National Transportation Safety Board
Office of Railroad, Pipeline and Hazardous Materials
Washington, DC 20594

RRD24MR004

COMMUNICATIONS

Group Chair's Factual Report

June 27, 2024

Table of Contents

A. ACCIDENT

Type:	Collision
Date and Time:	January 4, 2024, 15:00PM
Location:	Express Track 3 & Local Track 4 at 96th Street Station
Carrier:	New York City Transit
Train #1:	1345
Train #2:	1427
Injuries	22 passengers & 3 crew members
Fatalities:	0

B. COMMUNICATIONS GROUP

Group Chair	Brett Johnson National Transportation Safety Board Washington, DC
Group Co-Chair	Adolfo Rodrigues National Transportation Safety Board Washington, DC
Group Member	Tom Kropas New York City Transit Woodside, NY

C. SUMMARY

For a summary of the accident, refer to the *Accident Summary* in the docket for this investigation, RRD24MR004.

D. DETAILS OF THE INVESTIGATION

1.0 Post Accident On-scene Investigations

NTSB investigators conducted post-accident interviews with the train personnel involved in the accident. These included the train operator (who was acting as a flagger) aboard Train 1345, train service supervisor aboard Train 1345, conductor aboard Train 1345, conductor aboard Train 1427, and the railcar inspector aboard Train 1345.

In interviews with NTSB investigators, the flagger in the lead railcar of Train 1345 stated that he lost radio communications with the train service supervisor in the sixth railcar operating the controls near 96th Street Station. The train service

supervisor did not receive the flagger's instructions to stop, Train 1345 passed by a signal requiring a stop at the end of 96th Street Station platform, and collided with Train 1427.

The portable handheld two-way radios used by the train personnel involved in the accident were collected and documented. After documentation, NTSB released the radios back to New York City Transit (NYCT) for radio bench testing. After the lab testing, NYCT secured all the portable radios and were instructed to not release them into revenue service, until further notice by NTSB.

2.0 Description of the Communications Systems for Train Service Operations

NYCT train service employees rely on the mixed use of portable radios and underground radio repeater systems, to facilitate communications between train service employees, and between train service employees and the Rail Control Center (RCC). The frequencies used are in the Very High Frequency (VHF[1]) band, which are licensed and coordinated for NYCT's use by the Federal Communications Commission (FCC).

When employees use portable radios to communicate directly with one another on the same frequency, this mode of communication is called **Simplex**[2] When employees utilize a repeater system, which simultaneously rebroadcasts the transmitted message to a larger area, including to the Rail Control Center, this mode of communication is called **Duplex**[3]. In the transit industry, both Simplex and Duplex communication modes are required due to various environmental constraints and operational factors.

2.1 Train-to-Train Channel (Simplex Communication)

For **Simplex** communication, the receive frequency of a simplex channel is the same as the transmit frequency. Meaning, when the Push-To-Talk (PTT) button is depressed by the employee operating the portable radio, and he/she speaks into the microphone on the radio, the person's voice is converted into a modulated radio signal, which is simultaneously transmitted on the frequency programmed for that selected channel. Once the employee releases the PTT button, the radio will return

[1] VHF – Very High Frequency is the radio frequency band between 30MHz and 300MHz.

[2] A radio operating in Simplex mode, alternates transmitting and receiving over on one radio frequency. (*https://blog.icomamerica.com/2021/10/20/what-do-you-mean-by-simplex-duplex-half-duplex-full-duplex/*)

[3] A radio operating in Duplex mode, transmits on one frequency and receives on a different frequency. This allows for use of a radio repeater system that receives radio frequency transmissions and simultaneously re-transmits on another frequency. This allows for the use of higher power, remote antenna towers and/or by using other means of communication paths, often through Internet Protocol (IP) solutions, to other locations. (*https://blog.icomamerica.com/2021/10/20/what-do-you-mean-by-simplex-duplex-half-duplex-full-duplex/*)

to the same frequency that he/she transmitted on, to then be able to receive a message. In short, one frequency will be used to facilitate radio communication between the employees to communicate messages. The simplex channel that NYCT train service employees use, is referred to as the **Train-to-Train** channel, which has the same transmit and receive frequencies as discussed.

