Modernization of Signals in MTA:
Implementing New Signal Systems

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Abstract

The New York City Subway System is struggling with an antique signaling equipment build before World War II that is past its life span. This report presents a faster implementation of the new signal systems by analyzing the signal system in subways that is being used today controlled by MTA (Metropolitan Transportation Authority), explore how this system works for trains in details, investigate what other systems can be implemented to improve the old signal system and have a solution to preclude future delays. In addition, we will present the CBTC system and the ATS system, we will compare and contrast the new systems and show that indeed is better for the subway in general. Our recommendations to the board will raise a lot of revenue that would otherwise be lost in delays and repairs, Also, will improve the MTA system without affecting the people who use the MTA or with the least effects on their daily transportation.

TABLE OF CONTEXT

1.Introduction

New York City is one of many cities in the World that is known by its large population of over 8 million people and by its economic activity. Although New York might seem to be the best place to live for some people, it could have some disadvantages while living there. Sometimes in New York City, it is hard for someone to transfer from one place to another. Manhattan would be a great example to represent this issue because there is always vehicular traffic around every corner, and because the majority of the streets in the city are extremely long; which can be an obstacle to most people who have their jobs in the city. The citizens of New York instead of taking other ways of transportation, such as taxi or bus, most citizens decide to take the subway in order to get to their destinations faster.

Taking the Subway might be the best way of transportation when the destination someone is trying to reach is located at a long distance or simply because it is the best answer to escape from traffic. Most trains can get from point A to point B with no issues, but what happens to the trains that experience technical difficulties? One problem that occurs very frequently in subways is the lack of maintenance to the “Signal System”. How does this affect the customers? What can be done to avoid this obstruction?

The main objective of this report is to analyze the signal system in subways that is being used today controlled by MTA (Metropolitan Transportation Authority) underground and aboveground, explore how this system works for trains in details, investigate what other systems can be practical to improve the old signal system and have a solution to preclude future trouble, particularly; delays.

Currently, the majority of the New York subways are running an old system called "Automatic Block Signaling" or known as "ABS". ABS is mainly focused on controlling the movement of train between the blocks on the rail using automatic signals, but throughout the past few years, delays are starting to happen more repeatedly while operating this ABS method. This system is so obsolete that it cannot recognize accurately where trains are located, needing more space between them. This process of signaling has caused so many delays on subways due to improper conservation of the old sensors, lights or the whole system in general which is making passengers complain about the services. Because of these delays, passengers usually get to their destination several minutes late. Lateness caused by signaling on subways can make people lose revenue for the most part. When subways commuters are late, they cannot begin their workday at their planned time, costing the economy the amount of some of that work time that has been lost. Most of these cases are because their workplace is located too far and because of these technical issues, these locations might be hard to reach. According to an economic analysis accomplished by Comptroller Stringer, "the annual economic cost of stalled trains could reach nearly $400 million dollars under worst-case scenarios, with delays on the 5, A, F, and 4 subway trains being the costliest, topping out at a whopping $140 million a year combined" (2017). If the MTA wants to renovate every line in New York, it could take almost a period of almost 50 years and have an approximately cost of $20 billion for this particular project.

One solution to stop delays in subways, is to modernize the system by implementing "Communications-Based Train Control" or "C.B.T.C". With a more advanced signal network, trains on the system could run closer together and subsequently more habitually, permitting the subway to integrate more riders as the city's populace develops. It can also track the train's position and automates speed control which is helpful to keep different trains at a safe gap from each other. Based on an article from The New York Times, "C.B.T.C can be even safer than the current system because trains can be stopped automatically in case of an emergency" (2017). But challenges can be encountered while applying C.B.T.C to the old system. First, the new system should be available as soon as possible in order to increment the number of trains at peak periods with more reliable services. Second, the C.B.T.C system will cost millions to complete the job which can affect the state financially and lastly, the closure of certain stations to renovate the signal system can lead to massive delays for a long period of time like the lines 7 and L which took almost 8 years to complete the installation of C.B.T.C.

A second solution to the problem is to have more installations of the "Automatic Train Supervision" or ATS in other lines. This system has been already applied in the A division, consisting of line 1, 2, 3, 4, 5, and 6. ATS permits dispatchers in the other Operations Control Center (OCC) to see where trains are in real time, and whether each train is on time or late to get to their final destination. According to the U.S Department of Transportation, “The Automatic Train Supervision is a $200M+ plan that will give a system that will benefit the service management for NYCT subdivision A rail region excluding line 7 since it is already running C.B.T.C. It will combine most of the work currently performed at both, the Master Towers and the Subway Control Center in Brooklyn” (2016). The U.S Department of Transportation also stated: “ATS will provide: Improving safety, coordination of emergency response activities between operating divisions to accelerate solutions, developing train arrangements based on schedule or service conditions and overall system productivity” (2016).

