Alternative Technology Pilot Report

August 2017

Background and Introduction

On October 15, 2015, the New York City Taxi and Limousine Commission (TLC) authorized a year-long pilot program evaluating software-based taximeters, as well as streamlined Taxicab Technology System ("TPEP") solutions. The pilot lasted for one year, beginning May 6, 2016 - the first day that a yellow taxi with pilot technology began providing service to the public.

Alternative Technology Systems

TPEP systems were originally approved for use in taxicabs in 2005, when the TLC issued a Request for Proposals ("RFP") seeking vendors to build, install, and maintain equipment. The equipment had five core features:

1. processing credit card payments,
2. enabling taxicab drivers to receive text messages from the TLC,
3. collecting electronic trip sheet data,
4. providing trip notifications to passengers including passengers with visual impairments, and
5. displaying PSAs and other TLC content on the Passenger Information Monitor ("PIM").

TPEP systems were first installed in taxicabs in 2009 under contract with the Taxi and Limousine Commission. Following the execution of the vendors' contracts, the TLC passed rules in 2013 establishing updated requirements for TPEPs and an "Authorized Provider" structure for TPEP Providers, whereby any technology provider that meets TLC's requirements can become authorized to provide TPEPs in medallion taxicabs. However, the rules largely reflected the contracts, circumscribing design with strict specifications, which limited potential innovations and caused the TPEP systems to go largely unchanged since their first introduction 8years ago.

Technology now exists that can provide most of the core services provided by a TPEP without a Taxi TV, allowing for a more streamlined taxi technology system. In response to complaints about the intrusiveness of the Taxi TV and other calls for more adaptable and passenger-centric systems, the TLC authorized the Alternative Technology Pilot to allow for Alternative Technology Systems ("ATS") that provide the core functions of a TPEP while deviating from the specifications outlined in Chapter 75 of the Rules of the City of New York. The goal of the pilot was to evaluate how best to guide in-taxi technology to provide passengers, drivers, and medallion owners with the most up-to-date service and technology.

Software-based taximeters

The pilot also permitted companies to install software-based taximeters ("soft meters"). Traditional taximeters are specialized pieces of hardware physically wired into the vehicle's transmission that calculate fares by sensing tire rotation. This makes traditional taximeters dependent on tire size and pressure and requires invasive installation. Conversely, soft meters can be run on standard mobile devices like smartphones or tablets and incorporate a mix of signals including GPS and readings from the On-Board Diagnostic system, reducing dependence on tire variation and potentially making installation

cheaper and faster. Due to their enhanced computational power, soft meters can more easily allow for added consumer protections and new fare mechanisms, such as concurrent fare calculations and fare-splitting.

In New York State, taximeters are certified by the New York State Department of Agriculture and Markets Bureau of Weights and Measures ("Weights and Measures") based on standards set by the National Institute of Standards and Technology ("NIST"). During the pilot, there were not any national standards for soft meters. However, the US National Working Group on taximeters, of which the TLC is a member, had been revising the taximeter codes to account for soft meters since 2011. The TLC used its experience with soft meters in the pilot to help guide the new codes, which were adopted by the National Conference of Weights and Measures in July 2017.

Pilot Structure

Pilot Scope

Pilot participants could create and install an Alternative Technology System, a soft meter, or both technologies in up to 175 yellow taxis, with installation taking place in three batches. After initial approval, participants could install in 10 taxis. After the taxis completed 4,000 trips, the participant could request approval to install in an additional 90. Before receiving approval, the TLC would perform a preliminary evaluation of the system's operation. After completing 80,000 additional trips, the participant could again apply to install in 75 more taxis.

Up to 7 companies could participate in the pilot with 175 taxis each:

10 initial taxis +
90 taxis after 4,000 trips +
75 taxis after 80,000 additional trips.

Approval process

Pilot applicants underwent a two-step process to receive approval. Applicants first provided proof of necessary insurances and business documentation, as well as a detailed system description. TLC staff evaluated all documentation and followed up with the applicant as necessary. Subsequently, the applicant provided working demonstration units for the TLC to review. In the approval process, TLC worked closely with the Mayor's Office for Peoples with Disabilities to ensure the accessibility of the payment process and notifications for people with visual impairments. Additionally, all Alternative Technology Solutions were required to meet the accessibility requirements contained in the New York City Administrative Code and the Americans with Disabilities Act.

