NATIONAL TRANSPORTATION SAFETY BOARD
Vehicle Recorder Division
Washington, DC 20594

April 1, 2015

Sound Study

Specialist's Study Report
By George Haralampopoulos

1. EVENT

Location:	Valhalla, New York
Date:	February 3, 2015
Vehicle #1:	2011 Mercedes ML350
Vehicle #2:	Metro-North Train #659 – 8 Car Train
NTSB Number:	DCA15MR006

2. SUMMARY

For a summary of the accident, refer to the *Crash Summary Report*, which is available in the docket for this investigation.

3. SOUND STUDY

A test was conducted on April 1, 2015, at the Commerce Street grade crossing to determine the audibility of the train's horn experienced inside and outside the Mercedes ML350 at the location of the crossing. An exemplar 2011 Mercedes ML350 vehicle was used as the test vehicle, along with regularly scheduled trains on an active track.

3.1. Test Procedure

Prior to the test, ambient measurements were taken inside the exemplar vehicle under three different vehicle settings as a baseline: engine off, idle, and idle with air conditioning setting on maximum.

Figure 1 shows an overview of the grade crossing and its approach. Approximate accident conditions were recreated by placing the exemplar vehicle as close to the west side crossing gate as possible without fouling the track. A track sign known as a whistle post was located about a quarter mile prior to the crossing and signals the train engineer to begin the horn cadence. Two sound level meters were used to measure the sound level of the horn as the train passed the crossing. A test point consisted of measurements collected at the activation of the grade crossing lights until the train passed the crossing.[1]

[1] A horn cadence consists of a long, long, short, long sequential horn activation.

The test was repeated on the east side of the track to determine the change in sound pressure from the power station present on the west side of the track (figure 2). A total of 6 data points were captured; 4 from the west side, and two from the east side.[2]

Figure 1. Overhead and street view of west side of test area.

[2] The east and west track is referenced consistent with Metro-North's convention at that crossing.

Figure 2. Equipment set up on east side of test area.

3.2. Equipment Used

Two Extech SDL600 sound level meters were used during the testing. One device was placed inside the vehicle and the other was placed outside. Both meters were set up to measure A-weighted sound pressure[3] using a fast time weighting time constant to account for quickly changing sound events such as train horn use and approach speeds. A tri-pod and appropriate wind screen was used for the outside device. Each device was calibrated using the SDL600's included 94 dB potentiometer.

A LIDAR speed detection device was used to measure the speed and distance of the passing trains. All LIDAR measurements were taken in line with the passing trains on the east side of the track.

Two video cameras were used to film the LIDAR readings and sound level meters. The video recordings were also used to provide a common time reference between the two sound level meters.

3.3. Car Ambient Condition Test Results

Table 1 shows the car's measured ambient sound pressure levels under three conditions with no train present:

- Engine off
- Engine idle
- Engine idle with maximum air conditioning

[3] A-weighting applies a filter to unweighted sound measure to more closely approximate the frequency response of the human ear.

Table 1. Ambient sound pressure level readings inside car.

Number	Condition	Sound Pressure dB(A)
1	Engine Off	31.4
2	Engine Idle	43.0
3	Idle with A/C	48.7

The duration of each sample was at least 10 seconds. All conditions were measured with the car windows up.

3.4. Completed Test Points

All trains used for testing were regularly scheduled northbound local and express Bombardier M-7 trains. The car's configuration used for all test points was windows up, and engine in idle. The speed as measured from the LIDAR was consistently reported at about 57 miles per hour through each test point. All samples taken from the sound level meter are recorded at one sample per second.

3.4.1. Passing Train East Side Results

Figures 3 through 5 show the inside vehicle vs outside sound level meter readings during each test point taken on the west side of the track. Dashed lines denote where the horn was heard with respect to the recorded video. The x-axis shows time in eastern daylight time, while the y-axis shows weighted sound pressure in dB(A).

Table 2 summarizes the horn activation time in seconds before the grade crossing, and maximum recorded sound level measurement from each meter in dB(A). Data from test point 4 was not used due to improper readings taken during the test.

Table 2. Outside and inside sound pressure readings for west side of crossing.