2.2 Command Channel (Duplex Communication)

For the almost exclusive purpose of communicating with the RCC, NYCT employees rely on the use of a radio repeater system.

2.2.1 Repeater Base Stations with Leaky Coax Antenna Networks

The location where radio repeater system control hardware is housed are known as repeater base stations. The repeater base stations within effective range of the track segments between 79th Street and 96th Street stations, are housed at 103rd St & Broadway and at 72nd Street.

The antenna network that connected to repeater base stations, utilizes specialized coaxial cable which functions as an antenna. The cable originates at the repeater base stations and is installed throughout the subway tunnel infrastructure. The industry term for this cable is "Leaky Coax," due to its ability to conduct radio frequency (RF) energy over long distances and allows for the distributed transmission and reception of radio waves where installed.

2.2.2 Repeater Base Stations and RCC Communications

Repeater base stations are connected to the NYCT RCC communications system, through Internet Protocol (IP) based networking, allowing both remote control and monitoring from the off-site RCC location.

When a repeater base station receives transmissions from an employee's portable radio, set on the **Command** channel, the repeater base station simultaneously broadcasts (or transmits) the message through the leaky coax cable network and transmits the message via IP networking, to the RCC. Similarly, when a RCC employee transmits on the Command channel, the repeater transmits the message across the repeater system being delivered via IP networking, from the RCC.

Wherever there is leaky coax cable running along the subway portals, nearby radios would be able to receive transmissions from anyone using the Command channel. This enables two-way communication between employees in the RCC and those employees working throughout the subterranean NYCT network, in some places, many miles from each other and/or the RCC.

2.2.3 Repeater Base Stations and Train Service Employee Communications

With the repeater base stations frequencies programmed on NYCT portable radios as Command channels, utilization of the repeater base station is achieved by two concurrent operation radio operations. First, by using two different frequencies, one frequency for transmitting and a different frequency for receiving. Second, while transmitting an inaudible tone encoded in the frequency being transmitted, which in turn activates the retransmitting functionality of the repeater system receiving the transmission. The generic term for this second inaudible tone is "tone squelch" with the specific type of tone squelch used by NYCT radio networks as Continuous Tone-Coded Squelch System (CTCSS)[4].

If the repeater system receives a transmission on the Command channel frequency but does not have the pre-programmed CTCSS tone squelch encoded within the transmission, the repeater base station stays dormant, and does not broadcast that message, nor does it simultaneously send the message to the RCC. The Command channel CTCSS tone squelch is a parameter that is programmed into all the NYCT train service radios, enabling use of the repeaters.

An example of repeater system use is as follows:

- Example 1: NYCT field employees using portable radios set on the **A-Command** channel ("**A**" is for the A Division) will transmit on [redacted] Mhz w/[redacted] Hz tone squelch, while the repeater simultaneously broadcasts the message on the [redacted] Mhz frequency through the repeater network footprint and into the RCC. Once the employee releases the push-to-talk (PTT) button on the radio, the employee's portable radio will resume listening/receiving on the [redacted] Mhz frequency. Using these offset frequencies and repeaters enables long range communication through the underground subway network.

2.3 Train-to-Train & Command Channels Having the Same Receive Frequency

An important commonality of train service radios is the Train-to-Train (simplex) channel and Command (duplex) channels are programmed with the same receive frequencies. This introduces a unique dynamic in radio communication in the sub-terrain operating environment. From Example 1, refer to table 1.1 for how the frequencies are programmed:

[4] Continuous Tone-Coded Squelch System sub-audible tone system used on some repeaters. When added to a carrier, a CTCSS tone allows a receiver to accept a signal. (*https://www.arrl.org/ham-radio-glossary*)

Radio Unit	Portable	Portable	Repeater System
Channel	Train-To-Train	A-Command	A-Command
Transmit Frequency	[redacted] Mhz	[redacted] Mhz	[redacted] Mhz
Receive Frequency	[redacted] Mhz	[redacted] Mhz	[redacted] Mhz

Table 1.1

3.0 Post Accident NYCT Radio Inspection and Testing

NYCT has an engineering department responsible for maintaining, repairing, calibrating, and programming all the radios owned and operated by the agency. This facility is headquartered in Woodside, NY. Staff at the Woodside engineering facility performed the post-accident testing of the radios. The testing procedures and test result data was shared with NTSB investigators[5]. In summary, all handheld portable radios met the NYCT operational testing requirements.