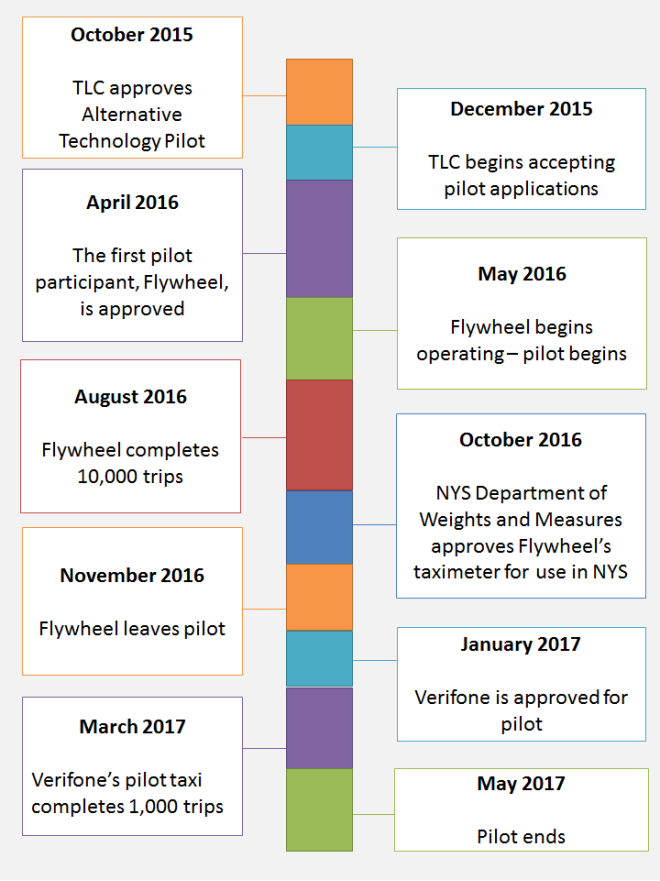
Alternative Technology Solutions provided the same fare, rate, and toll notifications to passengers currently provided by the PIM. In order to ensure that passengers receive the same level of security in their credit card payments all Alternative Technology Systems met the same Payment Card Industry standards as existing TPEP solutions.

Additionally, if the applicant's system included a soft meter, that meter was required to be approved by Weights and Measures to ensure that it met the same accuracy and reliability standards as existing taximeters. The approval process included lab testing, running the meter on a measured mile, and, for meters that use location services such as GPS, additional distance tests in downtown Manhattan. Weights and Measures compared the results of the soft meter to the results of a second, finely calibrated pulse-based meter to ensure that the GPS was able to perform accurately in dense urban

areas with tall buildings, which can interfere with GPS readings due to multi-path effects (i.e., signals bouncing off buildings). Meters that performed within established national tolerances were given approval to participate in the pilot.

Approved Participants

The pilot was authorized to accept up to 7 participating companies. The TLC received 7 written applications for the Alternative Technology Pilot in December 2015 and approved two, Flywheel Software Inc. and Verifone Inc.



The first participant, Flywheel Software Inc. ("Flywheel") was approved on April 20, 2016. The first vehicle was put into operation on May 6, 2016, officially beginning the pilot. The second participant, Verifone Inc. ("Verifone") was approved on January 12, 2017. Both systems consisted of 4 components connected via Bluetooth:

1. A smartphone or tablet mounted to the dashboard that was both a soft meter and a Driver Information Monitor;
2. A wireless device connected to the vehicle's On-Board Diagnostic system for backup distance inputs;
3. A small haptic credit card reader or a point-of-sale with a 7" touchscreen display; and
4. A portable receipt printer.

Flywheel received approval for a TPEP solution on July 20, 2016 and statewide approval for their taximeter on October 6, 2016. These approvals allowed Flywheel to operate outside the pilot with their approved soft meter so they officially left the pilot in November 2016.

Other Applicants

After submitting initial documentation, the remaining applicants did not submit demonstration units and stopped pursuing pilot approval. The applicants reported that, considering the considerable startup cost, they were deferring participation until their systems could have access to the entire market through rulemaking. Access to the entire fleet, applicants noted, is very important for certain innovations in service where scale is a crucial requirement, particularly in regards to offering shared rides and finding new media content providers.

