be produced under those conditions. Sets of trials are conducted for each of several distances between the objects and the Alert Zone. Successful performance in the out-of-path nuisance alert tests is based on the performance for all valid trials of the tests.

Suppose that the requirement for out-of-path nuisance alerts is that there be less than one alert in some time, T_i, of driving. Suppose that the number of encounters with sources of out-of-path nuisance alerts in time T_i is N_i. Then the requirement corresponds to a limit of $1/N_i$ on the probability that an encounter will cause a crash alert.

Terminology

A *scenario* is a general term that designates a combination of a driving pattern, a set of environmental conditions, and a set of objects or other vehicles that could cause a FCW system to produce an alert. Examples of scenarios include driving under a sign or approaching a stopped motorcycle.

An *incident*, or *encounter*, is a specific instance of a scenario. For example, each time a vehicle drives under a sign is one incident.

A *trial*, *run* or *repetition* is a specific experiment in which a vehicle equipped with a FCW system is driven toward one or more objects. A single trial can involve exposing the system to multiple incidents, such as driving past a row of slowly moving cars or over a series of road surface objects.

A *test* involves performing one or more repetitions of a scenario. The repetitions may be done so that each repetition is as similar as possible to the other repetitions. Alternatively, the repetitions may be done with one or more independent variables changed, such as when each run is closer than the previous to some roadside object.

A *sample* is the result of an experiment. An experiment may be one incident, one run, or one test.

A *sample space* is the set of all possible outcomes of an experiment. In statistics an *event* is a subset of the sample space. If an experiment involves exposing a FCW system to three incidents then sample space is the set of all possible combinations of outcomes from the three incidents and an event may be any outcome in which the FCW satisfies the minimum requirements all three times.

An *exposure rate* or *exposure frequency* is the number of times per day, week, or year that a FCW system is likely to experience a particular combination of conditions. For example, a system may be exposed to 500 roadside signs per week. Similarly, a system may be exposed to 20 cut-ins per week.

Trial Repetition Analysis

We want to conduct an experiment that will demonstrate whether or not a FCW system meets the requirements. So, an experiment will be conducted to estimate the frequencies of alerts.

Let p_i be the actual probability of an alert in one exposure. Let $q_i = 1 - p_i$ be the probability that an encounter will not generate an alert.

Let n be the number of trial exposures to sources of out-of-path nuisance alerts. Let x_i be the number of alerts generated in n exposures. The probability of x alerts in n exposures, p(x) is a binomial distribution. For large n the binomial distribution can be approximated by the Poisson distribution with mean $\mu = np$ and variance $\sigma^2 = np$. In addition, if $np \geq 5$ and $nq \geq 5$ then the binomial distribution can be approximated by a normal distribution with mean $\mu = np$ and variance $\sigma^2 = npq$. However, since we want to minimize the number of trials, we hope that we can use $n < 5N_i$, in which case the normal distribution approximation will not be very accurate.

The formula for the Poisson distribution is given by:

