Florida's Turnpike Enterprise Tolling System and 5G Interference Test Plan at SunTrax

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1. Introduction

Florida's Turnpike Enterprise (FTE), as part of the Florida Department of Transportation, operates toll sites throughout the state of Florida. These toll sites use radio frequency (RF) readers mounted on gantries to read SunPass transponders and transponders of FTE interoperable tolling agencies. The accuracy and reliability of these readers in reading and writing to transponders is critical to the ability to accurately collect tolls from customers traversing under toll gantries.

With the deployment of 5G small cell installations increasing throughout the State, FTE would like to collaborate with the wireless carrier industry to determine if there are impacts to the FTE tolling reader's performance from 5G sites that may be in close proximity to toll sites. FTE tolling readers are RF readers that read multiple tolling protocols. They are mounted on a gantry approximately 18.5 feet above the pavement and centered on both the centerline of each lane as well as the stripes. They are arranged in a "triangle" pattern or zig-zag and are angled between 10 to 15 degrees towards oncoming traffic. A toll site consists of these readers as well as other equipment including cameras, illuminators, lasers, and inductive loops.

The FTE tolling systems operate in the 903 MHz – 930 MHz frequency range. FTE utilizes the TransCore Encompass 6 Multiprotocol Reader and the AA3152 universal toll antenna in its toll lanes. The readers read three protocols:

- Super eGo (SeGo) – ISO 18000 6B based tolling protocol. Supports read and write capabilities.
- EZ-Pass Interagency Group (IAG) / TDM (Time-division Multiplexing) – The predominant protocol that the E-ZPass coalition of agencies from 18 states uses for toll collection. Supports read and write.
- 6C – Transponder programming standard based on the ISO/IEC 18000-63 (known as 6C) communication protocol for tolling applications. Supports read only.

It is critical that the 5G systems and tolling systems do not interfere with each other as both could be negatively impacted.

2. Objective

This proposed test plan is a joint collaborative effort between FTE and the wireless carrier industry companies. The objective of this testing is to ensure that the 5G frequencies do not interfere with the toll system frequencies and vice versa.

3. Test Layout

Testing will be performed at the FTE SunTrax facility located at 100 Transformation Way, Auburndale, FL 33823. SunTrax consists of a 2.25-mile-long oval test track with four toll gantries surrounding a 200-acre infield. FTE will be responsible for its test tolling equipment. Each wireless carrier company (Carrier) would bring their equipment mounted on a van or trailer. Each Carrier's equipment will be placed near the Gantry 1 or Gantry 3. Both toll systems utilize the same E6 reader. Carrier equipment will be placed 50 feet longitudinally before the front edge of the closest antennas on each toll gantry, at approximately 20 feet above the ground, and alongside the track behind the concrete barrier in order to mimic as close as possible a real scenario. Carriers will transmit at XX watts and antenna propagation settings will be set for a typical urban omnidirectional installation [Insert additional information from carriers]. The toll systems are setup to mimic production systems.

An overview of the SunTrax facility with the locations of the test gantries and a picture of one of the toll test gantries is shown below. Note: Construction is ongoing on the infield area, but the oval track is complete and is currently being utilized for testing. This construction should not interfere with the testing. Also note, there is a cell tower approximately 1,830 feet from gantry 3 and approximately 2,575 feet from Gantry 1.

4. Test Concept

The concept will be adjusted based on the number of Carriers involved the concept. The testing scenario below assumes that two Carriers will participate and each Carrier sets up their respective equipment, one at each of the test gantries. Both Carriers would transmit at the same time during the test. Distance between each Carrier's equipment will be approximately 2,100 feet apart (distance between the gantries on the diagonal across the track). Testing will be between midnight and 6:00 AM to minimize interference from outside sources.

The test will utilize an assortment of toll transponders that FTE typically reads in production lanes and uses for similar testing of toll lane performance. Additionally, a mix of different vehicle types will be used for this test. FTE will rent these vehicles for the purpose of this test and provide drivers.

Test Vehicles

The test will use an assortment of vehicle types to represent the diversity of vehicles that use the toll facilities. It is anticipated that the following vehicle types will be rented (assuming availability from the rental company).

- Economy (2 vehicles)
- Intermediate (2 vehicle)
- Full Size Car (1 vehicles)
- Pickup Truck (2 vehicles)

- Minivan (1 vehicle)
- Intermediate SUV (2 vehicles)
- Standard SUV (1 vehicle)
- Full Size SUV (1 vehicle)

Test Transponders

The following 12 transponders will be used for the test. This includes various FTE issued SunPass transponders as well as transponders from interoperable partners that are currently read on FTE toll facilities.

