MODERNIZING THE MTA'S SIGNALING SYSTEM WITH ULTRA WIDEBAND

HOW HUMATICS PILOTED UWB WITH THE MTA

THE CHALLENGE

Metropolitan Transit Authority (MTA) challenged the transit community to propose Ultra Wideband (UWB) train positioning solutions. The pilots would have to prove three things, all within one year: they would have to be viable for train control; meet MTA environmental requirements; and be safety-certifiable.

OUR SOLUTION

Over the course of 10 months, Humatics partnered with MTA to launch the world's largest UWB proof-of-concept, and the first-ever UWB deployment for train control. Humatics deployed its Rail Navigation System on 5.5 miles of track in Brooklyn, NY and on four R143 subway train sets, successfully completed functional train control testing and collected terabytes of positioning data for algorithm development.

WHAT WE FOUND:

- **Humatics Rail Navigation System is safety-certifiable**
  Meeting all conditions to pursue safety certification including a robust architecture, strict positioning performance metrics, and proof that the tech can be integrated with existing train control systems to ensure its a viable replacement.

- **Quicker and cheaper train installation and maintenance**
  UWB train installation is four days per train with no under-vehicle access required. No equipment is mounted underneath the train reducing maintenance costs.

- **Environmental and climate resilience**
  UWB technology is proven to work in all weather conditions and installed to minimize flooding impacts

- **Clearer trackbeds**
  UWB beacons are installed above the trackbed ensuring they remain out of the way of workers and are less likely to be blocked or moved

- **Real-time health monitoring**
  Real-time insights into wayside infrastructure

- **Fewer UWB beacons required**
  Maintain position coverage and accuracy, minimizing maintenance and installation effort

- **Continuous navigation throughout the entire right of way**
  Enables additional applications in work-train tracking and maneuver optimization, Capital Construction General Order (GO) efficiency, and worker protection systems. Improving GO efficiency by a meager 1%, for example, could yield up to $35 million savings annually and reduce service disruption.

The New York City Subway has been the heart of New York City for over a century--always-on, moving six million people per day throughout a complex web of more than 600 miles of rail. With increasing ridership demands and unpredictable climate and emergency events, it has become increasingly important to help the riders to get on their way, on-time, anytime, reliably.

However, the subway's signaling infrastructure sits at the center of the system in a state of disrepair. Dating back to the mid-1900s, with some components that haven't been updated in over 80 years, the signaling infrastructure not only negatively impacts on-time performance and train reliability, but limits capacity on a system expected to accommodate more people year after year.

The Metropolitan Transit Authority (MTA) has installed modern signaling systems over the course of the past fifteen years which have yielded significant improvements, but the reality is that these systems simply can't be implemented fast enough to make the improvement to subway performances needed to accommodate rapid urban growth.

One quick fix? Improving navigation within the system, which could take some of the burdens off of signaling improvements to deliver more service and better on-time rates.

In 2019, Humatics worked alongside Siemens and the MTA to deploy its Rail Navigation System across 5.5 miles of track in Brooklyn New York, and on four R143 subway trains, representing the largest Ultra Wideband (UWB) proof-of-concept in the world.

The pilot proved to be extremely successful:

Humatics and the MTA proved that UWB technology is safety-certifiable, meeting all conditions for certifications across the system; it is hearty enough for the New York City transit environment, holding up against the stresses of use; it is quickly installed, in a matter of hours, meaning riders spent less time waiting for the completion of capital work; it is storm-resistant, mounted five to nine feet above the floor to reduce the chance of flooding; and it reduces maintenance needs by replacing complex and easily-breakable hardware.

Modern Signaling Technology

To initiate the transformation of its transit signaling system, New York City Transit (MTA) has implemented Communications Based Train Control (CBTC). CBTC is the worldwide modern signaling standard used to minimize headways, increase capacity and improve reliability over legacy signaling systems.

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At the highest level, CBTC has three core functions: navigation, train control, and communications.

Navigation uses discrete transponders installed in the middle of the trackbed and surveyed to identify their exact positions. Equipment mounted underneath the vehicle reads the transponders to determine their exact locations, while other sensors collect information on speed.

Train control uses this navigation information, pairing it with track maps and other data to control the train for speed, braking and maintaining safe headways.