Equation 6-2

$$p(x) = \frac{\alpha^{x}}{x!} \times e^{-\alpha}$$

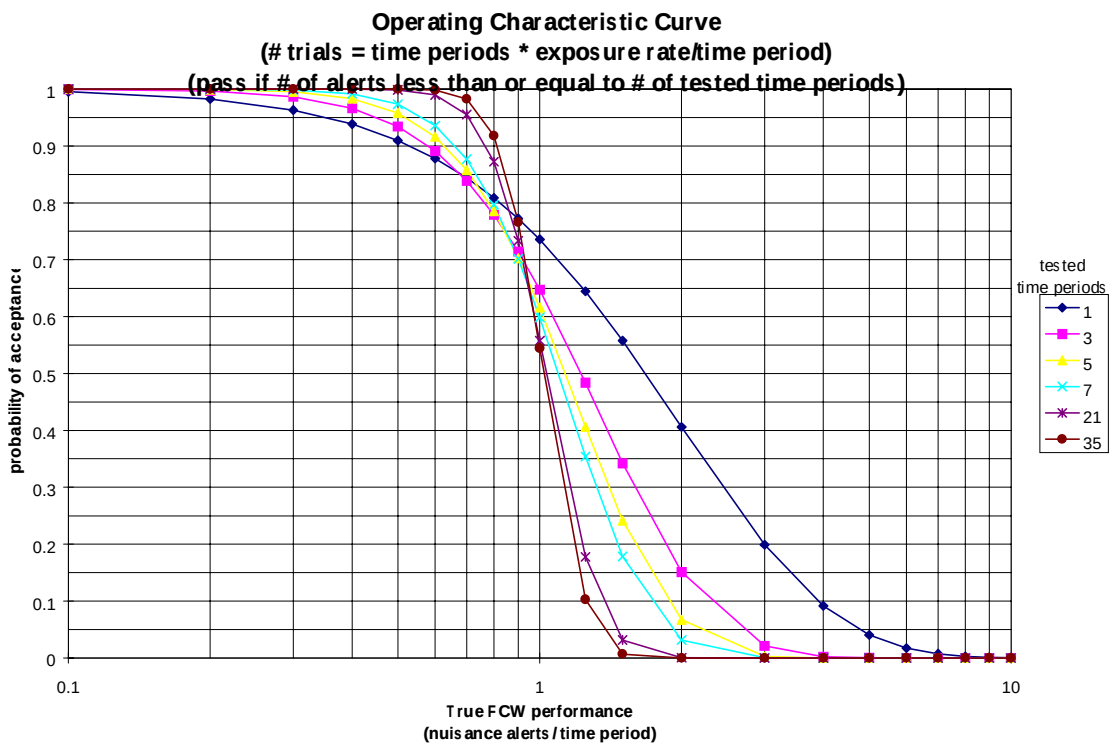
where

$$\alpha = np$$

We will use the maximum likelihood estimator of p_i which is x/n. The test specification will be that a system passes the test if $x_i/n \leq 1/N_i$.

The question is to determine a value for n that adequately discriminates between systems that meet the requirements and those that do not. Figure 6-1 shows a set of operating characteristic curves for different values of n.

Figure 6-1 Test Procedure Operating Characteristic Curves



The operating characteristic curves show the relationship between the true performance of a FCW system and its likelihood of passing the tests for different values of n. In Figure 6-1, the number of exposures is shown as an integer multiple of N_i. The tradeoff for selecting n involves examination of the likelihood that systems that exceed or do not meet the requirements by some amount will pass. It was decided to consider systems whose true nuisance alert rates are either half or twice the requirement. It is also informative to consider the likelihood of passing for a system whose performance is just at the limit for passing.

Consider a test set where $n=N_i$. Then a system whose p_i is $1/N_i$ will have a 74% chance of passing the test. Also, a system that has $p_i = 1/2N_i$ will have a 91% chance of passing and one that has p_i =

$2/N_i$ has a 40% chance of passing. As the number of exposures increases, the likelihood that a system will pass goes down if it has p_i exactly at the limit or twice the limit. Also, as the n increases the likelihood that a system that has a p_i that is half the limit will pass goes up. A value of $n=3N_i$ would provide less than a 15% chance that a system with twice the acceptable nuisance alerts would pass. Also, if $n=3N_i$, there is an 89% chance that a system with half the acceptable nuisance alerts will pass. This was judged by CAMP to provide adequate discrimination between systems that meet and those that do not meet the nuisance-alert rate requirements.

6.4.2 Data Analysis and Reporting For Specific Out-Of-Path Nuisance Alert Tests

6.4.2.1 Test N-1: Overhead Sign at Crest of Hill

This procedure test the sensitivity of a FCW system to objects commonly found over the traffic lanes of roads. The test covers the difficult condition wherein a crest curve causes the overhead object to appear directly ahead of the SV. The test is conducted using an overhead sign, which is used to representative both signs and bridges commonly found over urban and rural roads.

Additional Requirements to Demonstrate Test Validity

The test involves selecting a driving speed that corresponds to the design speed for the vertical curvature of the hill. The profile of the hill and the minimum rate of vertical curvature (in meters per % change in grade) must be reported.

The test should be run with the sign directly ahead of the SV and perpendicular to the grade of the hill before the crest. The report must include analysis of the orientation and position of the sign to show that the sign position and orientation satisfied this requirement when the tests were run.

If an alert occurs, verify that the sign caused the alert by comparing the measured distance between the SV and the sign with the reported distance to the object that caused the alert.

Countermeasure Performance Evaluation

The following table indicates a hypothetical distribution of heights that should be used in the tests. The total exposure is based upon the pilot study's estimated exposure of 12 overhead signs and 16 overhead traffic signals per day.