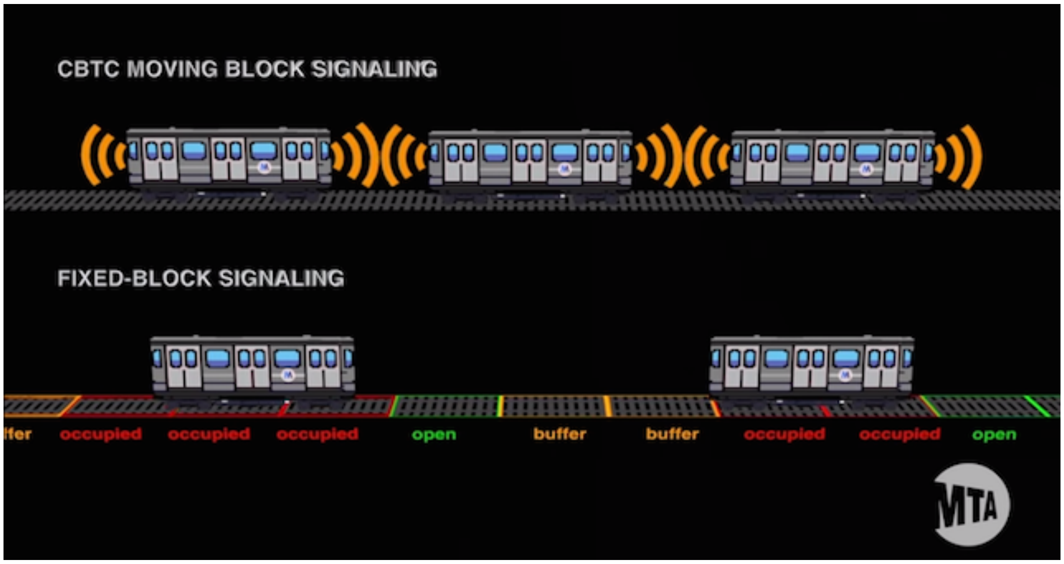
Based on our findings, in order to preserve a strategic distance from these delays that happen too often in certain trains, we suggest the MTA to adjust the antique system with “Communications-Based Train Control” or “C.B.T.C”. We are looking for a system that will be capable to increase safety, economy, train effectiveness and decrease lateness on every line. For these reasons, we believe that even though C.B.T.C system is more expensive, it can make some major changes in the city. It is time to once again to revolutionize the subway to a modern world so it can be prepared to serve the next generation of New Yorkers.

2. BACKGROUND

CURRENT SYSTEM:

Automatic Blocking System(ABS) is one of the oldest signal systems in New York, in fact this system was created before War World I, over more than one-hundred years old.
Automatic Blocking System is one of the current concepts utilized in railroads to help signaling. This system is including 14,80 signal blocks, 3,538 principal-lines controls, 183 track intersections, 10,104 automatic train stops, and 340,000 electrically operated switch.

With the assistance of the tracking circuit, this system will classify the movement of trains and the product will be given to the Blocking System. A long train route will be transformed in smaller tracks and each little track will be specified with semaphores at each section. Each semaphore contains red, green, orange, double orange.



Each portion of the track will confine them by a small hole which is exclusively called as “Block”. When the vehicle is moving to one piece of the track or to another block, at this point, the two blocks in front of the existing block must be clear in order for the train to continue with its path. If there is an event that involves another moving train that is ahead for two other blocks, then the semaphore will instantly return back to red and notifies the train to stop. Blocking System will permit the train to advance the next block only when another train is not making physical contact of with the same block.

In the case of the driver running the train while the signal is indicating to stop the vehicle using the red light, then the Automatic Blocking system will make all the signals Red for next remaining blocks. The purpose of changing all the lights for each block is to avoid railway tragedies or prevent collisions between two trains.

ORGANIZATION OF AUTOMATIC BLOCKING SYSTEM

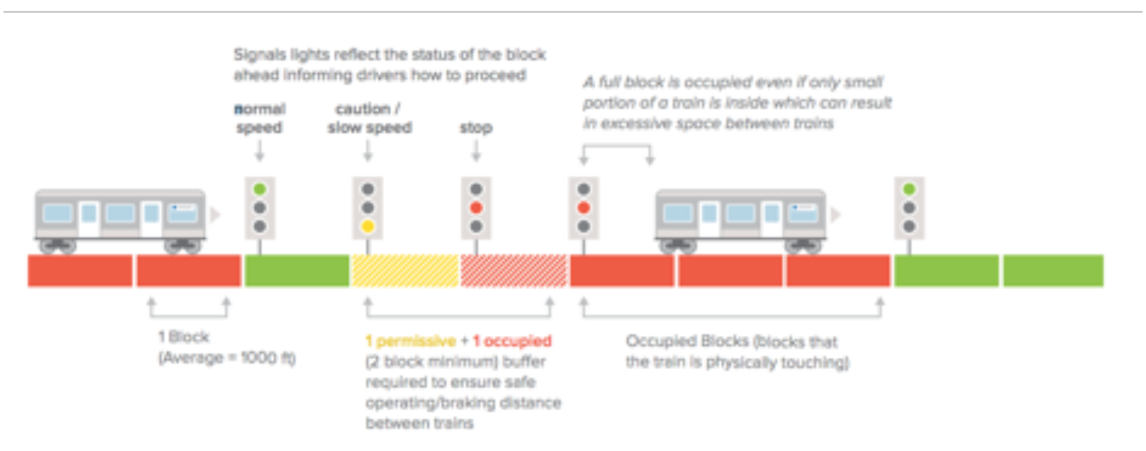


Figure 1 Automatic Blocking System(ABS)

3. Methodology

3.1 Evaluating CBTC

CBTC stands for Communication Based Train Control, and it relies on the use of five subsystems to operate properly. The five subsystems are:

- Central Control System (CCS)
- Station Control System (SCS)
- Onboard Control System (OCS)
- Block Control System (BCS)
- Communication Network System (CNS)

The Central Control System is the main brain of the system, and it is responsible for controlling every other part of the system. It is used to produce train graphs and train plans, which demonstrate the position of the trains at a given time, as well as allow for planning of train routes in real time. The CCS is used to control the movements of trains as well as control the dispatches of the trains, to reduce conflict between different trains. The CCS not only is responsible for controlling every other system in the system, but it is also the system that all the other systems report their data to in order to ensure that the CBTC system is working properly.

The other integral part of the CBTC system is the station control system. This system is responsible for controlling the various functions that occur in the station. This system is responsible for controlling functions like the switches, signals, and routes in the stations. The system is designed in a CBTC system so that it is failsafe. In other words, if the system fails for any reason like there being a loss in the transmission of information or a lapse in operation, instead of the system operating as is, the system immediately brings the train to a halt and prevents movement until the problem has been fixed, should there be a train within that system. If there is no train that is under the influence of the system, then the system prevents potential damage by relaying information to the CCS. or communicating with Block Communication System (BCS), and/or the Onboard Control System (OCS), directly. It is interesting to note that this system also works very well with the traditional train control systems that may be in place, and this is significant because the trains can still be in operation with the traditional systems, while the CBTC system is being installed, to provide a seamless transition between the signaling and communication systems.

