



Section 6. Coverage Acceptance Test Plan

6.1 Bit Error Rate Coverage Acceptance Test Plan for Voice

6.2 Overview

This Coverage Acceptance Test Plan (CATP) is designed to verify that the voice radio system implemented by Motorola meets or exceeds the required coverage reliability within DuPage County ETSB's service area as indicated on Motorola's coverage maps. The CATP defines the coverage testing method and procedure, the coverage acceptance criterion, the test documentation, and the responsibilities of both Motorola and DuPage County ETSB.

Coverage Acceptance Testing is based upon a coverage prediction that accurately represents the implemented infrastructure and parameters that are consistent with the contract agreements. If the implemented system varies from the design parameters, then a revised coverage map will be prepared. New test maps will reflect the measured losses and gains associated with the implemented infrastructure and subscribers. These will be used to define the test configuration and potential areas from which test locations may be included in the evaluation process. To verify that the radio coverage reliability is met, the indicated coverage area within DuPage County ETSB's operating area will be divided into equally sized test grids.

The following text provides a detailed description of the CATP:

6.3 CATP Definitions

Several definitions are needed to accurately describe the coverage test method. Where cited, these terms or methods are defined in TSB-88A-1¹.

¹ *Wireless Communications Systems --- Performance in Noise- and Interference-Limited Situations --- Recommended Methods for Technology-Independent Modeling, Simulation, and Verification*, Technical Service Bulletin TSB-88A-1, Telecommunications Industry Association (TIA), Arlington VA, 1999 & 2002.

6.3.1 Coverage Area

The coverage area is the geographical region in which communications will be provided which meets or exceeds the specified Channel Performance Criterion at the specified reliability for the specified equipment configuration(s). Radio systems are typically designed to maximize the coverage area within the customer’s service area (users’ operational area, jurisdictional boundaries, etc.) {TSB-88A, clause 4.1} The predicted coverage area for this system is indicated on Motorola’s coverage map(s) supplied with this proposal.

6.3.2 Channel Performance Criterion (CPC):

The CPC is the specified minimum design performance level in a faded channel. {TSB-88A, clause 4.2} ***For DuPage County’s system, the CPC is a Delivered Audio Quality of DAQ-3.0.*** The DAQ definitions are provided in Table 1. {TSB-88A, §4.5.1, Table 1}. Given the static reference sensitivity of a receiver, the faded performance threshold for the specified CPC is determined by using the projected CPC requirements for different DAQs listed in TSB-88A, Annex A, Table A-1] For digital voice systems, the faded performance threshold is for a Bit Error Rate (BER) that provides the specified CPC. The CATP pass / fail criterion for each test location is the Delivered Audio Quality of DAQ-3.0.

Table 6-1: Delivered Audio Quality Definitions

DAQ (Delivered Audio Quality)	Subjective Performance Description
1	Unusable, speech present but unreadable.
2	Understandable with considerable effort. Frequent repetition due to noise / distortion.
3	Speech understandable with slight effort. Occasional repetition required due to noise / distortion.
3.0	Speech understandable with repetition only rarely required. Some noise / distortion.
4	Speech easily understood. Occasional noise / distortion.
4.5	Speech easily understood. Infrequent noise / distortion.
5	Speech easily understood.

6.3.3 Reliability

The reliability is the percentage of locations within the coverage area that meet or exceed the specified CPC. Motorola’s coverage map(s) indicate the area within which this system is predicted **to provide at least 95% reliability of meeting or exceeding the CPC of DAQ-3.0.** {TSB-88A, subclause 4.4.2; **not** regulatory contour reliability }



6.3.4 Equipment Configurations

These are the types and configurations of radio network and field unit equipment upon which coverage acceptance is based. Motorola's coverage maps for this system indicate the coverage area for the following equipment configuration:

- ◆ Receiver voting coverage from 2.5 Watt ASTRO narrow pulse portables inside 12dB loss buildings. The APX7000 portable at hip, with half-wave antenna, in a swivel case with Remote Speaker Microphone (RSM).

6.3.5 In-Building Coverage

Motorola's coverage maps for portable in-building equipment configurations are predictions of coverage inside 12dB loss buildings as specified by the DuPage County ETSB. The definitions of different building types is in Table 2.

Table 2 – Building Type Definitions

Building Type	Definition
Large	Large downtown building, large commercial building, or large enclosed shopping mall.
Medium	Small to medium size stores, small apartment buildings, or a small to medium size factory or office buildings.
Light	Residential buildings (1 and 2 story houses) and small commercial buildings.