The height distribution is based upon an assumption that sign heights are evenly distributed between the minimum bridge height recommended by the AASHTO guidelines and a height 1 m above the minimum. The AASHTO guidelines recommend a minimum clearance for underpasses of 4.4 m with 5.0 m indicated as more desirable. In addition some roadways, including freeways and arterial systems, are parts of systems or routes for which a minimum vertical clearance of 4.9 m has been established for underpasses. The Manual on Uniform Traffic Control Devices (MUTCD) requires a minimum height of 17 feet (5.18m) unless the sign is placed on another lower structure such as a bridge.

The number of alerts generated during 21 days worth of exposure is I_{N-1} in equation 6-1.

Sign height above road (meters)	4.4-4.65	4.65-4.9	4.9-5.15	5.15-5.4
Average exposure per day	7	7	7	7

6.4.2.2 Test N-2: Road Surface Objects on Flat Roads

This test is used to determine the sensitivity of a FCW system to small objects that vehicles frequently drive over. The representative objects include lane-marking retro-reflectors, tire debris, beverage cans, and a piece of wood. The test is conducted on a straight section of track.

Additional Requirements to Demonstrate Test Validity

Report the manufacturer and model of the retroreflectors used in the test.

Report whether the vehicle passed over each of the types of road surface objects.

Countermeasure Performance Evaluation

When retroreflectors are used on rural roads, the AASHTO guidelines suggest that they be placed at intervals that are twice the interval for broken line segments. The recommendation is that broken line segments consist of 10' segments and 30' gaps. Therefore, when retroreflectors are present on rural roads the recommended spacing is one every 80' (24.4 m). Horowitz (1986) reported an average driving distance of 201 miles/week (323 km/week). However, typically only a fraction of the distance traveled would have raised retroreflectors as lane markings. The pilot study found no retroreflectors on the route traveled. To provide a meaningful test, The following table assumes that approximately 5% of the distance traveled would have raised retroreflectors.

The pilot study found no instances of debris in the through-traffic lanes of the route taken. To provide a meaningful test the frequency at which vehicles drive over debris such as beverage cans, pieces of wood, or pieces of tires is assumed to be less than once every other day (i.e., about once every 57 miles of travel).

The following table indicates a hypothetical distribution for exposure to road surface objects that should be used in the tests.

	Road Surface Retroreflectors	**Debris**
Average Exposure Per Day	100	0.5

The number of trial exposures for each type of object (retroreflectors or debris) is the number of each type of object on the course multiplied by the number of passes through the course.

The number of alerts generated during 21 days worth of exposure is I_{N-2} in equation 6-1.

6.4.2.3 Test N-3: Grating at Bottom of Hill

This test is used to determine the sensitivity of a FCW system to metal road surface objects, such as a grating, that vehicles frequently drive over. The test is conducted so that the visibility of the grating is increased by its location on a sag vertical curve.

Additional Requirements to Demonstrate Test Validity

Document the construction of the grating to demonstrate it meets the requirements set forth in Chapter 5.

Countermeasure Performance Evaluation

Although gratings and manhole covers are common, they are less commonly found in the center of a lane at the bottom of a hill. No such instances were found during the pilot study. The following table indicates a hypothetical distribution for the typical exposure of FCW systems, to gratings at the bottom of a hill.

	Grating at Bottom of Hill
Average Exposure per Day	1

The number of alerts generated during 21 days worth of exposure is I_{N-3} in equation 6-1.

6.4.2.4 Test N-4: Guardrails and Concrete Barriers

This test is used to determine the sensitivity of a FCW system to roadside barriers such as metal guardrails and concrete dividers.

Additional Requirements to Demonstrate Test Validity

Document the construction of the guardrails and Concrete Barriers to demonstrate that they conform to the requirements contained in Chapter 5.

Countermeasure Performance Evaluation

The following table indicates a hypothetical distribution for the typical exposure of FCW systems to guardrails and concrete barriers. The total exposure is based upon the pilot study, which suggests vehicles are exposed to 19 guardrails and 5 concrete barriers per day in the near vicinity to the lane they are traveling in.