The Block Control System has, relatively speaking, the same function as the block system that is found in the Automatic Block System (ABS). However, the way they function is quite a bit different from one another. While one system uses fixed blocks and a rather antiquated circuitry system to open and close blocks to access by other trains, with no regard to train speed and other factors, the BCS of the CBTC system takes into account factors like train speed, rate of acceleration, rate of deceleration, sudden emergencies, and other factors into account so that trains can be as close to each other as possible without risking major accidents. The system takes these variables into account by communicating with the Onboard Control System (OCS) as well as the Station Control System (SCS), in addition to the CCS. This is a well desired trait of subway systems the world over as the metropolitan areas that rely on them need higher train frequencies to accommodate for greater ridership amongst people in the areas that are served by the subways. Another factor which is well appreciated about this part of the CBTC system is the fact that it is very flexible. This is needed not only to increase volumes at peak times, but also to allow for increased speeds during off peak times, which the ABS system cannot allow for due to limitations that are predetermined. While the BCS can be readily controlled by the CCS quickly with a few changes to the settings, the ABS system cannot be changed like that unless the entire system is overhauled to accommodate for the changes; an overhaul made all the more complicated by the fact that mechanical parts have to be removed and replaced or reconfigured. This could in fact, greatly increase costs, even if the entire system need not be overhauled, especially when compared to the CBTC system. This system is also designed to be failsafe, forcing trains to a stop if there is a malfunction in the system, to prevent further damage and inconveniences from happening.

Another key part of the CBTC system is the OCS, or the Onboard Control System. This system is located inside the train, and it is responsible for controlling the speed, acceleration, breaking, and other functions of the train. Some systems are also designed to be completely autonomous and they open the doors of the train as well, essentially removing the need for a driver. But in many cases, the driver is often there to check for track obstructions and account for variables that the OCS cannot take into consideration. This system communicates with the CCS, the BCS, the SCS in order to ensure that the train is functioning properly. In addition to controlling the train operations, the OCS also sends information about the train to the other systems so that a great many of the benefits of CBTC can be realized, like the adaptive block interface, which allows trains to run closer to each other and still be safe. This system is also designed to be failsafe and so if there is a lapse in proper operation of the system, the train is immediately brought to a halt until the problem has been fixed. In this system, it is necessary to have new rolling stock and subway cars that are relatively computerized, as the OCS requires that the train be able to function without a driver in some cases, even if there is a driver present.

The final part of the CBTC system is the CNS, or the Communication Network System, essentially connects all these components of the CBTC system together in order to ensure that the entire system is working in tandem and with proper operation. The CNS relays information from one system to another, and it relies on up to date information from all these systems.

It is important to note that there are different companies who manufacture the CBTC system in different manners and methods. As a result of that, specific details about how a system works cannot necessarily be mentioned as the methods of operation are often kept secret and hidden from the public eye. Some examples of CBTC system designers include Siemens, Alstom, Thales, and so on and so forth.

Some of the advantages of CBTC, like increased flexibility, greater modularity, and reliability and safety can be realized when a system moves to the technology. However, it is also important to mention some of the drawbacks the exist as a result of implementing CBTC. It is important to note however that these issues are not necessarily specific to the system at large, but rather, they are issues that arise as a result of the current state of the MTA. The fact of the matter is that because of the fact that the MTA never shuts down, it is difficult to install an entirely new system. Many other systems that exist across the world that feature CBTC have a set window of repairs and construction where such a system can be installed. Another issue that arises is upfront costs, because a lot of things, like the subway cars, and the signaling systems would need to be modified as a requisite to installing the CBTC system. Granted, it is possible and rather reasonable to change the rolling stock of the MTA subway after a while due to age and wear and tear, and so it would be reasonable at that point to find a system which is CBTC ready.

3.1.1 CBTC Applied in Other Systems:

For the purpose of this report, two systems which already have CBTC systems, the London Underground and the SF Muni Metro, will be discuss the issues that surrounded them prior to and the results after the installation of the CBTC system will be discussed.

3.1.2 CBTC in the London Underground:

One key example of CBTC in action is the London Underground, also known as the Tube, and indeed, it is revolutionary how much something as simple as a signaling system can affect the health of a subway system. Some of the circumstances which pushed the London Underground to change their system include increased ridership from the 1980's to the present. Furthermore, another problem that had also caused problems for the London Underground was related to administrative problems, in that The Tube was handed over to private corporations. This resulted in a bevy of problems stemming from the use of different equipment, which led to compatibility issues in the tooling of different systems, once the Tube was brought back again under the auspices of the government. The agency running the Tube decided that they wanted to overhaul the system so that they can have increased passenger capacity, as well as increased reliability, which was also a problem for the system prior.

Once they installed the CBTC system in the London Underground, there were increased savings in the operation of the system, as less people were needed to repair the antiquated system that was present prior. Furthermore, the time needed to repair anything at all due to signaling was also eliminated, as the system runs on software more so than hardware. There was also a noticeable increase in the amount of trains that ran per hour, from around 36 an hour to about 40. All of these combined to reduce the amount of hours that were lost by customers as a result of delays by overcrowding and malfunctions in the system.

3.1.3 CBTC in the SF Muni Metro:

The SF Muni Metro system had largely the same issues that needed to be solved as the London Underground, however, there were a few extra issues that were present that made the situation in the SF Metro different in many ways. It is important to mention the fact that the SF metro is mainly a streetcar and light rail on street tram system. Therefore, a lot of the issues pertaining to the transit system were far worse in this system than in many other systems. For instance, there are two tunnels that are present in the SF metro system.

