Cell Service Underground in NYC Subway System:

Problems and Solutions by ConnectU

By

Elizabeth Koretsky, Nicholas S. Weatherley, Salma Taher

Writing for Engineering
Instructor: Thomas Barber
The City College of New York
Fall 2018
12/11/2018

Table of Contents

Page Number

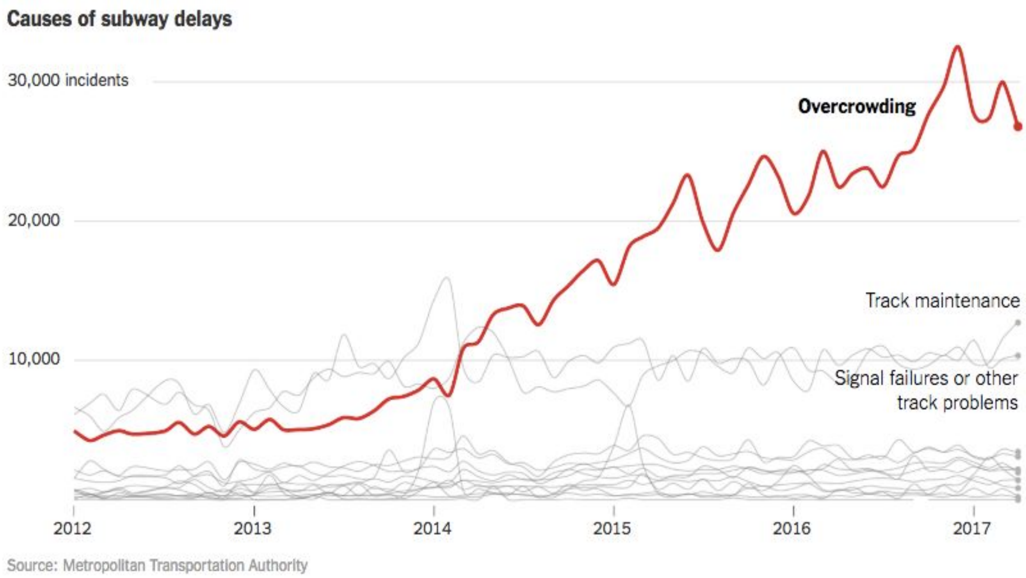
Abstract

New York City is a largely populated city that heavily relies on it's vast subway system that millions take everyday. However, although it is one of the most technologically advanced cities in the world, the transit system isn't as progressive due to the age of the system itself. As society becomes more dependent on the Internet and smartphones, public access to WiFi is now becoming more integrated within the underground subway system. However, once the train leaves the station this cellular service evaporates leaving those who rely on their phones for directions in the dark until they reach the next station. No underground cellular service is an issue, especially when it comes to train delays as those who rely on it have no means of communicating whether they may be late or opting for alternative means of transportation to avoid the delays. The solution we will provide to this problem is to extend the currently used system of active DAS within the tunnels of the Q-line that extends throughout Manhattan. This will take approximately three years for completion and will be a multi-billion project.

Introduction

Often known as the city that never sleeps, New York City is one of the most advanced cities, not just in the United States—but in the world, as well. Geometric buildings fill the sky as countless subways crawl underneath them, transporting approximately 5,580,845 [1] riders a day to their desired whereabouts. The New York City Subway System is the largest transportation system in the world in terms of stations with 472 stations [1] and is one of the oldest transit systems in the world—after opening in 1904 [2]. Often a major problem for those 5,580,845 million riders [1] are train delays which are very common and are now factored into one's daily commute. As shown in Figure 1, the occurrence of train delays are rising due to various reasons such as track maintenance, signal problems, or other unforeseen issues [3]. This can lead to much frustration for riders, especially when stuck underground for an extended period of time with no information as to why their commute isn't running smoothly.

Figure 1: Causes of Subway Delays in New York City from 2012-2017

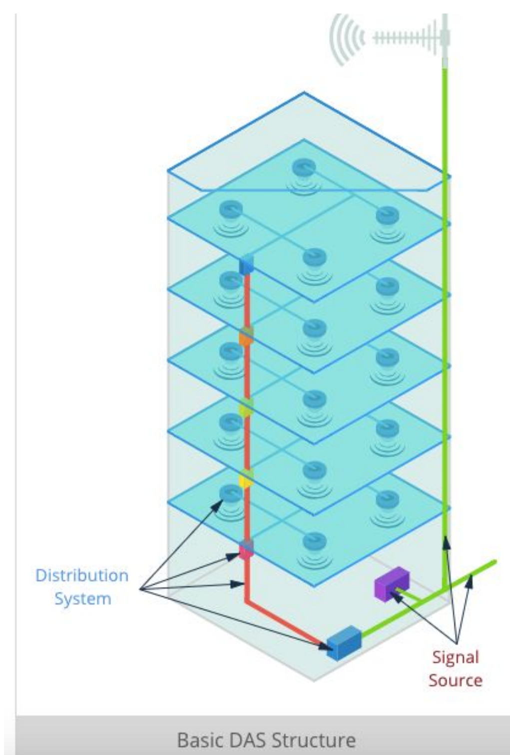


[3]