Since building loss varies significantly depending on the construction of buildings, Motorola's coverage maps do not predict coverage within any specific building. Rather, the in-building coverage maps indicate the area within which this system is predicted to provide 95% reliability of meeting or exceeding the CPC of DAQ-3.0 within buildings that have up to the specified Building Loss.

The in-building coverage maps apply only to the above ground portions of buildings. The coverage maps do not apply to in-building locations that are shielded from radio penetration, such as elevators, basements below ground level, tunnels, bank vaults, x-ray rooms, nuclear facilities, and other locations shielded by metal walls or with heavy construction and with no external windows or doors.

6.4 CATP Method

The method used to test coverage is statistical sampling of the predicted coverage area to verify that the CPC is met or exceeded at the required reliability for each of the defined equipment configurations. It is impossible to verify every point within a coverage area, because there are infinite points; therefore, coverage reliability will be verified by sampling a statistically significant number of randomly selected locations, quasi-uniformly distributed throughout the predicted coverage area.



This CATP provides a method of tracking test tile location using Motorola's VoyagerSM hardware and software. A GPS receiver will provide location information indicating when a valid test tile is available for testing. The method follows TIA TSB-88A section 7.0, "Performance Confirmation" for statistical sampling.

6.4.1 Determine the required number of test tiles in the coverage area

The predicted service area will be divided into a grid pattern to produce at least the number of uniformly sized test locations (or tiles) required by the Estimate of Proportions formula. {TSB-88A, subclause 7.2.1, equation 52} The minimum number of test tiles required varies for different systems, from a hundred to many thousands, depending on the size of the coverage area, desired confidence in results, type of coverage test, and the predicted versus required reliability.

6.4.2 Constraints on test tile sizes

The minimum tile size is 100 by 100 wavelengths; however, the minimum practical tile size is typically about 400 by 400 meters (about 0.25 by 0.25 miles). The minimum practical tile size for any system is determined by the distance traveled at the speed of the test vehicle while sampling, GPS error margin, and availability of road access within very small tiles. A related consideration is the time, resources, and cost involved in testing very large numbers of very small tiles. The maximum test tile size is 2 by 2 km (1.25 by 1.25 miles). {TSB-88A, subclause 7.4.3}. In some wide-area systems, this constraint on maximum tile size may dictate a greater number of test tiles than the minimum number required by the Estimate of Proportions formula.

For DuPage County's Declared Service Area, 0.25 by 0.25 miles tiles are used to a total of 7093 tiles.

6.4.3 Accessibility to test tiles

Prior to testing (if possible) or during the test, Motorola and DuPage County ETSB will determine whether any test tiles are inaccessible by road for the coverage test (due to lack of roads, restricted land, etc. Any tile that is found to be inaccessible by vehicle at the point of the drive test will **not** be counted in the CATP pass/fail count. Motorola and the driver will use commercially reasonable efforts to drive all tiles that are part of the gridded coverage area, which includes contacting local forest preserve officers to request access to non-public roads and going as far as reasonably possible in the vehicle in residential and commercial neighborhoods.



6.4.4 Randomly Select a Test Location Within Each Tile

Using VoyagerSM, the actual test location within each tile will be randomly selected by the test vehicle crossing into the tile at an arbitrary point, with an arbitrary speed and direction.

6.4.5 Perform Measurements in Each Tile

In each test tile, a series of sequential measurements (subsamples) will be made. This test location measurement, containing a number of subsamples, constitutes the test sample for this location. The test sample will establish the local mean BER within the test tile. The distance over which the subsamples are measured will be 40 wavelengths. A mean of multiple BER subsamples is used rather than a single measurement to ensure that the measurement is not biased by taking a single sample that might be at a peak or null point on the radio wave.

6.4.6 Determine If Each Tile Passes or Fails the CPC Requirement

For each test tile, the pass / fail criterion is the Bit Error Rate (BER) that provides the specified CPC. To measure BER, the coverage test will be performed with the appropriate attenuator value installed in the test receiver's antenna line, to establish an equivalent signal level performance for each configuration. Coverage for the portable in-building equipment configurations will be verified for acceptance by attenuation of the test receiver for BER tests. The attenuation will be the difference between the mobile test receiver's antenna system and the additional loss used in Motorola's coverage prediction to account for portable antenna performance and in-building penetration. The attenuator values calculation is provided below. This provides an objective method of verifying that the radio system provides the faded performance threshold (BER) for the specified CPC for each of the defined equipment configurations.