On February 14, 2024, NTSB investigators visited the Woodside engineering facility and reviewed the testing procedures, processes, test instrumentation, and interviewed the facility staff that performed the post-accident testing of the portable radios, used by the train service employees operating train 1345.

NYCT engineering staff supplied NTSB with the programming details that are common to all the train service employee radios. In summary, the NYCT network is split into 3 different divisions. In each division, there are three main frequencies assigned to individual channels in radio programming, as discussed in section 1.3.2.

3.1 NYCT Handheld Portable Two-Way Radio Specifications and Programming Details

NYCT train service employees are assigned portable radios to use for communication while on duty. As noted in section 1, these devices operate in the VHF frequency spectrum, with an optimum transmitting power of five watts. Additionally, these portable radios use narrowband[6] (NB) channel spacing with analog frequency modulation (FM).

3.1.1 Portable Radio Make and Models

There were two different make and model radios used by the NYCT employees involved in the accident. The TSS and Flagger were using IC-F70S model radios manufactured by Icom. The Conductor was using a VX-P824 model radio

[5] Refer to docket item *96th St Portable Radio Test Report 011224.pdf*

[6] Narrowband – The Federal Communications Commission summarizes the term "Narrowband" in the VHF/UHF spectrum as a land mobile radio system using technology enabling the use of 12.5kHz channel spacing." www.fcc.gov

manufactured by Vertex Standard. Both make and model radios were programmed by NYCT with the same frequencies, modes, modulations, and channels, uniform with NYCT's radio communication plan.

3.1.2 Programming and Controls

Frequencies are assigned to named channels, within the programming of NYCT radios per table 1.2. This enables a user to not have to remember the precise details of each frequency, but to instead having to know what channel name or number that he/she may need to use. To access the desired radio channel, the user will turn one of the two control knobs on the top of the radio, which will cycle through the programmed bank of channels, per picture 1.1.

Channel Switch Position	Radio Display Tag	Channel Description	Receive Frequency (Mhz)	Receive CTCSS (Hz)	Transmitter Frequency (Mhz)	Transmitter CTCSS (Hz)
1	A-CMD	A Division Command	[redacted]	[redacted]	[redacted]	[redacted]
2	A-TR-TR	A Division Train to Train	[redacted]	[redacted]	[redacted]	[redacted]
3	YARD A	Yard A	[redacted]	[redacted]	[redacted]	[redacted]
4	B1-CMD	B1 Division Command	[redacted]	[redacted]	[redacted]	[redacted]
5	B1-TR-TR	B1 Division Train to Train	[redacted]	[redacted]	[redacted]	[redacted]
6	YARD B1	Yard B1	[redacted]	[redacted]	[redacted]	[redacted]
7	B2-CMD	B2 Division Command	[redacted]	[redacted]	[redacted]	[redacted]
8	B2-TR-TR	B2 Division Train to Train	[redacted]	[redacted]	[redacted]	[redacted]
9	YARD B2	Yard B2	[redacted]	[redacted]	[redacted]	[redacted]

Table 1.2

Picture 1.1

4.0 Post Accident NTSB On-Scene Radio Communications Testing

During NTSB interviews with the NYCT employees involved with moving train 1345 from 79th Street Station to 96th Street Station, details were shared about the difficulty they experienced with establishing and maintaining radio communication from the first car operating cab to the sixth car operating cab, using the Train-to-Train channel. Communication became an area of focus during the subsequent investigative steps. It was determined necessary by NTSB investigators, to further investigate the efficacy of using the Train-to-Train channel, in the operating environment between the two stations, which the crew of train 1345 were required to operate in.