Prior to the installation of CBTC, two trains needed to be coupled together to ensure that the tunnel was operating at peak efficiency, as the previous block system would often prevent trains from going into the tunnel if another train just left from the other side. Furthermore, another issue that arose as a result of the coupling of the systems was that the trains would need to wait for another train to come to get coupled with, and there needed to be a dedicated team of people who were present to do the coupling. Quite often the coupling would fail and it would need to be done again. It should be abundantly clear by now that a lot of time was wasted just to make sure that the trains could be coupled together. In addition, there were a few cases in the system where a train hit another train from the rear, owing to the fact that there was a lot of blind corners that arose from the dense design of the system. The reasons for which SF Metro decided to install the CBTC system include the need to increase safety, as well as increase the reliability of the system, as well as capacity.

After CBTC was installed in some parts of the system, safety markedly increased, and there were essentially no accidents that were caused by signal malfunctions or miscommunication. Furthermore, the number of people using the system, though remaining steady, ride on less crowded trains as the trains are distributed in a more equitable manner over a given time frame. Furthermore, it was no longer necessary for trains to couple together to go through the tunnels together as the communication system is able to maintain proper operation of the system. Reliability also increased as the number of repairs needed to fix the signals became next to none.

3.2 Evaluating ATS signal

Broadly speaking, ATS system is not an independent system. It's commonly integrated within most of the CBTC solutions. Its main task is to act as the interface between the operator and the system, managing the traffic according to the specific regulation criteria. Also, it may include the event and alarm management as well as acting as the interface with external systems.

Moreover, the ATS system is responsible for monitoring and controlling the rail system to ensure that it conforms to an intended schedule and traffic pattern, in order to optimize railway operations and service reliability.

ATS helps to avoid or reduce damage resulting from system abnormalities and equipment malfunctions by performing the following tasks:

1. supervision of train status
2. automatic routing selection
3. on-the-fly adjustment of train operations
4. automatic schedule creation
5. automatic operations logging
6. statistics and report generation
7. automatic system status monitoring
8. coordination of personnel scheduling for train management.

In other words, ATS system is specifically designed to provide more effective service management for operating divisions, allowing improved performance and more regular headways. Other benefits include the provision of real-time passenger information, centralization of maintenance management and, in the event of an emergency, improved coordination between NYCT and fire and police services.

According to International Railway Journal that after a "learning phase" lasting around a year. 82 operating consoles monitoring lines 1, 2, 4, 5, 6 and the entire subway system is covered by the end of 2006. It controlling all of this is the Vicos operations control system. Subway operations at more than 150 stations and 92 interlocking will be controlled, measured and dispatched by 53 operator consoles in a control center. A large screen, 45m wide and 1.5m high, provides an overview of lines under its control.

In detail, ATS system has three core parts, Centralized traffic control, real-time train tracking, and automatic vehicle identification. Also, it integrates voice communications, computer-aided automatic routing and dispatching (based on scheduled data), and automatic report generation to replace the current handwritten reports. Moreover, smooth operation of the service during disruption is handled by automatic service strategy implementation, which is able to reroute trains without operator intervention if needed.

With such high demands on it, the system has been designed to handle the load by using distributed computer power, where the processing load is shared between multiple computers. The New York control center uses three redundant server pairs, compared with the usual single pair installed elsewhere.

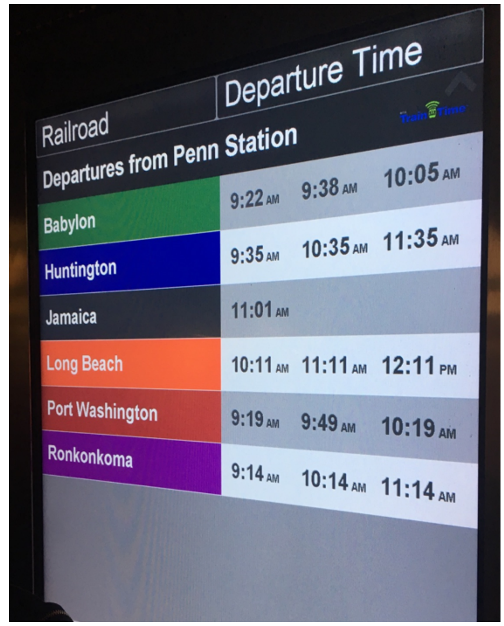
Another key requirement demanded by NYCT is availability. The specification said: "A computer room must be capable of being flooded and the system must continue to be available." This means that almost every component has been designed to be both redundant and geographically separate. Servers, for example, are installed doubly in "hot standby" configuration. The network, data lines to the interlocking’s, and all telephone and radio links exist in duplicate form. If a component in a computer room fails, the same component in the other room immediately assumes the function involved. In the control room, every line section can be controlled from each operator console, and the entire range of system functions is available at each workstation. At yards and terminals, 29 operator consoles are installed so that yard and terminal dispatchers are also provided with the complete range of ATS functions.

For NYCT, commissioning of the ATS system marks a leap across two technology generations, from relay-based technology to state-of-the-art computer technology. NYCT is able to handle its operations more efficiently and with greater punctuality. ATS centralizes all major operating information at one control center and provides the information to all departments involved in operations. NYCT is now in a position to perform preventive maintenance on vehicles and interlocking cause ATS calculates the distance traveled by each car and provides this data to the car maintenance department. Fault indications from interlocking are sent directly to maintenance personnel so they can immediately react to faults.

ATS also supplies all necessary real-time data to a passenger information system, which is currently being set up. This means NYCT can provide passengers with up-to-date operational information both visually on 1000 new screens, and through a new public address system.