CBTC communications then give a full, system-wide picture of activity, reporting vehicle position to operations centers and onboard train control computers.

Innovative navigation technologies can augment CBTC's precision, installation time and reliability. Currently, CBTC's navigation system can take longer to install than an industrial-grade UWB navigation system.

Transponders are mounted in the trackbed in between the rails which are 'read' by an antenna installed under the train. These transponders are exposed to the environment, difficult to access and prone to misplacement during routine maintenance activities.

Similarly, undercarriage CBTC equipment, composed of a variety of sensors and antennas, suffers the tracks' wear-and-tear.

Maintenance for this equipment can be difficult, requiring re-installation which could involve taking up space in an already full maintenance depot.

FREQUENTLY ASKED QUESTIONS

What is Ultra Wideband (UWB)?

Humatics UWB is a radio frequency technology that uses a very large bandwidth to transmit and receive information used to calculate precise locations. Humatics uses a technique called Two Way Time of Flight (TWToF) along with proprietary algorithms to provide industry-leading ranges over 1,600 feet and precision within one inch.

Is UWB a replacement for legacy train control systems?

No, UWB is not a train control system in and of itself. The Humatics Rail Navigation system serves as a one-to-one replacement for legacy localization equipment such as transponders, transponder interrogator antennas, wheel sensors, and accelerometers while providing precise location information that is processed for train control operations.

What is the difference between Humatics UWB and the UWB that cell phone providers are advertising?

Ultra Wideband is a misnomer in the cell phone provider space referring to 5G high bandwidth millimeter waves that operate at various frequencies for data transmission in consumer and commercial grade services. Humatics provides industrial-grade localization UWB technology that uses proprietary hardware and algorithms to provide highly precise and accurate range/distance measurements.

How Does Humatics' Rail Navigation Solution Work?

The Humatics Rail Navigation System serves as a "drop-in" replacement for train control navigation, consisting of Humatics industrial-grade UWB beacons embedded on the train and within the fixed infrastructure on the wayside of the track. Humatics industrial-grade UWB technology offers ranges of up to 1600 feet, precision down to an inch, and robustness against radio frequency (RF) challenges such as multipath and interference. This always-on system uses real-time positioning providing a unified location layer for an entire transit system, allowing system operators and workers to locate trains, assets and people in-real time.

FASTER INSTALLS, LESS MAINTENANCE, ROBUST

The MTA Pilot has been a rousing success, with faster installation times and less maintenance needed to keep the system in a state of good repair.

Faster installation along the tracks

Humatics proved that its Rail Navigation System can be installed in weeks with minimal infrastructure, simplifying deployment and getting trains running quickly.

Simple, standard mounting mechanisms are employed to reduce training requirements and speed up installations.

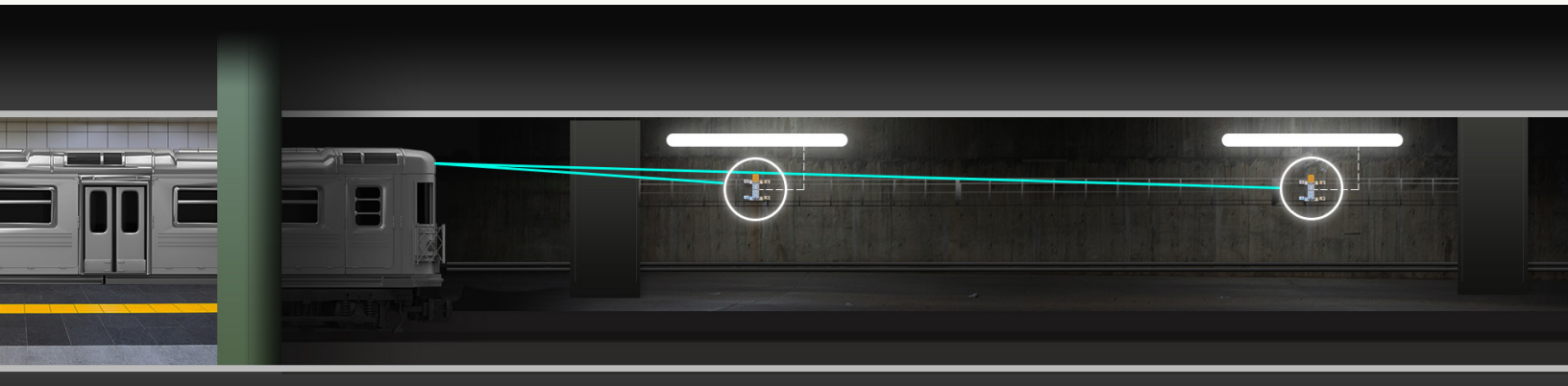
These features mean less time on the tracks, reducing costly and frustrating impacts to revenue service.