Accompanied by the issue of train delays is the issue of no cellular service as the train travels between stations. Keeping in mind that 443 miles of mainline track [4] run underground, riders lose connection to the Internet and their cellular carriers during a majority of their commute until the next station. This is a problem because many people rely on their phones during their commute whether its to search for directions, watch Netflix, read book, or simply communicate. The issue lies in the fact that once stuck underground, people can't inform others of their whereabouts until they reach the next station or search up alternative means of transportation. The convenience of having cellular service within the tunnels would allow people to inform others that they might be late to a meeting, or email their professors if they're late to an exam. However, the value of this solution is also shown from the perspective of those who control the entire transit system—The Metropolitan Transportation Authority (MTA). Cellular service and access to WiFi would allow the arrival clocks to be more accurate and would also be beneficial in the case of an emergency such as a passenger who may need medical assistance.

In 2016, a company known as Transit Wireless established public connectivity to Wifi amongst the 282 stations that run underground [5] and continue to modernize the subway system. It took Transit Wireless about twelve years to complete the task [6] which left the tunnels under question. To modernize such an outdated system was a challenge within itself as the tunnels were built much "narrower than the engineering standards used today for modern transit" [6]. Thus, this means that the equipment that was implemented required extra precision due to the limitation of space. To accomplish their goal, Transit Wireless implemented the use of a DAS or Distributed Antenna System [7] which is a "network of antennas that sends and receives cellular signals on a carrier's licensed frequencies, thereby improving voice and data connectivity for end users" [7]. A DAS is comprised of two basic components which are a signal source and distribution system as shown by the figure below. However, Transit Wireless relied on an active

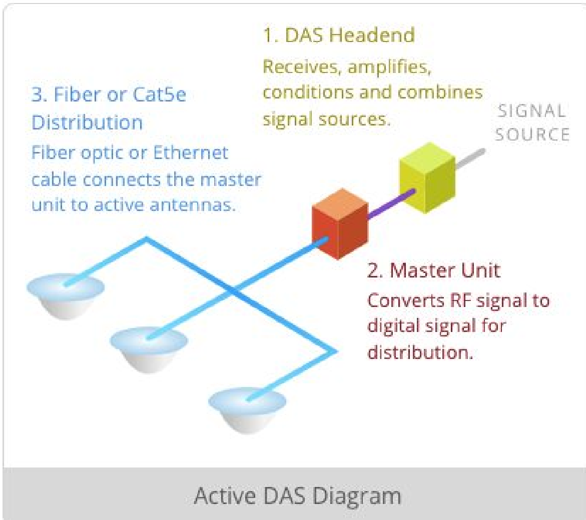
Figure 2: The Basic Structure of a Distributed Antenna System



[7]

DAS system to "convert the analog radio frequency transmissions from the signal source to a digital signal distribution" [7]. As shown by figure 3, the master unit converts the radio frequency to the digital frequency and can do so for multiple cellular carriers.

Figure 3- A Diagram of an Active DAS



[7]

The project of implementing underground cellular service will focus on the Q-Line—specifically the route within Manhattan— which was opened in 1920 [8] and provides service from Coney Island-Stillwell Avenue in Brooklyn to 96th street in Manhattan. The Q-line was chosen since it is one of the shortest within the city as it extends from 96th street to Canal Street—a total of 9 stops and is also one of the more modernized routes throughout the city with the addition of the Second Avenue-96th street station. Our company proposes to extend this active DAS system that was implemented by Transit Wireless further within the tunnels of the Q-Line as it is much more expandable and will be able to cover much more subterrain due to no limitations of how long the cables can run [7].

Plan of Work

Our plan of work is to install and an active DAS System along the Q line from the 96th street stop to the Canal Street stop. This process has three four main steps that are shown below.

1. Survey of tunnel system for problem areas and optimal broadcast locations.
2. Installation of wiring and antenna housing units
3. Installation of antennas along with alpha and beta tests.
4. Network wide activation of system to the public

Step 1: Survey of tunnel system for problem areas and optimal broadcast locations.

Each subterranean system is unique and has their own problem areas. Before any wire or housing is installed, these locations need to be noted and plans drawn to deal with them.