Test Point	Horn 1 (sec)	Horn 2 (sec)	Horn 3 (sec)	Horn4 (sec)	Max in-car dB(A)	Max outside dB(A)
1	17	10	6	3	95.9	119.5
2	13	6	3	1	102.9	117.0
3	17	11	6	3	102.6	120.2

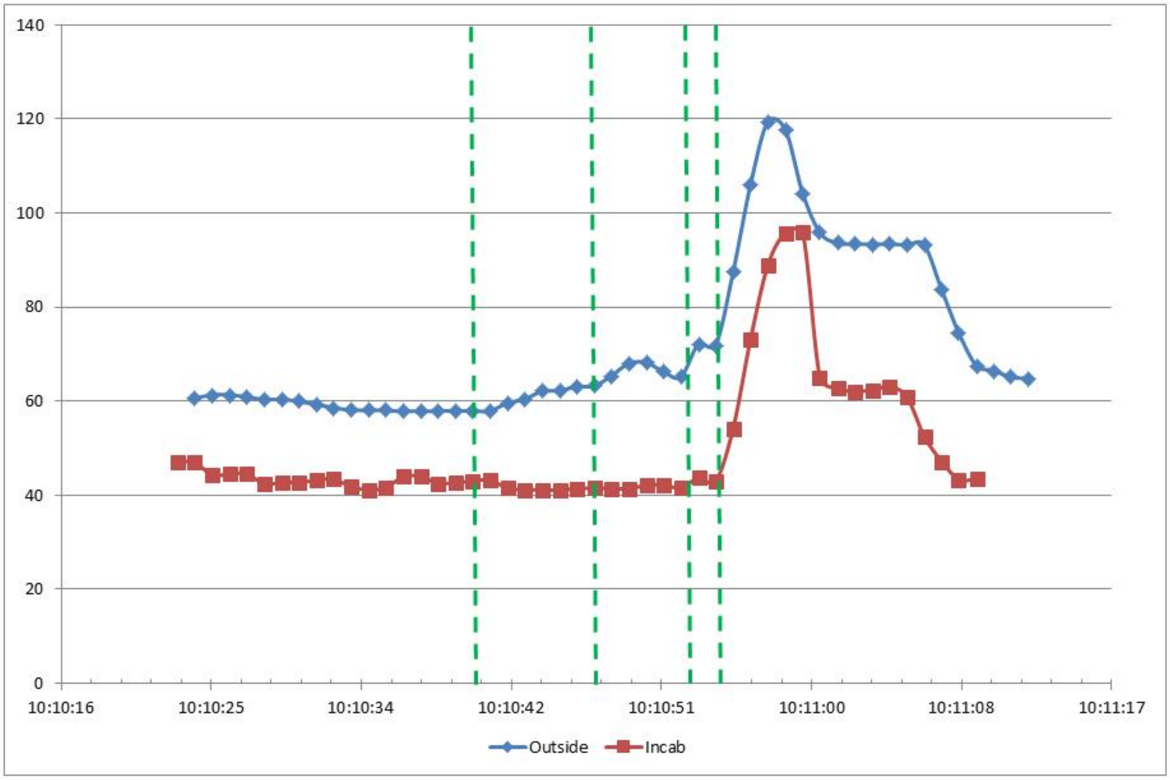

Figure 3. Summary of sound meter results from Test Point 1.