4. Evaluating the use of ATS

Pros:



1. visible over on 1000 new screens.
2. real-time data to a passenger
3. Greater punctuality
4. supervision of train status
5. automatic routing selection
6. coordination of personnel scheduling for train management.
7. on-the-fly adjustment of train operations
8. automatic schedule creation
9. automatic operations logging
10. statistics and report generation
11. automatic system status monitoring

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Cons:

1.Expensive
2.Long implement period
3.Difficult construction projects
4.High demand for train arrival displays
5.MTA does not have enough own workers and good training contractors

5. CBTC and ATS in other countries
(development/cost/results)

5.1 ATC for Shanghai Metro extensions

Union Switch & Signal has been awarded two contracts worth $22.31 million for ATC (automatic train control) on extensions of the Shanghai Metro Line 2. The first contract is for the Shanghai Line 2 East Extension project, which will extend the existing system eastward by 18.37 miles to provide service to Pudong International Airport. The second contract is for the Hongqiao Integrated Transportation Hinge Mating project ("West-West Extension"), a westward extension of 5.32 miles that will link the present system with Hongqiao Airport. US&S's contract values for the two projects are $17.63 million and $4.68 million, respectively. US&S will supply its AF-900 profile-based ATC system for signaling and train control. AF-900 integrates ATP (automatic train protection), ATO (automatic train operation), and ATS (automatic train supervision).

5.2 France, Hong Kong: Thales and Alstom to supply advanced CBTC signaling system to Hong Kong seven metro lines

Thales and Alstom were awarded a contract worth 330 million by MTR Corporation, the operator of Hong Kong s metro network, to resignal and upgrade the signaling systems of seven metro lines. A maintenance option is also included in the contract. This extensive project will equip seven MTR lines with the latest Communications Based Train Control (CBTC) technology, safely adding capacity, reliability and maintainability on the existing infrastructure system.

Thales and Alstom will be responsible for the replacement of the existing signaling system including Automatic Train Supervision (ATS), interlocking, and Automatic Train Control (ATC) in the control center, trains and stations. Thales will provide the advanced SelTrac CBTC system. The project implementation will be carried out by a dedicated Alstom Thales joint project team. Thales, the consortium leader, has the technical leadership and Alstom will ensure the overall project management, as well as the supply of the remote trackside equipment controllers to deliver seamless interface with the existing field elements.

CBTC is the latest generation of technology for metro and suburban rail networks. It gives operators precise control in the movement of their trains, allowing them to run on the line at higher frequencies and speeds in total safety - with or without drivers. CBTC can largely improve capacity, efficiency, reliability, safety of metro lines and reduce operating costs for operators.

6. INFRASTRUCTURE OF NEW SYSTEM

C.B.T.C permits more trains per hour, superior exactness, and less construction preservation. But in order to begin with the C.B.T.C system, the MTA has to finish executing it. The computerized system is presently being used by one of the 34 lines, with another transition nearly finalized. Emma G. Fitzsimmons from The New York Times mentioned: “The process is complicated. It requires installing transponders every 500 feet on the tracks, along with radios and zone controllers, and buying new trains or upgrading them with onboard computers, radios and speed sensors. The authority also had to develop a design and software that was tailored to New York’s subway” (2017).

According to some studies in 2014 based on the subway`s signal system, Regional Plan Association or also known as RPA has recommended some advices in order to complete the project effectively.

1. Lines should be prioritized based on their age, capacity and ridership growth potential.
2. The MTA should be replacing the damaged fixed-block signals with the new C.B.T.C signal system.
3. Retrain and relocate workforce to take full advantage of innovation funds and way better serve clients.
4. Adapt subway to driverless processes by 2040s, meaning that this method will save millions annually and offer more flexibility.

Expand stations to reduce crowding so it allows trains to run at full capacity.

CBTC is mainly concerned on the age of the signals because this is one of the main reasons why delays happen almost all the time. We are assuming that the majority of these signs that are several years old are in poor conditions and based on this, the MTA is requested to make early replacements with CBTC.

Labor also needs to be mentioned in this discussion. Because this project can take many years to complete, this can give many people a new opportunity to work in the field which can also increase their prestige since there will be greater responsibilities and skills while upgrading the service for passengers. Raising costs can be attributed to equipment and labor. Older powered equipment needs more labor-intensive maintenance and operations, including drivers, conductors and trackside signal maintainers. All important signal components such as features, adjustments, brake stops, relays and other characteristics of the system are operated using electromechanical equipment. Because most of the signaling system was introduced during the first decades of the 20^{th} century, the old machinery must be custom requested from ancient parts to preserve compatibility with other system components. The parts of the system that have been restructured; still utilize mechanical parts that require labor and time.

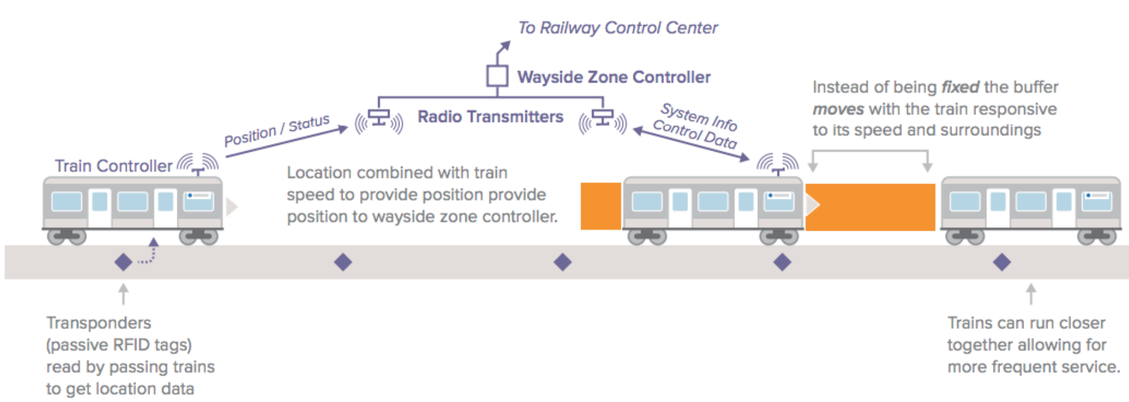
Also, CBTC offers information about the capacity for peak- periods which is calculated by applying the NYCT`s space protocol. For the stations that are most of the time stacked, their capacity is calculated by the number of seats plus 3 square feet per individual for standees, which sums to almost 4.1 square feet per passenger when considering the full measurements of both A and B Division cars.