NTSB and NYCT coordinated a plan, to run a northbound non-revenue train between the same stations, with the same route Train 1345 did, for testing and measuring the Train-to-Train radio channel performance. The test would also be performed with the same portable radios, that the crew used on January 4th, 2024, leading up to the collision.

On February 14th, 2024, at 9:30AM, NTSB investigators met with NYCT and MTA staff at the 2 Broadway MTA headquarters in New York City, to brief about the work plan and testing procedures for the test train run scheduled for 3:00pm that afternoon.

The meeting opened with NYCT leadership giving everyone a brief synopsis of the accident that occurred on January 4th, 2024. NTSB investigators then briefed NYCT staff on the scope, focus, goals, and safety factors of the test train radio testing procedures (see section 1.4.1), with a route encompassing 79th Street Station to 96th Street Station. The meeting progressed into pre-test briefing and is summarized below:

- NTSB would collect, inspect, and document from NYCT, the five handheld portable radios that were used by employees involved in collision.
- NYCT arranged for a ten car non-revenue train to run the same route, at the same approximate time in the afternoon, as train 1345 did prior to the point of impact near 96th Street Station. However, unlike train 1345, which had 50% of the train being disabled and being controlled from the sixth car operators cab, the test train would be operated as a normal train would from the lead car operating cab.
- NYCT would provide radio spectrum analyzers capable of monitoring and measuring the Received Signal Strength Indication (RSSI).
- NYCT would provide staff to operate the non-revenue test train, operate the portable radios, and communication technicians to operate the RF spectrum analyzers for testing and measuring RF performance in the operating environment between stations, leading up to where the 1/4/2024 collision occurred.
- NTSB advised NYCT and MTA of the testing protocol involving transmitting test messages at specified intervals, using only the three NYCT radios, which were used by the employees operating Train 1345.
- The locations of the three radios to be used in the test were to be operated in the same subway car locations, as the Train 1345 crew did as they moved between 79th and 96th Street Stations.
    - The three radios were the Flagger's, the Conductor's, and the TSS's assigned radios, three of the five that were secured by NYCT management, on the day of the collision.
- NTSB discussed the measurements that were to be captured by video recording of the spectrum analyzers screens, and the purpose of the test procedure.
- NYCT then briefed NTSB on the afternoon operational plan for the ten car non-revenue test train including:

- NTSB investigators and NYCT staff would board the train at Bowling Green Station
- The test train would operate northbound from Bowling Green Station to 96th Street Station.
- The test train, with the test team onboard, was to be routed into a storage track for a short duration prior to reaching 79th Street Station.
- What train it would follow behind to arrive at shortly before 3pm, at 79th Street Station.
- From 79th Street Station it would move at approximately 10MPH or less, northbound to 96th Street Station where the test would conclude, and all involved with the test would disembark the train for a debrief at the 79th Street Control Tower.

At 1PM local time, NTSB and NYCT reconvened at the 2 Broadway MTA headquarters, where the 5 NYCT portable radios, collected from the Train 1345 accident scene, were delivered by NYCT radio technicians. There, NTSB reviewed chain of custody documentation, serial numbers, and other details. Also, the NYCT radio technicians briefed NTSB investigators on the RF Spectrum analyzers' capabilities. The radio technicians were in turn briefed on the test parameters and the procedure. With the technician's input, several test procedures, pertaining to the timing between transmissions, were adjusted to better suit the operational requirements of the analyzers.

NTSB investigators and NYCT staff departed MTA headquarters and met at Bowling Green Station to board the northbound test train at approximately 2:45PM. The train traveled northbound to a storage track prior to the 79th Street Station, to wait for approximately 10 minutes for two trains to pass by. During that time, both NTSB investigators and NYCT staff re-briefed on the safety parameters of the test train operation, where personnel were to be stationed with their assigned tasks, and the test procedures (see section 4.1). Once all parties were on board the test train, a re-briefing ensued for all on board to confirm location assignments and tasks, then everyone moved throughout the train to their assigned places. The test team performed pre-test radio transmissions between the first car operating cab and the sixth car operating cab, which confirmed the test procedure was ready to proceed. The test train moved into the storage track for a short duration of time, and after waiting for the two trains needing to pass by.