Our company will send two small teams of four engineers to step through the subway system and locate problem areas and optimal antenna locations. Each team will be comprised of structural and electrical engineers. The first team will step through the tunnel system noting locations with material that has a high signal damping ratio, low clearance areas, high moisture areas, possible signal connection terminals, and critical wiring and housing that cannot be altered. Our second team will lag behind the first noting the optimal locations of antennas by measuring tandem antenna signal strength as passenger trains, finding dead signal locations, and resolving any issues team one missed. The data these teams collect will be sent to our headquarters where our engineer team will finalize the construction plans. This team will work four weeks ahead of our construction team to allow an adequate buffer if any issue arises.

Step 2: Installation of wiring and antenna housing units

Our company will send two construction teams of 12 to 14 workers to lay and install plenum grade fiber optic wire along with the antenna housing units. Each team will also be accompanied with a certified structural engineer who will work in tandem with the team's forman to resolve any on site issues, and ensure that each anchor does not jeopardize tunnel stability.

The first construction team will lay and set the plenum fiber optic cable according to the schematics drawn by our engineering team. The wires will then be taped at each end ensuring that their is not ingress of water or particulate matter. Our second will follow the first and install the antenna housing units. They will also check all anchors and ensure that the plenum fiber optic cable did not sustain damage during installation.

Step3: Installation of antennas along with alpha and beta tests

Our company will send two small teams of four certified technicians to install the antenna units in the antenna housing units. This team will run an initial diagnostic test for each unit and ensure that all of the antenna units in each section will intercommunicate.

If the tests are successful, our teams will move to beta testing where they will be checking signal strength, conducting stress tests, system handoffs, and fine tuning of the antenna placement. This team will be able to resolve any logical and electrical bugs before the system is used with the public.

Step 4: Network wide activation of system to the public

Our team will send two technicians to activate the system to the public. They will be onsite 24/7 during this period if any issue arises. After one month we will reduce the team size to one technician as our studies have shown an decrease in issues and maintenance after this period.

Timeline for the Construction of Underground Cellular Service

The project will begin with the approval of the MTA. If approved, it will initialize by providing wifi connection in two consecutive stops locally in Q line stops. The entire installation of the DAS system within the Q line of Manhattan will take no more than three years. If our project of setting carrier based wifi will gain success, we might get more work from MTA to set up carrier based wifi in other lines connected with different boroughs such as Brooklyn, Bronx, Queens. The table of initial stops of Q line in Manhattan is given below in figure 2 and list of Manhattan communities where we will set up carrier based wifi is also given below in table 1.

Figure 2: Timeline for the setting of Carrier Based Wifi In Underground Subway

Station	Timeline		
96th St			
86 St			
72 St			
Lexington Av-63 St			
57St-7th Av			
49 St			
Times Square-42 St			
34 St-Herald Square			
28 St			
23 St			
14 St-Union Sq			
8 St-NYU			
Prince St			
Canal St			
	1st Year	2nd Year	3rd Year

We will set up WiFi at the first four stations in the first year, then the next five stops in the second year and last five stops in the third year.

Table 1: List of Manhattan Neighbourhoods with Q-Line Service

Names of Neighbourhood	Installation
Upper East Side, East Harlem	TBD
Upper East Side, Yorkville	TBD
Upper East Side, Lenox Hill	TBD
Upper East Side, Lenox Hill	TBD
Midtown Manhattan	TBD
Midtown Manhattan	TBD
Midtown Manhattan, Times Square	TBD
Midtown Manhattan, Herald Square	TBD
Midtown Manhattan, NoMad	TBD
Flatiron District, Madison Square	TBD
Union Square, Gramercy	TBD
Greenwich Village, NoHo	TBD
SoHo	TBD
Chinatown, Little Italy, SoHo	TBD

[9]

Budget

The budget breakdown below shows an initial estimate based off of public schematics of the MTA Q line in Manhattan. Our companies estimate uses the timeline above and all amounts are subject to change based off of timeline changes or client specifications.

Table 2: Estimated Material Cost for Project

Materials	Number of Units	Raw Cost	Total
Plenum Armored Fiber Optic Cable	29040 feet	$2.72 per foot [10]	$78,988.80
Antenna Housing Unit	500	$15.22 [11]	$7,610.00
Active DAS Systems	13	$500,000.00 [12]	$6,500,000.00

[13]

Table 3: Estimated Wage Costs for Project

Labor	Crew Size	Hours	Per Hour Pay	Total
Structural Engineers	20	400	$200.00	$1,600,000.00
Electrical Engineers	10	800	$200.00	$1,600,000.00
General Construction	28	2400	$80.00	$5,376,000.00
Forman	2	2400	$100.00	$480,000.00

[14]

As seen in table two and three, the main cost of the project is in the manhours and the Active DAS systems themselves. While the man hour totals may seem high in table three, these hours allow for a safe and smooth workflow that minimizes its impact on the surrounding subway network.