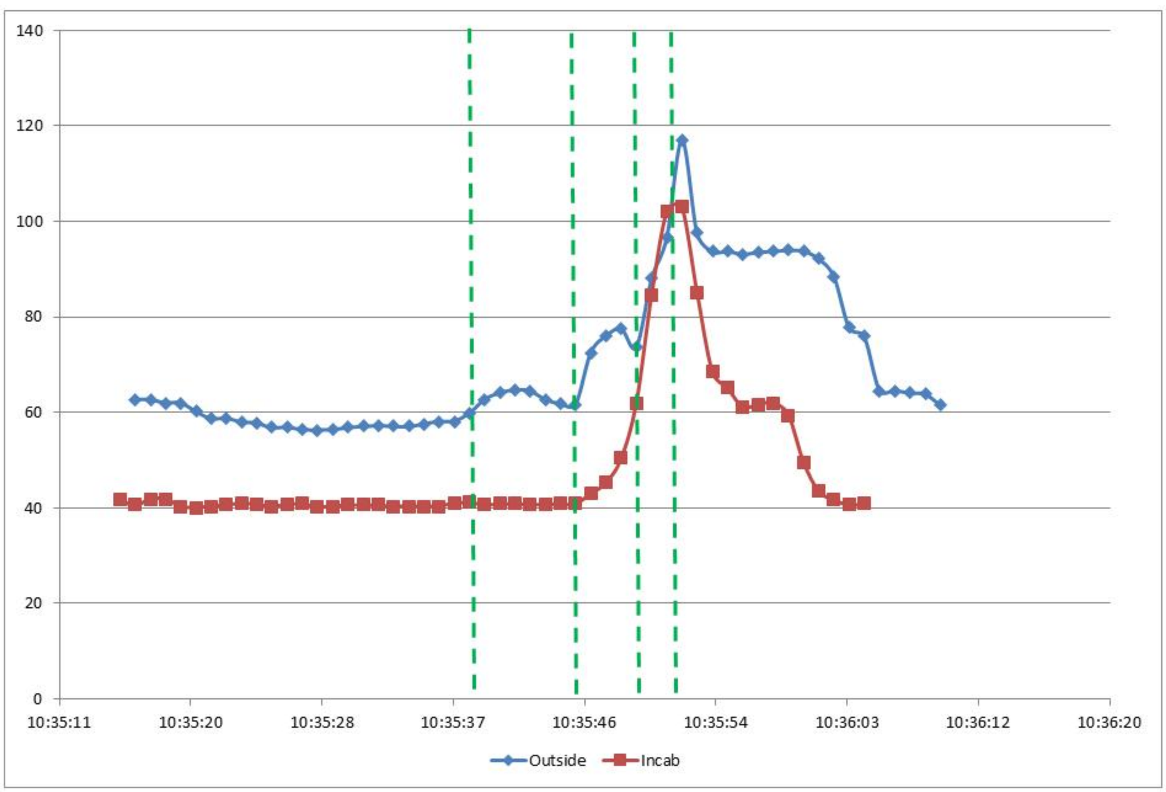

Figure 4. Summary of sound meter results from Test Point 2.

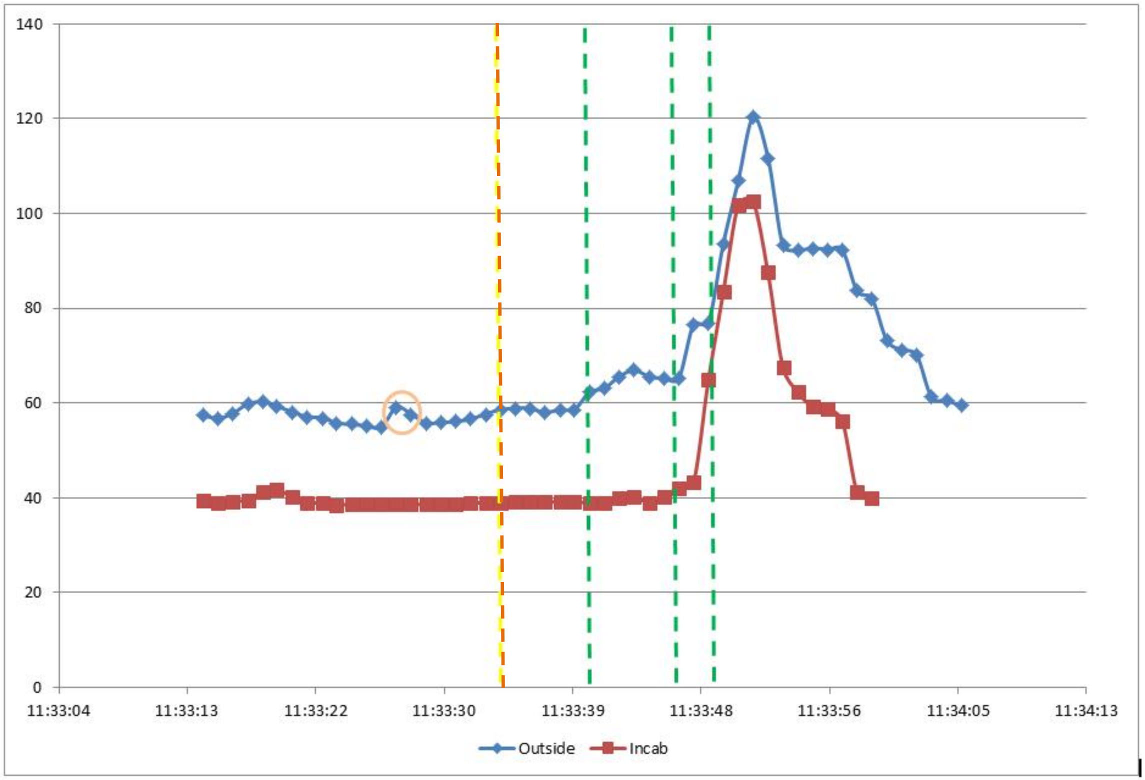

Figure 5. Summary of sound meter results from Test Point 3.

The orange dashed line in figure 5 shows the horn was only audible from the recorded video on the east side of the track. A circle denotes an increase in the ambient noise from passing vehicles during the test point.

3.4.2. Passing Train West vs East Side Results

Test points 5 and 6 were conducted using only the outside sound level meter. Data from test point 6 was not used due to improper readings taken during the test.