Faster installation onboard

Similarly, embedding Humatics onboard equipment in the operator cab provides easy access for maintenance and decreases installation time to just four days. Installing the equipment within the train protects the technology from the wear-and-tear associated with undercarriage positioning reducing required maintenance activities.

Robust

Humatics Rail Navigation System has proven itself to survive the harshest transit environments and weather conditions. Designed for ruggedness, the Humatics Rail Navigation system passed all environmental testing required to operate in the MTA system.



To provide precise speed and position, the Humatics Rail Navigation System UWB beacons are installed along the trackside five to nine feet off the ground and within the enclosed bonnet of the train. Humatics UWB beacons on the train and on the wayside communicate using a technique called Two Way Time of Flight, to calculate ranges, or distances, which are delivered to the Humatics onboard computer. Humatics' sensor fusion technology within the onboard computer uses AI algorithms to then combine ranges with train acceleration data, providing an output of precision location, position, and speed. Humatics real-time location data can then be integrated with a train control computer and uploaded onto the cloud-enabling applications beyond train control, continuous analysis, monitoring, and algorithm improvement.

The MTA 2019 UWB Pilot

Metropolitan Transit Authority (MTA) challenged the transit community to propose UWB-based train positioning solutions. The pilots would have to prove three things, all within one year: They would have to be viable for train control; meet MTA environmental requirements; and be safety-certifiable.

The project was aggressive in both scope and schedule --- equipping miles of track and going from proposal to substantial completion in 10 months. Success required meeting strict positioning performance metrics, ensuring installation time and maintenance costs were improved over traditional systems, and integrating UWB positioning with existing train control systems to demonstrate UWB as a viable replacement.

MTA's UWB pilot represented the largest, most ambitious deployment of UWB technology ever.

The Humatics Rail Navigation System successfully integrated with the onboard train control system, performed formal train control operations as part of functional testing and, through a rigorous and extended data collection period, proved the ability to locate trains within a few inches meeting the accuracy and precision requirements.

The Humatics Advantage

Backed by a 30-year legacy in Ultra Wideband, Humatics technology offers the most precise, secure, robust and low power rail navigation system on the market. These advantages have made Humatics UWB the "technology of choice" for two of the four winners in the signaling category of the MTA Genius Challenge.

MTA PILOT BY THE NUMBERS

5.5
MILES OF REVENUE TRACK

4-9FT
DISTANCE MOUNTED OFF THE TRACK

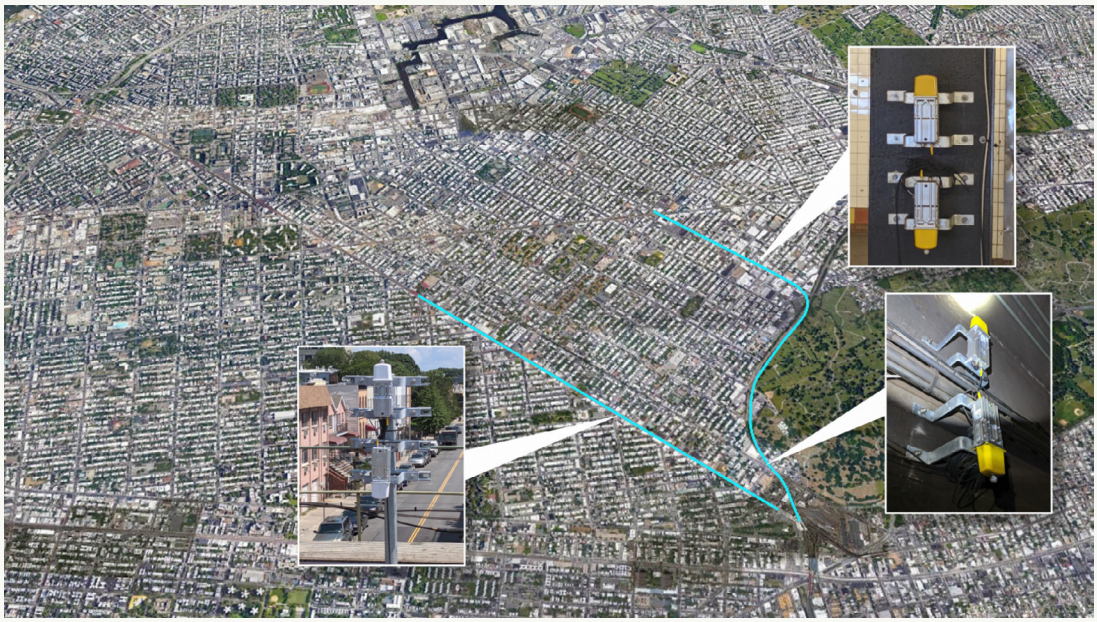
242
WAYSIDE BEACONS
average spacing of 300ft / maximum spacing of 900ft