The cost of $500,000.00 for each Active DAS is reflective of your user specifications. The systems will be able to broadcast cell service in 3G and 4G simultaneously, withstand minor water and dust ingress, and include vibration dampeners to reduce wire strain.

Qualifications

To complete this project, we have several extremely qualified team members as shown below:

1) Elizabeth Koretsky, **Biomedical and Electrical Engineer**: With a Ph.D. from the Massachusetts Institute of Technology in Biomedical Engineering and a concentration in Electrical Engineering and Computer Science, Elizabeth has worked on several civil engineering projects. As a resident of New York City, she is very familiar with the transit

system and assisted in the design of the 96th Street Subway Station. She also worked as an electrical engineering intern at General Electric for 3 years.

2) Nicholas S. Weatherley, **Electrical and Structural Engineer**: With a Ph.D in Electrical Engineering from the Massachusetts Institute of Technology and a Ph.D. in Structural Engineering from the University of California - Berkeley. He is extremely familiar with the current MTA wired and wireless systems and has helped engineer multiple high traffic metropolitan subterranean transport systems across China and Europe.

3) Salma Taher, **Software Engineer and Computer Engineer**: With a Bachelor's degree in Computer Science from The City College of New York and Ph.D. from the Massachusetts Institute of Technology in Computer Science and a minor in Mathematics and Computer Engineering, Salma has worked in several Software Engineering and Computer Engineering projects. She is familiar with the Softwares and Electronic systems that are related to the transit system. She also assisted in the set up of the WiFi present within the 36th Street station in Queens. She also worked in Google for 5 years as a Software Engineer.

Reference List

[1] “Introduction to Subway Ridership,” *MTA | Capital Programs Second Avenue Subway*. [Online]. Available: http://web.mta.info/nyct/facts/ridership/. [Accessed: 08-Dec-2018].

[2] A. Walker, “A visual history of NYC's subway cars,” *Curbed NY*, (2017). [Online]. Available: https://ny.curbed.com/2017/9/20/16305388/nyc-subway-history-mta-train-cars. [Accessed: 08-Dec-2018].

[3] E. G. Fitzsimmons, F. Fessenden, and K. K. Rebecca, “Every New York City Subway Line Is Getting Worse. Here's Why.,” *The New York Times*, (2017). [Online]. Available: https://www.nytimes.com/interactive/2017/06/28/nyregion/subway-delays-overcrowding.html. [Accessed: 08-Dec-2018].

[4] *www.nycsubway.org: Rapid Transit Tunnel Begun - Ground Officially Broken (1900)*. [Online]. Available: https://www.nycsubway.org/wiki/. [Accessed: 08-Dec-2018].

[5] “A Look at Transit Wireless Connectivity in the Underground NYC Subway,” *Untapped Cities*, (2018). [Online]. Available: https://untappedcities.com/2018/05/21/a-look-at-transit-wireless-connectivity-in-the-underground-nyc-subway/. [Accessed: 08-Dec-2018].

[6] D. Crichton, “Engineering against all odds, or how NYC's subway will get wireless in the tunnels,” *TechCrunch*, (2018). [Online]. Available: https://techcrunch.com/2018/02/17/engineering-against-all-odds/. [Accessed: 08-Dec-2018].

[7] “Distributed Antenna Systems (DAS): The Definitive Guide (2018),” *RepeaterStore*. [Online]. Available: https://www.repeaterstore.com/pages/das-distributed-antenna-systems. [Accessed: 08-Dec-2018].

[8] P. Derrick, Tunneling to the Future: The Story of the Great Subway Expansion That Saved New York, *NYU Press, (2002).*

[9] D. Devkota, S. M. Hossain, A. Guevara, (2018). Public Restrooms in NYC: Problems and Solutions [CUNY Blackboard] Available: file:///C:/Users/Thankyou/AppData/Local/Packages/Microsoft.MicrosoftEdge_8wekyb3d8bbwe/TempState/Downloads/Proposal%20Example%20(1).pdf

[10] "12 Strand Multimode OM4 Armored Indoor Distribution Fiber Cable Plenum | Fiber Savvy", *Fibersavvy.com*, (2018). [Online]. Available: https://www.fibersavvy.com/12-strand-armored-distribution-fiber-optic-cable-multimode-om4-corning-fiber-indoor-plenum.aspx. [Accessed: 10- Dec- 2018]

[11] "Polycase", *Polycase.com*, (2018). [Online]. Available: https://www.polycase.com/sk-26. [Accessed: 10- Dec- 2018]

[12] "How much does a DAS system cost? - Day Wireless Blog", *Day Wireless Blog*, (2018). [Online]. Available: https://www.daywireless.com/blog/2015/09/11/how-much-does-a-das-cost/. [Accessed: 10- Dec- 2018]