Capacity of Peak Load Points

	Route	Peak Load Point	Passenger Volume	Avg. Trains per Hour	Volume to Capacity Ratio with NYCT Standard	Volume to Capacity Ratio with RPA Standard
North of 60th Street	1	103rd St.	17,397	20	0.81	0.99
	2 3	72nd St.	22,685	23	0.91	1.11
	A D	125th St.	22,298	20	0.80	0.98
	B C	72nd St.	9,267	14	0.56	0.68
	4 5	86th St.	29,049	26	1.02	1.24
	6	68th St.	23,515	23	0.95	1.16
Queens	F	Roosevelt I.	17,586	16	0.77	0.94
	N Q	Queensboro Plaza	19,665	15	0.92	1.12
	R	Queens Plaza	9,316	10	0.69	0.84
	E	Jackson Hts./ Roosevelt Av.	22,758	16	0.99	1.21
	M	23rd St. / Ely Av.	5,839	9	0.54	0.66
	7 (express)	Woodside / 61st St.	15,670	13	1.02	1.24
	7 (local)	40th St.	12,872	13	0.81	0.99
North Brooklyn	L	Bedford Av.	21,522	18	1.03	1.26
	J Z	Marcy Av.	11,023	12	0.88	1.07
	M	Marcy Av.	6,793	7	1.00	1.22
South Brooklyn	A C	Jay St. /Metrotech	21,064	25	0.65	0.79
	F	2nd Av.	17,026	14	0.91	1.11
	D N	36th St.	22,902	20	0.89	1.09
	B Q	7th Av.	19,964	20	0.70	0.85
	R	Union St.	8,162	11	0.63	0.77
	2 3	Clark St.	11,405	19	0.55	0.67
	4 5	Fulton St.	1,337	25	0.66	0.81
Intra Queens	G - nb	Greenpoint Av.	3,472	9	0.68	0.83
	G - sb	Clinton / Washington Avs	4,185	9	0.83	1.01

Table 1. Analysis from RPA showing the capacity that each train has during peak periods.

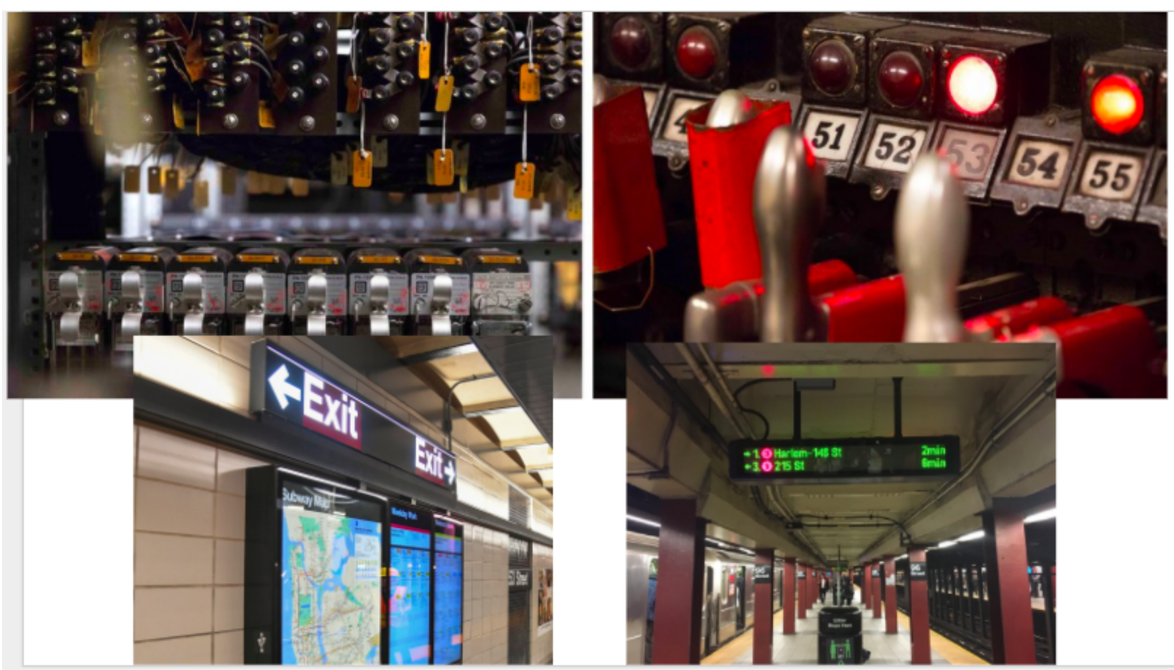
In addition, to complete the C.B.T.C project; the Regional Plan Association specified that "this program would cost on average over $2 billion in each five-year capital plan or $13.8 billion in total. The conversion to equip the subway fleet for CBTC running is assessed to cost an additional $5.4 billion, or about $1 million per car, based on past occurrence with the Canarsie and Flushing lines projects. This would bring the total cost for CBTC to over $19 billion in today's dollars over a 35-year period; this figure does not include the cost of upgrading all interlocking or new car discoveries.