Report Scope

This report discusses the reliability and accuracy of software-based meters for the entire pilot period – May 2016 to May 2017. As specified in the pilot resolution the TLC also attempted to analyze passenger

and driver acceptability and confidence through online surveys and in-person focus groups. However, TLC only received feedback from 20 passengers and four drivers, limiting its ability to confidently draw statistical conclusions about user acceptability.

Through May and June 2016, Alternative Technology Systems were installed in a total of 11 taxis. These taxis performed 13,314 trips and were driven by 39 unique drivers.

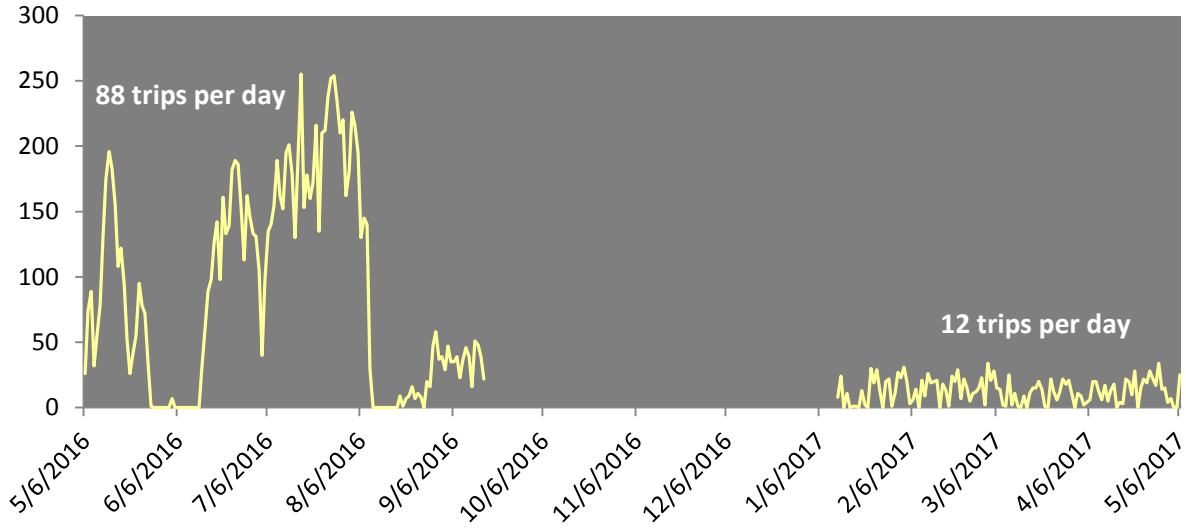


Figure 1: Count of trips per day performed in pilot taxis

Results

Section 1. Software-based taximeters

With proper calibration and safeguards, soft meters can meet the same accuracy and reliability standards as pulse-based taximeters. Determining accurate locations with GPS requires triangulation from a constellation of satellites. The most accurate results involve signals from three or more satellites. When one or more of those signals are blocked or reflected, location can be measured inaccurately. When GPS signals reflect off of objects, the readings are altered through what is called the multipath effect. The multipath effect can be particularly problematic in urban environments with tall buildings and limited lines of sight to satellites ("urban canyons.") See Figure 2 to the right for an illustration of the urban canyon and multipath effects.

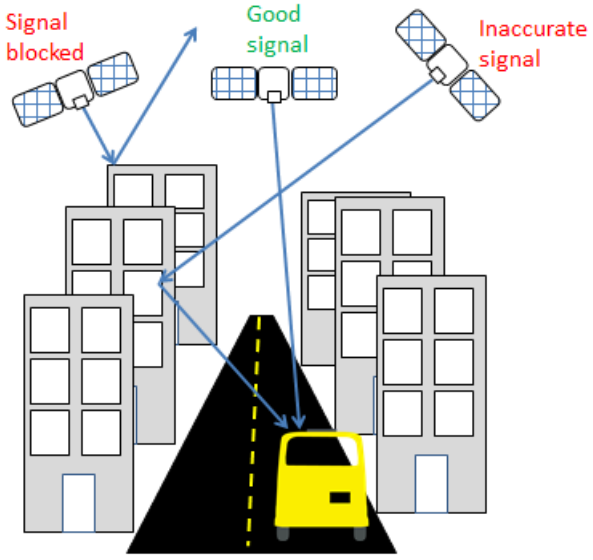


Figure 2: Example of urban canyon and multipath effects

Like yellow taxis in general, pilot taxis drove primarily in midtown and downtown Manhattan, which are prime candidates for the urban canyon

effect (see Figure 3.) However, the soft meters seemed to perform well in this environment, which aligns with findings from rigorous testing by NIST. Additionally, the TLC has not received any passenger or driver complaints about meter accuracy. Note that the meters currently in the pilot use a mix of location-based and vehicle-based signals and so are not wholly reliant on GPS.