The distribution of distances from the Alert Zone is based upon an assumption that the distribution of barriers from the edge of a lane is evenly distributed from the minimum recommended by the AASHTO guidelines to the maximum that is 4 meters from the edge of the lane. The AASHTO guidelines suggest that barriers on highways be placed no closer to the roadway than the recommended shoulder width. On local roads and streets barriers may be as close as 0.5 m from the roadway. The minimum shoulder width in the median of highways is 1.2m on four lane highways with a minimum of 3.0 m on six lane highways. For the right hand shoulder the recommended minimum shoulder width for the lowest volume roadways is 0.6 m with a preferred

width of 1.2 to 2.4 m. For high-volume high-speed roadways the recommended minimum is 3.0 m with a preferred width of 3.6 m.

Distance of Object from Alert Zone (meters)	0.5-1.5	1.5-2.5	2.5 to 3.5	3.5 to 4.5
Guardrails (Typical Exposure per Day)	5	5	5	5
Concrete Barriers (Typical Exposure per Day)	1	1	1	1

The number of alerts generated during 21 days worth of exposure is I_{N-4} in equation 6-1.

6.4.2.5 Test N-5: Roadside Objects by Straight and Curved Roads

This test is used to determine the sensitivity of a FCW system to common roadside objects. The representative objects include small and large signs, mailboxes, and construction barricades.

Additional Requirements to Demonstrate Test Validity

No Lane Markings – The user should document that the test is executed on a roadway that meets the requirement of a site with "no lane markings." (See Chapter 5, Definitions, for a definition.)

Countermeasure Performance Evaluation

The following table indicates a hypothetical distribution for the typical exposure of FCW systems to roadside objects. The total exposure for each type of object is based upon the pilot study results.

The distributions of distances from the Alert Zone are based upon an assumption that sign locations are evenly distributed between the minimum distance from the roadway to a distance 2 m farther than the minimum. The MUTCD recommends that signs should not be closer than 6 feet (1.8 m) from the edge of the shoulder, or if no shoulder is present, no less than 12 feet (3.65 m) from the edge of the traveled way. In urban areas, where necessary, a clearance of 1 foot (0.3 m) from the curb face is permissible. The table takes into consideration that vehicles do not always travel in an outside lane and do not normally travel along the edge of a lane. In addition it is assumed, for lack of a better estimate, that there are an average of 8 small signs, 4 large signs, and 4 mailboxes per mile of travel. Based on Horowitz (1986) the average distance driven per day is 28.7 miles.

Part VI of the MUTCD includes recommended practices for the location of temporary barricades to divert traffic in road maintenance zones. The guidelines include recommended practices for shoulder tapers and tapers for shifting lanes. In general, there will not be a shoulder between temporary barriers and the traveled way. Therefore, the table assumes that the barriers will be on the edge of the traveled way. The recommended practice is to space the barriers so that the distance between them (in feet) does not exceed the speed (in mph) when used for a taper and should not exceed twice the speed when used for tangent channeling. The table assumes, for lack of a better estimate, that FCW equipped vehicles will pass an average of 0.5 km of road with construction barriers per day spaced at 40-ft intervals.

Distance of Object from Alert Zone (Meters)	0.5-1.5	1.5-2.5	2.5 to 3.5	3.5 to 4.5
Small signs	50	50	50	50
Large signs	16	16	16	16
Mailboxes	11	11	11	11
Construction barricades	24	24	24	24

The number of alerts generated during 21 days worth of exposure is I_{N-5} in equation 6-1.

6.4.2.6 Test N-6: U-Turn with Sign

This test is used to determine the sensitivity of a FCW system to signs found near U-turn lanes in the median of a road. The signs are placed so that they are directly in front of the SV as it approaches the U-turn, at a distance of 3 meters from the edge of the roadway. The SV approaches the U-turn at a high speed, decelerates at the last moment, and then negotiates the turn.

Additional Requirements to Demonstrate Test Validity

None.

Countermeasure Performance Evaluation

The following table suggests a hypothetical distribution for the typical exposure of FCW systems to this scenario. The total exposure is based upon the pilot study, which suggests that two U-turns per day.

	U-Turns
Average Exposure per Day	2

The number of alerts generated during 21 days worth of exposure is I_{N-6} in equation 6-1.

6.4.2.7 Test N-7: Slow Cars in Adjacent Lane at a Curve

This test is used to determine the sensitivity of a FCW system to slower moving traffic in adjacent lanes. The test is conducted where a curve puts slower traffic directly ahead of the SV as it approaches the curve.