600K+
HOURS
of wayside equipment uptime to date

Installed on four R143 trains taking **4 days per train**

Geolocation features accurate to a **foot or less**

Notice to Proceed to install completion in **5 months**



Capital Construction Operating Picture Reduces Go Costs

Worker Protection Ensures Employee Safety

As a navigation company, Humatics leverages its sensor fusion capabilities to apply the right sensors to the challenge at hand: inertial measurements, LIDAR, and cameras when appropriate. Humatics sensor fusion algorithms are designed and built in-house and provide estimates of the train's position and speed as well as continuous uncertainty calculations, enabling use in safety-critical applications.

Software applications such as real-time and historical data visualizations, analytics, and machine learning algorithms enable optimal decision making and identify inefficiencies and bottlenecks. These key features provide futureproof solutions that are easily integrated with third parties.

What's Next

Geolocation of trains is just the beginning of potential uses for UWB technology. A single, unified location system could help solve a variety of high-priority problems, such as environmental resilience and rider safety, improving reliability, reducing system maintenance, expediting completion of capital programs, and enhancing safety.

Speed up capital projects by helping locate materials, work vehicles, and maintenance issues:

- Lack of visibility into where work trains are and when they will be onsite results in wasted time and project delays. Improving capital construction efficiency could yield up to $35M savings a year and reduce service disruption.
- Right now, in the event of an unexpected maintenance need, workers mostly use paper records and walkie-talkies to locate materials and work trains for quick fixes are in the system. UWB can be used to quickly identify where these critical assets are and get them to the site faster.
- UWB could also be used on the opposite side of the maintenance equation: helping workers precisely identify where maintenance areas to reduce wasted time and maintenance 'misses'.
- In addition to geolocating materials and maintenance orders, UWB could also be used to identify where trains are in rail yards, protecting against incidents by ensuring safe clearances and alerting operators of proper stopping positions.

Protect workers on the tracks:

- Workers identify where they are in the system using antiquated mile markers, that aren't consistent from one line to the next, leading to confusion and disorientation.
- UWB can be used to help workers identify where they are in the tunnel more easily, replacing invasive cameras for anonymized geolocation services.
- Ability to locate a train of interest in an emergency situation.

Provide better insights for transit commuters and riders:

- UWB networks could also help inform and locate affected riders in emergency situations within stations and "turnstile-to-turnstile" rider journey metrics for greater understanding of capacity and rider flows throughout the day.

Humatics Rail Navigation System Keeps Trains Moving

With the Humatics Rail Navigation System, transit systems can accelerate signal modernization, improve revenue service reliability, reduce system maintenance, expedite completion of capital programs, and enhance worker, rider and system safety through a variety of applications that build upon a single localization foundation. Through a successful pilot with the MTA, the Humatics Rail Navigation System and the underlying UWB technology are the ticket to getting the transit systems back on track and on their way to helping riders get from point A to point B safely, reliably and on-time, enabling workers to stay safe and informed on the tracks, and providing system operators with a full picture of what's going on within the system in real-time.

Would you like to keep your transit system on-time and moving?
To learn more about the Humatics Rail Navigation System, contact **transit@humatics.com**

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