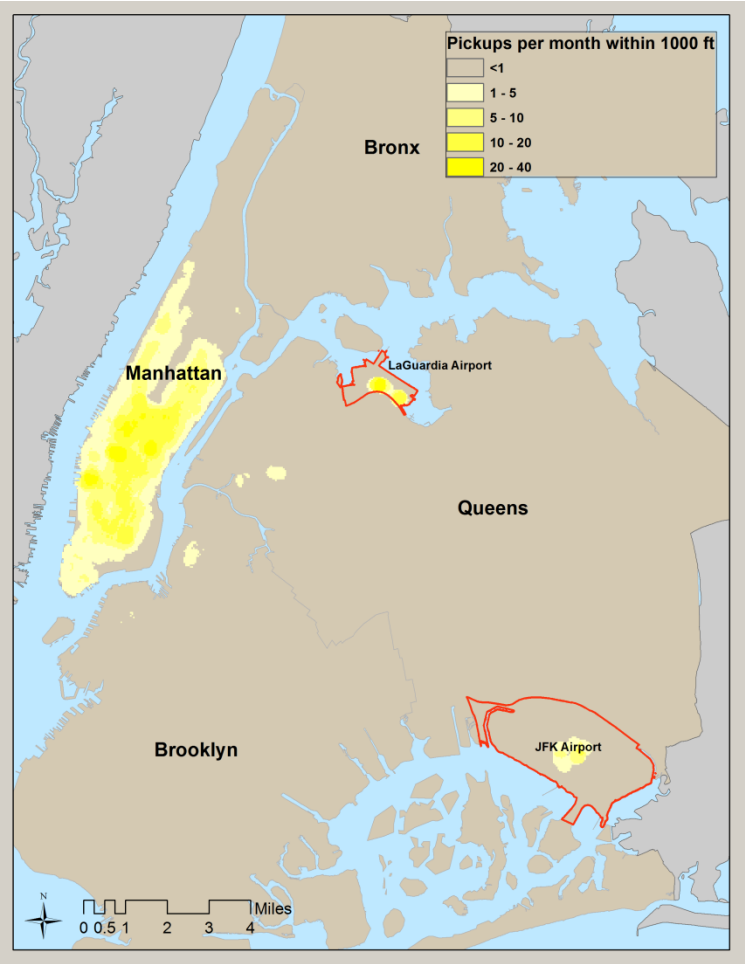


Figure 3: Distribution of pickups in pilot taxis

On October 6, 2016 NYS Weights and Measures granted conditional statewide approval to a software-based meter for the first time, obviating the need for companies to participate in the Alternative Technology Pilot. Software-based taximeters companies may now undergo the standard approval process to be used in New York City taxis. Taximeters must prove their metrological accuracy to Weights and Measures by undergoing rigorous testing and be licensed by the TLC by proving that they are properly programmed for New York City use and follow all TLC rules and regulations. Since the start of the pilot, one software-based taximeter, Flywheel's, has received all necessary approvals and licenses by the TLC and NYS Weights and Measures. A second software-based taximeter, Verifone's, is currently being reviewed by Weights and Measures.

Section 2. Equipment durability

During the evaluation period, two meter screens cracked due to rough handling. The devices were replaced on the same day that they were reported. Traditionally, when a taximeter is replaced, the TLC is notified and the vehicle inspected by the TLC before resuming operation. This is done to ensure that the taximeter is properly calibrated and has not been reprogrammed locally. The TLC knows when a taximeter has been replaced or recalibrated because each taximeter has a catalogued physical seal preventing the taximeter from being opened. However, in this instance the TLC was unable to discern that the physical device had been changed until informed by the company. The revised NIST taximeter code recognizes that a physical seal is not an effective means of securing a meter that is software-based, uses device-independent cloud-based location services, and can be remotely updated. The TLC's experience in the pilot informed the inclusion of more appropriate security standards for soft meters, such as event logging to identify recalibration of the meter, in the new code that was approved by the National Conference on Weights and Measures in July 2017.