4.1 NYCT Test Train On-Board Radio Testing Procedure

4.1.1 Radios Tested:

- Flagger's Portable ICOM Radio NYCT# 2415
- Conductor's Portable Vertex Radio NYCT# 9946
- TSS' Portable ICOM Radio NYCT# 25426

4.1.2 Test Team Assignments

Flagger Radio Test Team ---- 1st Car Operating Cab----

- NYCT TSS with the Flagger radio in the cab.
- NYCT radio technician with a RF spectrum analyzer in the cab
- NTSB investigator in the cab doorway to observe and video record the received RSSI values on the spectrum analyzer.

Conductor Radio Test Team ---- 1st Car Passenger Bench Area Directly Behind Operating Cab Bulkhead ----

- NYCT radio technician with a RF spectrum analyzer sitting on the bench up against the cab bulkhead.
- NTSB investigator with the Conductor radio standing directly behind cab bulkhead, to observe and video record the received RSSI values on the spectrum analyzer sitting on the bench.

TSS Radio Test Team ----6th Car Operating Cab ----

- NYCT TSS with the TSS radio in the cab
- NYCT radio technician with a RF spectrum analyzer, sitting on the opposite side of the car, behind the bulkhead from the TSS in front of the 6th car, with the operating cab door open.
- NTSB investigator sitting next to the NYCT radio technician in the 6th car, to observe and video record the received RSSI values on the spectrum analyzer.

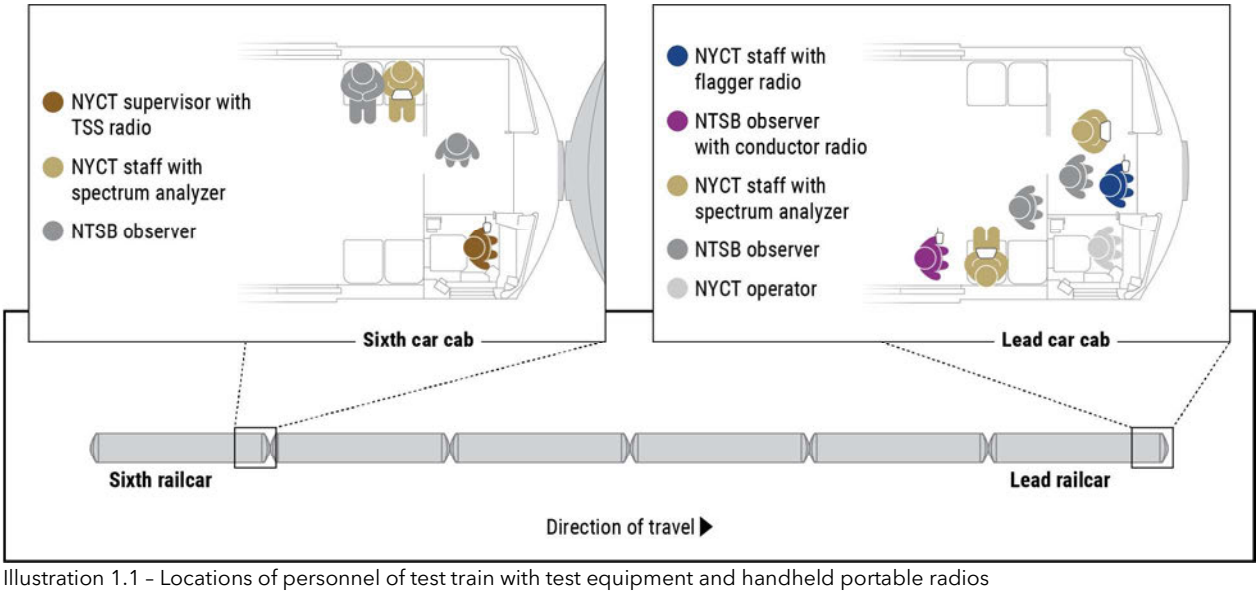

Illustration 1.1 – Locations of personnel of test train with test equipment and handheld portable radios