7. UPGRADE TO C.B.T.C SYSTEM AND A.T.S SYSTEM

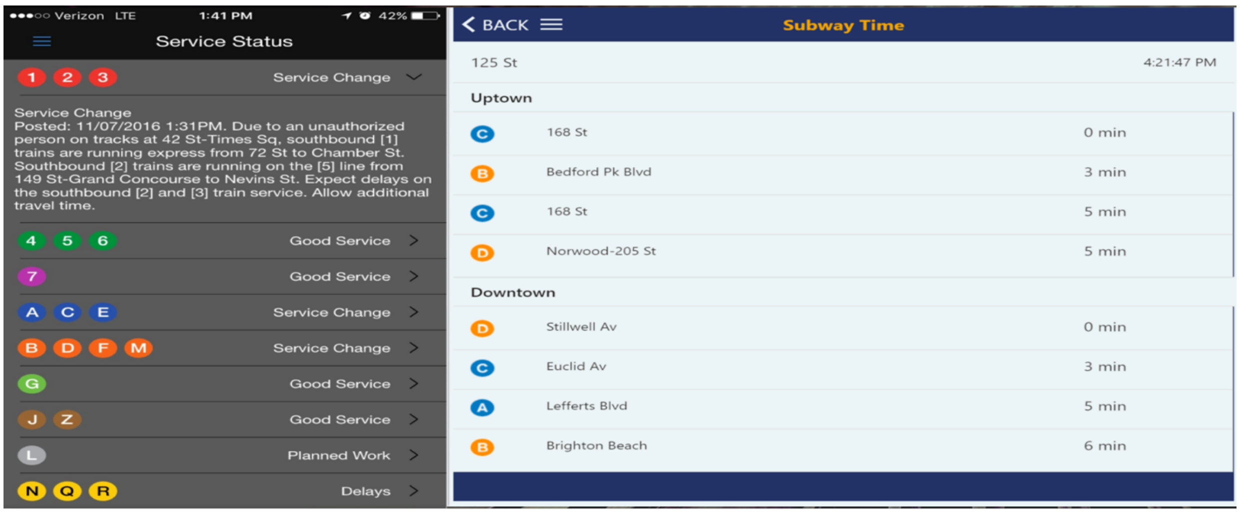
Nowadays, New York's complex subway system is receiving a radical upgrade of its train control system over a third of its network to the "Communications-Based Train Control" CBTC and “Automatic Train Supervision” ATS, replacing the current ageing relay-based technology.

CBTC has been in service on the Canarsie L Line for the past 11 years, with full ATO operational since 2009. In August 2015, the Metropolitan Transportation Authority (MTA) gave preliminary approval to two contracts totaling $205.8 million to Siemens Industry Inc. and Thales Transport & Security for the installation of a Communications-Based Train Control (CBTC) signaling system on the Queens Boulevard Line, one of New York City Transit’s busiest subway lines. The signaling system, which is currently in operation on the Canarsie L Subway Line and being installed on the Flushing 7 Subway Line, enables the MTA to address overcrowding and record subway ridership by operating subway trains more closely together, adding passenger capacity to the century-old subway system.



CBTC allows NYC Transit to operate more trains per hour, thereby increasing passenger capacity; provide improved and more reliable service, and make more efficient use of its track and car fleet. The system is more flexible than the current block signals system because CBTC continuously updates train positions, distances, and travel speeds, allowing for faster and more efficient operations. Continuous updates allow the subway system to recover quickly from delays and restore consistent wait times at subway stations.

The ATS system is responsible for monitoring and controlling the rail system to ensure that it conforms to an intended schedule and traffic pattern in order to optimize railway operations and service reliability. ATS helps to avoid or reduce damage resulting from system abnormalities and equipment malfunctions by performing the following tasks: supervision of train status, automatic routing selection, on-the-fly adjustment of train operations, automatic schedule creation, automatic operations logging, statistics and report generation, automatic system status monitoring, and coordination of personnel scheduling for train management.