6.4.7 Determine the Coverage Area Reliability for Acceptance

After all accessible tiles in the coverage area have been tested; the coverage area reliability (%) will be determined by dividing the number of tiles that pass by the total number of tiles tested. {TSB-88A, clause 7.1, equation 51} The coverage test acceptance criterion is that the tested coverage area reliability must be equal to or greater than the required reliability.



6.5 Responsibilities and Preparation

This information will help set the expectations of DuPage County ETSB and Motorola regarding requirements for equipment, personnel, and time during the coverage test.

DuPage County ETSB will provide the following for the duration of the coverage test:

- ◆ At least two test vehicles that are representative of the vehicles used by DuPage County ETSB
- ◆ At least two DuPage County ETSB representatives, to drive each test vehicle and/or to be the customer representatives for the test teams

Motorola will provide the following for the duration of the coverage test:

- ◆ At least ***one*** Motorola representative, to navigate and to operate VoyagerSM per test vehicle
- ◆ At least one calibrated Motorola VoyagerSM coverage testing package per test vehicle
- ◆ At least one laptop computer equipped with VoyagerSM software per test vehicle

Coverage acceptance testing will be performed throughout DuPage County ETSB's declared service area, as indicated on the coverage map. Motorola will determine the minimum number of test tiles required, as described in the Method section of this CATP. Motorola and DuPage County ETSB will plan the route for the test vehicles through the coverage test area, to ensure that at least the minimum required number of tiles are tested. If possible, any tiles not accessible to the test vehicle(s) will be identified while planning the route.

Motorola will calibrate the test receivers used with the VoyagerSM coverage testing package. Depending on the system, the test receivers may be provided by either Motorola or DuPage County ETSB. Motorola will provide the attenuator values required to evaluate each equipment configuration from the outbound BER measurements.

Motorola will conduct this test only once. If any portion of the test is determined to be unreliable because of proven equipment malfunctions or failures, Motorola will repeat the portion of the test affected by the equipment malfunction or failure.

DuPage County ETSB will have the option to accept the coverage at any time prior to completion of the coverage test. Before starting the test, DuPage County ETSB and Motorola will agree upon the time frame for Motorola's submission of a report containing the coverage test results.



6.6 CATP Procedures

A quantitative coverage acceptance test will be performed using Motorola's VoyagerSM package, to provide objective verification that the system provides the faded performance threshold for the specified CPC.

VoyagerSM consists of the following:

- ◆ A calibrated digital voice test receiver, connected to an antenna installed in a representative location on the test vehicle. The test receiver will monitor transmissions from the fixed network radio site(s).
- ◆ A Global Positioning System (GPS) receiver, which will provide the computer with the location and speed of the test vehicle.
- ◆ A laptop computer with VoyagerSM software and a mapping database, which includes highways and local streets political boundaries, rivers, and railroads.
- ◆ Coverage acceptance will be based on demonstrating that at least 95% of the tiles in the coverage test area for each equipment configuration are measured to provide a mean level of 2.6% BER or better at the test receiver input. A 2.6% BER value corresponds to the system target DAQ (Delivered Audio Quality) value of DAQ-3.0. The system coverage acceptance criterion will be the successful passing of each of the equipment configurations.
- ◆ Any tile that fails the objective VoyagerSM BER test described above will be re-tested using a subjective Delivered Audio Quality (DAQ) test. Any tile that fails the objective test, but passes the subjective re-test will be declared passed.
- ◆ If a coverage test, or a portion thereof, is suspected by Motorola to have failed due to external interference, those tiles suspected of being affected by an interferer may be retested. If the test tiles re-tested are confirmed to have failed due to interference beyond the control of Motorola, those test tiles will be excluded from all acceptance calculations and Motorola will work with DuPage County ETSB to identify potential solutions to the interference issues.

6.7 CATP Documentation and Coverage Acceptance

During the coverage acceptance test, VoyagerSM generates computer files that include the Reference Tile Levels for each test tile. A copy of this raw data will be provided to DuPage County ETSB at the conclusion of the coverage test. Motorola will process this data to determine whether the coverage test was passed for each equipment configuration, and to produce a map detailing the coverage test results.

Motorola will submit to DuPage County ETSB a report detailing the coverage test results.