4.1.3 Radio Test Message Functionality and RSSI Measurements

- The TSS in the operators cab of the first car, was tasked with transmitting "Test message one", to then wait approximately 5-10 seconds monitoring the radio for a response radio transmission message back from the TSS, in the operating cab of the 6th car, stating that it was received.
- The NYCT radio technician and NTSB investigator in the sixth car would measure the RSSI and record the RSSI values of the received "Test message one" transmission from the TSS in first car. Then after 5-10 seconds, the TSS in the sixth car operating cab would transmit "Test message one received".
- Both NYCT radio technicians and NTSB investigators in their first subway car positions were tasked with measuring and recording the RSSI of the received "Test message one received".
- If after 15-20 seconds from transmitting a test message, the team in the first car operating cab did not hear a response message, the TSS would transmit another message; "test message two" …wait 15-20 seconds…" test message three" ...wait 15-20 seconds…" test message four"…continuously, without regard of successful "test message received" confirmations from the team in the 6th car, until arriving at 96th Street Station. (This would ensure that transmissions would continue if for an unforeseen reason, the TSS radio in the sixth car had transmitter issues.)

Permission to proceed northbound by signal indication was received by the test train at approximately 2:50PM, which commenced the departure and subsequent northbound movement. At approximately 2:55PM, the test train arrived at 79th Street Station, where the radio testing began, and continued to 96th Street Station. The test train arrived at 96th Street Station at 3:00PM, concluding the radio testing. The radio test performance data and other important notes were transcribed by NTSB investigators (docket file *Consolidated Radio Testing Data.pdf*), from the recorded iPhone video footage. A summary of the test train procedure with radio test performance as illustrated in *Illustration 1.2*.

4.1.4 Communication Test Train Results Summary

- Sixteen verbal test messages were transmitted using the Flaggers radio from the operating cab of the first car, three messages were received in the sixth car operating cab, with the message complete and being able to be fully understood.
- Nine transmissions were made from the operating cab of the sixth car using the TSS radio, with only two messages being received by the Flagger radio, with the message complete. There were two additional transmissions received by the Flagger radio with the message partially intact.
- One message was received by the conductor radio from the TSS radio. There was one transmission received that was mostly intact, but not completely.