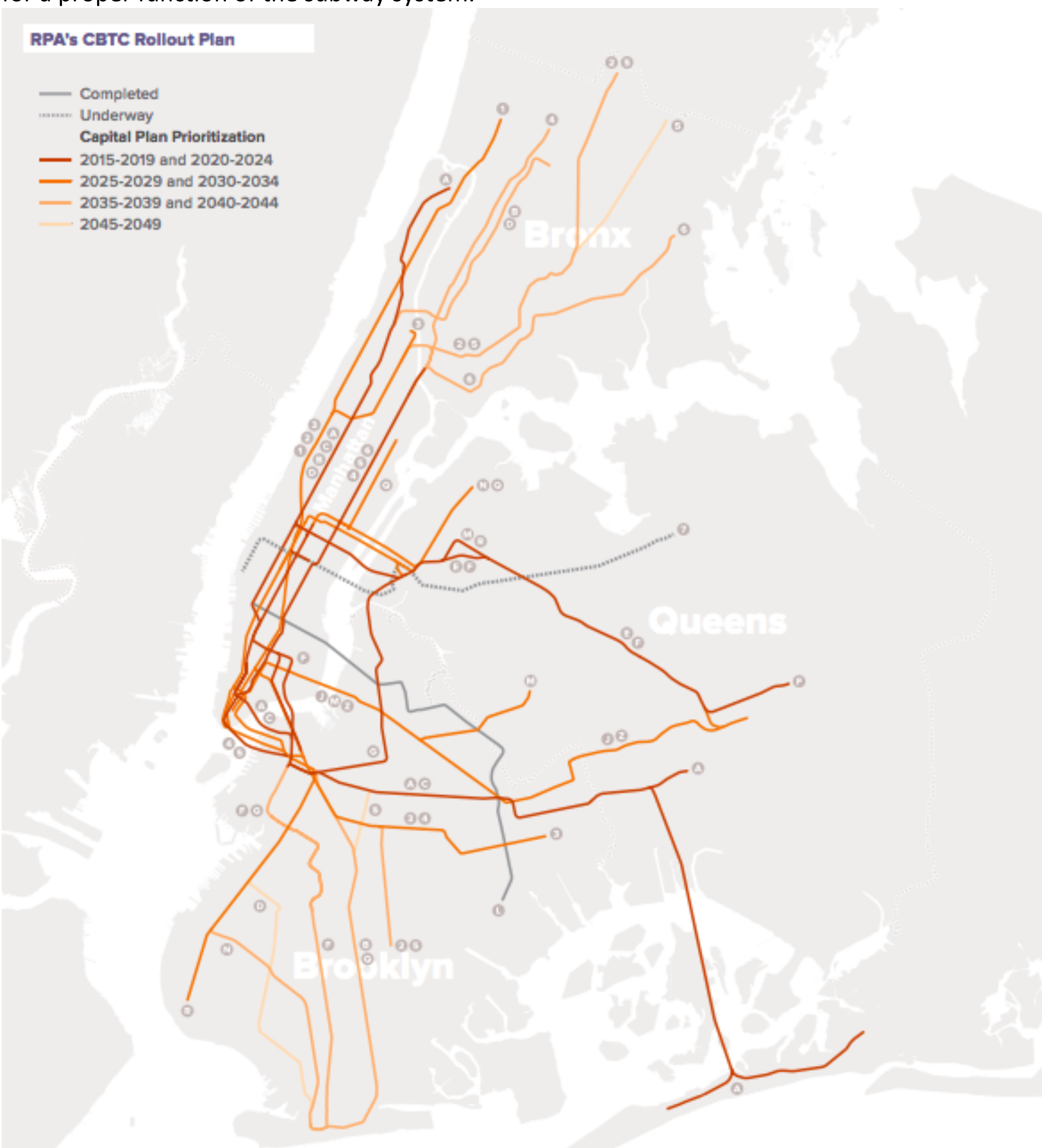


8. **CONCLUSION AND RECOMMENDATIONS**

Based on our findings, in order to preserve a strategic distance from these delays that happen too often in certain trains, we suggest the MTA board to adjust the antique system with "Communications-Based Train Control" or "C.B.T.C". We are looking for a system that will be capable to increase safety, economy, train effectiveness and decrease lateness on every line. For these reasons, we believe that even though C.B.T.C system is more expensive, it can make some major changes in the city. It is time to once again to revolutionize the subway to a modern world so it can be prepared to serve the next generation of New Yorkers.

The New York City Subway System is struggling with an antique signaling equipment build before World War II that is past its life span. This report presents a faster implementation of the new signal systems by analyzing the signal system in subways that is being used today controlled by MTA (Metropolitan Transportation Authority), explore how this system works for trains in details, investigate what other systems can be implemented to improve the old signal system and have a solution to preclude future delays. In addition, we will present the CBTC system and the ATS system, we will compare and contrast the new systems and show that indeed is better for the subway in general. Our recommendations to the board will raise a lot of revenue that would otherwise be lost in delays and repairs, Also, will improve the MTA system without affecting the people who use the MTA or with the least effects on their daily transportation.

The MTA Capital Program has a timeline and a budget to modernize the MTA Subway System, it does take a longer time and it does cost to implement new technology but thankfully the MTA Board expedites the implementation processes and uses the expenses from reconstructing and maintaining the old system to fund the new technologie that is necessary for a proper function of the subway system.



New York City Transit

SIGNALS & COMMUNICATIONS
T - 708

Commitments
($ in millions)

ELEMENT DESCRIPTION/PROJECT	NEEDS CODE	2015	2016	2017	2018	2019	Total All Years
03 SIGNAL MODERNIZATION							
01 CBTC: QBL West Ph2 (50 St - Union Tpke)	SGR	5.6	416.6	0.0	0.0	0.0	422.2
02 CBTC Technical Support Contract FLS	NR	0.0	0.0	0.0	1.0	0.0	1.0
04 CBTC: 8AV (59 St - High St)	SGR	0.0	10.7	1.1	364.1	0.0	375.9
06 Install Automatic Signals for Work Trains / CNR	SGR	0.7	4.3	0.0	0.0	0.0	5.0
07 Interlocking Modernization: Ditmas CUL	SGR	0.0	2.4	0.0	135.6	0.0	138.0
08 Interlocking Modernization: Kings Highway CUL	SGR	6.1	173.0	0.0	0.0	0.0	179.1
19 Signal Control Line Modifications, Ph6	NR	15.2	0.0	17.8	0.0	0.0	33.0
21 AC to DC Line Relay Upgrade Ph2 - FUL	NR	13.5	0.0	0.0	0.0	0.0	13.5
22 AC to DC Line Relay Upgrade BCT	NR	0.0	0.0	28.8	0.0	0.0	28.8
23 Signal Key-By Modifications, Ph4	NR	0.0	18.4	0.0	0.0	0.0	18.4
24 Code Cable Replacement BW7	NR	0.0	0.0	0.5	6.9	0.0	7.4
25 Signal Room Fire Suppression, Phase 2	SGR	1.5	0.0	0.0	14.1	0.0	15.6
26 Life Cycle Replacement of Code Systems	NR	0.0	0.0	4.8	30.6	0.0	35.4
27 Life Cycle Mod - Speed Enforcement Systems	NR	0.0	0.0	4.5	40.5	0.0	45.0
29 Upgrade 25 Hz AC Main Cable & De-Ion Switches DEO	NR	0.0	0.0	0.0	1.1	0.0	1.1
30 Interlocking Modernization: Parsons Blvd QBL	SGR	0.0	0.0	5.1	0.0	160.5	165.7
31 Eliminate Single Point of Failure Intrlckng Cntrl	SI	0.0	0.0	0.0	10.0	0.0	10.0
32 CBTC: CUL (Church Av to W8 St)	SI	0.0	5.7	0.0	148.6	0.0	154.3
33 Interlocking Modernization: Ave X CUL	SGR	0.0	4.5	0.0	139.7	0.0	144.3
34 Cable Messenger Brackets Replacement BRT	NR	0.0	0.0	0.0	0.0	10.0	10.0
35 Interlocking Modernization: 30 St & 42nd St / 8AV	SGR	0.0	7.2	0.0	221.2	0.0	228.4
Element Total 03		**$42.7**	**$643.0**	**$62.6**	**$1,113.4**	**$170.5**	**$2,032.2**

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