Figure 6 compares the sound profile readings from test point 3 and test point 5 from the outside sound level meter. The test points were time aligned based on their peak dB(A) readings. Test point 5 experienced a max dB(A) reading of 120.4 with a sequential horn activation of 18, 13, 8, and 2 seconds before entering the crossing. A dashed line represents the start of the respective test point's initial horn application; purple for test point 5, and green for test point 3.

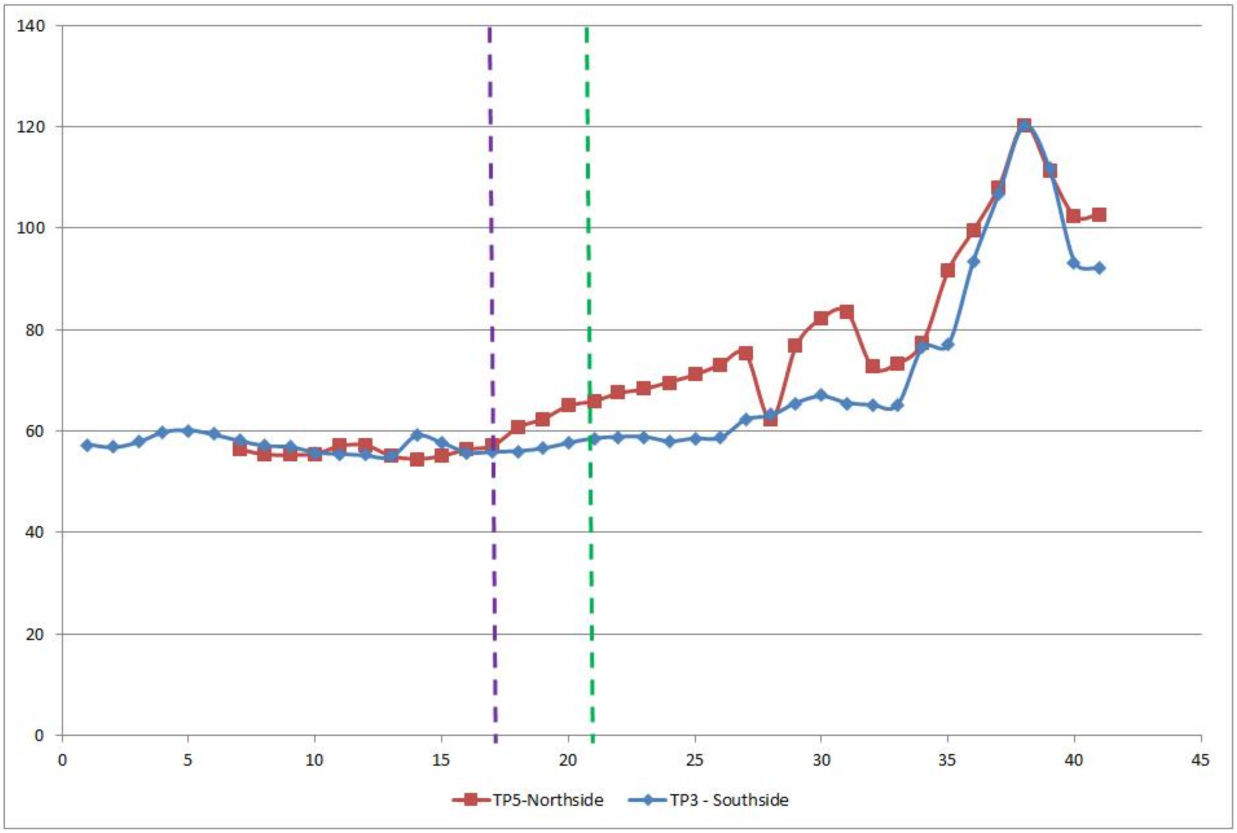

Figure 6. Test Point 3 vs Test Point 5.

3.5. Results and Limitations

The data collected in all three inside of vehicle test points showed that an increase in dB(A) was not noticeable until the 3rd horn application as the train approached.

The max dB(A) recorded from the vehicle's sound level meter was on average 20 dB(A) less than the outside sound level meter.

Horn applications from observed passing trains from two locations were compared: the east side of the tracks and the west side of the tracks (which contained a wayside power station). The horn was consistently 10 db(A) less on the west side when compared to the east side.

The following were identified as limitations to the test:

Use of the horn was at the discretion of the train operator, a significantly shorter cadence was noticed in test point 2.

The vehicle was set up behind the crossing arm adding an estimated 10 feet of distance between the center of the crossing to the location of the vehicle.

The use of the vehicle's heater or radio was not factored into the test, therefore, the car configuration was assumed to be a best case scenario for a driver to detect the horn.

George Haralampopoulos
Aerospace Engineer
Vehicle Recorder Division