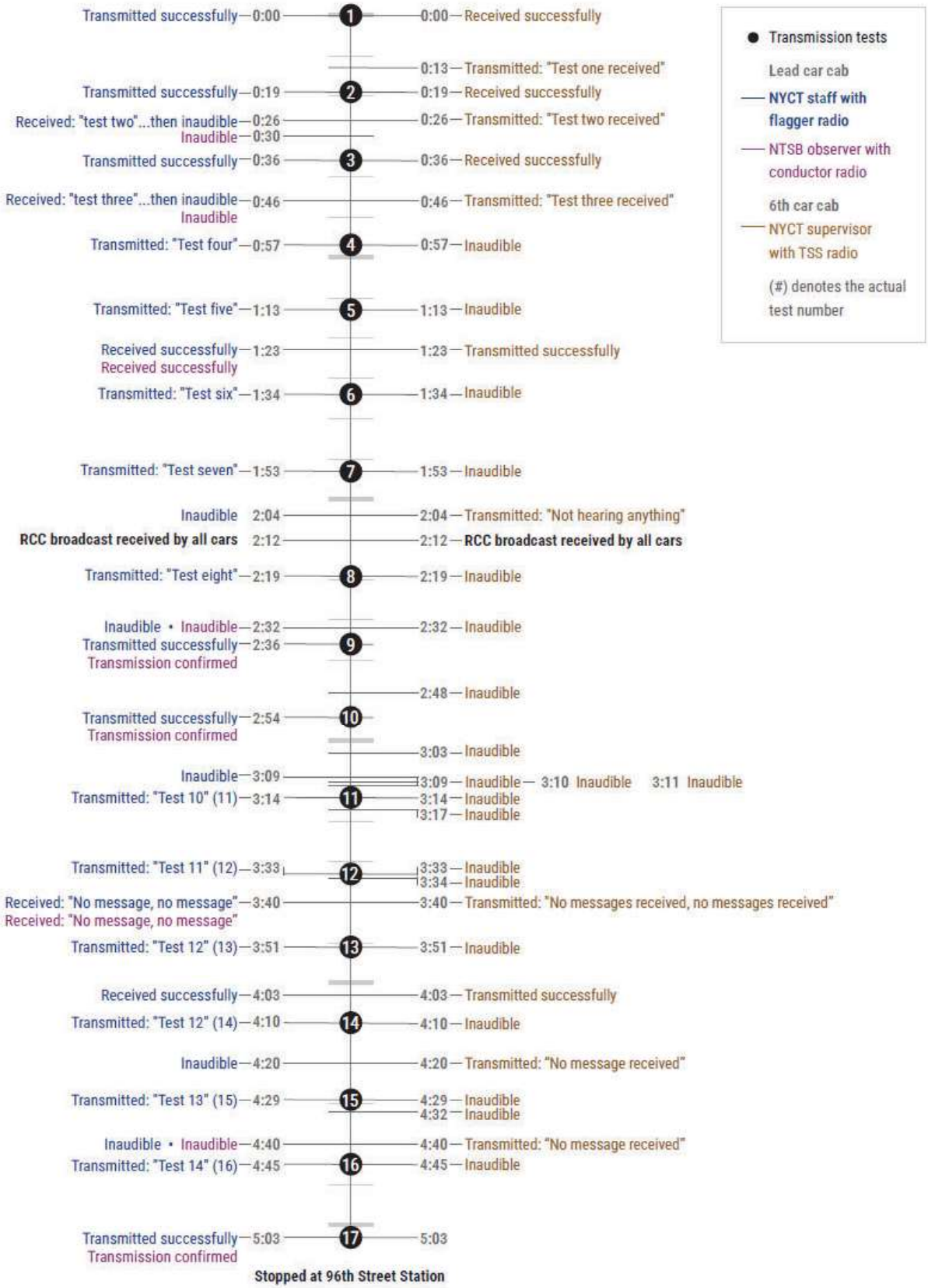

Illustration 1.2 – Timeline summary of radio message communication performance.

E. APPENDIX

Antenna –	A usually metallic device for radiating radio waves.
Broadcast –	To send our or transmit by means of radio.
Duplex –	In this mode, the radio has two frequencies per channel, often called a frequency pair. One frequency transmits while the other receives.
Leaky Coax Cable -	A coaxial cable designed to radiate or emit radio frequency signals throughout the length of the cable. In underground environments such as mining, highway tunnels, and rail tunnels, leaky coax cable is typically fastened to the tunnel structure walls and/or ceiling.
Modulate –	The process of converting data into electrical signals optimized for transmissions.
Simplex -	A simplex radio takes turns transmitting and receiving over that one frequency.
Squelch –	A circuit function that acts to suppress or mute the audio output of a receiver in the absence of a strong input signals.
Tone Squelch –	A sub-audible tone that is transmitted simultaneously with a voice message, which will unmute the squelch circuit of a receiving radio (when set or programmed to do so, for that sub-tone). Typically, sub-tones are between 67 Hz and 257 Hz for Continuous Tone-Coded Squelch System (CTCSS) operating modes.

F. COMMUNICATIONS INVESTIGATIVE GROUP SIGNATURES

Acknowledgment Signatures

The undersigned designated Group Member to the Investigation representatives attest that the information contained in this report is a factually accurate representation of the information collected during the on-scene phase of this investigation, to the extent of their best knowledge and contribution in this investigation.

National Transportation Safety Board

Thomas Johnson Digitally signed by Thomas Johnson Date: 2024.06.27 18:57:10 -04'00'

Date: 6/27/2024

National Transportation Safety Board

ADOLFO RODRIGUES Digitally signed by ADOLFO RODRIGUES Date: 2024.06.27 15:20:34 -07'00'

Date: 6/27/2024

New York City Transit

Date: _____