Additional Requirements to Demonstrate Test Validity

The make and model of the slow cars must be recorded. If they are not the same as the standard vehicles then their optical or radar cross sections (whichever is appropriate for the sensing technology) should be demonstrated to be within 20% of the cross sections for the standard vehicle.

The test is to be executed on wet pavement. Report whether the pavement is wet due to rain or artificial wetting.

Countermeasure Performance Evaluation

No statistical data or guideline information was available to support a value for the total exposure to slow moving cars in adjacent lanes. The pilot test indicated a total exposure of 2 slow moving and 16 parked or stopped vehicles in adjacent lanes per day. To provide a more meaningful test the frequency which vehicles drive past slow moving cars was assumed to be 20. There are two tests for this scenario, one with wet pavement (with good lane markings) and one with poor quality lane markings (and dry pavement). For the purposes of these tests, the total exposure is divided with 75% on dry pavement and 25% on wet pavement.

The following table indicates a hypothetical distribution of the distances of cars in adjacent lanes from the Alert Zone. The table is based upon an assumption that the lateral distances between cars will be evenly distributed with an average equivalent to the distance if both vehicles were in the center of their lane and with a minimum of 0.5 m. Assuming an average lane width that is half way between the AASHTO minimum for low-volume low-speed streets, (3.0 m) and the recommended width for interstate highways (3.6m) and an average vehicle width of 2.1 m yields an average separation of 1.2 m. The values in the following table are adjusted to account for the distance that the Alert Zone extends beyond the side of the FCW equipped vehicle and rounded for convenience.

Distance from Alert Zone (meters)	0.0-0.5	0.5-1.0	1.0-1.5
Average Exposure per Day	9	9	9

The number of alerts generated during 21 days worth of exposure is I_{N-7} in equation 6-1.

6.4.2.8 Test N-8: Trucks in Both Adjacent Lanes

This test is used to determine the sensitivity of a FCW system to slower traffic that is at the same distance in both adjacent lanes. The test determines whether adjacent vehicles may be mistakenly interpreted as one vehicle directly ahead of the SV.

Additional Requirements to Demonstrate Test Validity

The make and model of the trucks must be recorded. If they are not the same as the standard trucks then their optical or radar cross sections (whichever is appropriate for the sensing technology) should be demonstrated to be within 20% of the cross sections for the standard trucks.

Countermeasure Performance Evaluation

No statistical data or guideline information was available to support a value for the total exposure to situations where there are slow moving vehicles at the same distance in both adjacent lanes. The pilot study did not experience any events of this type. To provide a reasonable test, it was assumed that a typical driver would experience this scenario three times during an average day of driving (28.7 miles).

The following table indicates a hypothetical distribution of distances of cars in adjacent lanes from the Alert Zone. The distribution of distances is based upon the same logic as was used for the table in Section 6.4.2.7.

Distance from Alert Zone (meters)	0.0-0.5	0.5-1.0	1.0-1.5
Average Exposure per Day	1	1	1

The number of alerts generated during 21 days worth of exposure is I_{N-8} in equation 6-1.

6.4.2.9 Test N-9: Slow Cars in Adjacent Lane at a Curve, Poor Quality Painted Lane Markings

This new test is identical to N-7, except that this test is to be run on a dry roadway with poor quality painted lane markings.

Additional Requirements to Demonstrate Test Validity

The make and model of the slow cars must be recorded. If they are not the same as the standard vehicles then their optical or radar cross sections (whichever is appropriate for the sensing technology) should be demonstrated to be within 20% of the cross sections for the standard vehicle.

The test is to be executed at a test site with poor lane markings. Document all measurements and observations made that support the claim that the lane markings meet the requirements for such a test site.

Countermeasure Performance Evaluation

All remarks for Test N-7 apply here.

Distance from Alert Zone (meters)	0.0-0.5	0.5-1.0	1.0-1.5
Average Exposure per Day	3	3	3

The number of alerts generated during 21 days worth of exposure is I_{N-9} in equation 6-1.

6.5 Conclusions

This chapter specifies requirements for analysis and reporting of data collected during the execution of the objective tests. The outcome is a determination of whether or not a FCW system meets the set of minimum functional requirements developed in Chapter 4.

6.6 References

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