There have been no 311 complaints about broken or inoperable credit card readers, software, or GPS services in participating pilot taxis.

Section 3. User acceptability of Alternative Technology Systems by passengers and drivers
As mentioned above, the TLC received limited feedback from drivers and passengers. However, some comments include:

- Some passengers noted that they preferred systems that allowed payment via E-Hail app, which one of the pilot systems did not offer.

- One system only let passengers choose tips in percentages, which drivers felt led to lost tips. One driver explained that passengers would enter 10% without considering the actual dollar amount. This mostly affected fares under $10, where tips are normally higher than 10%.

- Some of the extra information on merged taximeters/DIMs can confuse passengers who are unfamiliar with the new taximeter. For example, in one pilot system the number of passengers is displayed in the top right hand corner of the screen. This is normally where the rate number is located in traditional meters. One driver recounted an incident in which he had three passengers who accused him of overcharging them and because the display showed “3” when they were accustomed to that part of the screen showing “1” (the standard city rate).

- It is common practice for drivers to disengage the taximeter while the vehicle is in motion to allow the passenger to pay and then exit the vehicle once the car is stopped. The TLC requires that TPEP and Alternative Technology Systems be inoperable while the vehicle is in motion. However, because the meter is part of the Alternative Technology System, this means that drivers could not end the trip until the taxi came to a complete stop. One driver requested that he be allowed to end a trip while in motion in order to save passengers' time and get better tips.

Conclusion

TLC staff monitored the Alternative Technology Pilot for impacts on passenger experience, driver experience, and taximeter accuracy. The results suggest that software-based taximeters are a viable technology for New York City Taxis. Additionally, the pilot did not generate any passenger complaints. This implies that the strict rules surrounding TPEP design and functionality can be relaxed without sacrificing consumer or driver protections, as long as the core functions of TPEP are still met.

Firstly, soft meters in the pilot underwent extensive testing and certification by both the New York State Department of Agriculture and Markets and the New York City TLC. Both authorities found the meters to be within established tolerances during testing. The pilot meters have performed well enough that NYS has given state-wide temporary certification to Flywheel and is reviewing the soft meters of other companies, opening the door for soft meters to be used in New York City without needing a pilot program. Flywheel was given temporary certification because, at the time, there were no national standards for soft meters specifically. However, in July 2017, the National Conference of Weights and Measures adopted new soft meter regulations that the TLC helped draft using its experience in the pilot.

Secondly, even though passengers like the existing payment system, they were pleased that there was no Taxi TV - i.e., advertisements and PSAs. Preliminary passenger feedback suggests that passengers prefer using the Passenger Information Monitor for payment due to its passenger-friendly interface but they dislike its secondary use: displaying advertisements and PSAs. This suggests that the TLC should focus its rules on providing annoyance-free and distraction-free rides for passengers and drivers that still ensure ease of payment. However, instead of codifying exact specifications, the TLC can focus on user requirements to allow companies to innovate and compete while ensuring consumer protections.

The most important factors of taxi-technology that were identified in the pilot are a fast, smooth payment process, specifically easy tipping options, and the ability to pay via E-Hail app. However, entrance into the e-payment market is limited as current TPEP rules require that all payment, including e-payment, be processed through the TPEP provider. TPEP providers are required to maintain an API for E-Hail companies to allow for e-payment but these rules need to be strengthened to close loopholes that discourage an open, competitive environment.

Based on preliminary passenger and driver feedback, TLC staff makes the following suggestions:

1. Continue to support the adoption of national standards for software-based taximeters, particularly surrounding security measures in place of a physical seal and methods to ensure that valid meters housed in commercially-available devices are easily recognizable.

2. Replace prescriptive TPEP hardware specifications with consumer-focused user requirements.
    a. Craft user requirements to improve the user experience to passengers and drivers and create a fast, reliable payment experience.

3. Encourage a fair and open E-Hail market and make it easier to offer services in yellow taxis by removing bottlenecks in payment processing.

4. Harmonize taximeter, TPEP, and E-Hail rules to take into account solutions where all three components are integral pieces of the same system.