- FTE SeGo Sticker Old Application-Specific Integrated Circuit (ASIC)
- FTE SeGo Sticker New ASIC (3 transponders)
- FTE SeGo Portable (2.75” x 4.25” tag)
- FTE SeGo Portable Slimcase (1.25” x 4.25”)
- FTE PRO (2 transponders)
- FTE SeGo Bumper Mount
- CFX SeGo Sticker - Agency Code 99
- WashDOT 6C Sticker
- E-ZPass NJ TDM Kapsch transponder G4

A baseline test will be run first with all 5G equipment turned off and the toll system turned on. The toll system will be configured as a typical production site. Three travel lanes will be used under each toll gantry. During the baseline test, twelve test vehicles will be used. Each vehicle will drive under each toll gantry at 60 mph and in each lane in a single file five times with only one test vehicle in the toll system read zone at any one time. Each vehicle will traverse the same lane five times with the same transponder before moving to the next lane for the next five passes. Once this is complete, five additional passes through each gantry will have vehicles oriented in a grid like pattern, three vehicles across by four vehicles deep. This grid configuration is typically used for testing the toll equipment. Seen counts (the number of times an RF reader is able to read a transponder) from each RF reader for each pass (five passes in the same lane) will be captured and an average of the seen counts will be recorded. Additionally, writeback data to transponders will be verified for a successful write for every vehicle pass. The baseline test will consist of thirty-five passes with twelve test vehicles in each pass (times two tolling systems) for a total of 840 vehicle passes.

Once the baseline test is complete the 5G equipment for the two Carriers will be turned on and the same test script that was used for the baseline test will be run again (test 2). This test will also have a total of 840 vehicle passes. Once complete the averaged seen counts from the baseline test and test 2 will be compared. Transponder writeback success rate will also be compared between the two tests.

If the average seen counts and the data written to the transponders successfully is within testing allowances (see section 5 of this document), then we can conclude that the 5G equipment is not interfering with the tolling systems. FTE would like to continue collaboration with the telecommunications industry for expanding the test in case interference is detected. If the 5G equipment does create interference, then additional testing would be needed to determine the distance the equipment needs to be from the toll gantry to avoid interference conditions. This could be done immediately at the track the following night if parties were amenable.

Carriers would set up their equipment a day or two before testing begins. Testing is estimated to take two nights, test 1 on night 1 and test 2 on night 2, (for two carriers) after setup is complete, assuming no weather or technical delays. If more than two carriers participate additional nights of testing will be needed. Rental vehicles would not be needed for setup or pre-testing.

Test Cases:

Test Case	Setup	Observation	Success
Baseline Test: 30 passes total. Passes 1 – 5 will be in lane 1. Passes 6 – 10 will be in lane 2. Passes 11 – 15 will be in lane 3. Transponders will then be switched between test vehicles and passes will be run to match passes 1 – 15. These will be passes 16 – 30. Passes 31 – 35 will be run in all three lanes. The test vehicles will line up in a grid like formation, 3 wide by 4 deep.	5G equipment will be turned off. All 12 test vehicles will have tolling transponders. Test vehicles will drive counterclockwise around the track through Gantry 3 then Gantry 1 at 60 MPH.	Seen counts will be captured for all vehicles at both tolling systems. Data written to the IAG and SeGo transponders will be verified after for every pass.	☐
Test 2: 30 passes total. Passes 1 – 5 will be in lane 1. Passes 6 – 10 will be in lane 2. Passes 11 – 15 will be in lane 3. Transponders will then be switched between test vehicles and passes will be run to match passes 1 – 15. These will be passes 16 – 30. Passes 31 – 35 will be run in all three lanes. The test vehicles will line up in a grid like formation, 3 wide by 4 deep.	5G equipment will be turned on. All 12 test vehicles will have tolling transponders. Test vehicles will drive counterclockwise around the track through Gantry 3 then Gantry 1 at 60 MPH..	Seen counts will be captured for all vehicles at both tolling systems. Data written to the IAG and SeGo transponders will be verified after for every pass.	☐

5. Pass/Fail Criteria

This test will be evaluated based on two factors, seen counts and write back. To pass the entire test, both factors require a passing result. Failure to either one will result in an overall failure for the test.

Seen counts. The toll system is required to perform at speeds from 0 to 100 mph. Typically, at 100 mph, 5 seen counts are observed on average. The toll system needs a minimum of 4 seen counts to correlate the transponder to the vehicle at the accuracy required by FTE performance specifications. This translates to a 20% margin. For passes 31 – 35 the seen count data will not be used due to variability of vehicles driving in the grid configuration. Average seen counts above 80% (do not drop more than 20%) as compared to the baseline will constitute a passing result for this area.

Writeback. For writeback there are 840 samples for baseline performance measurement and another 840 for performance measurement with the 5G equipment turned on. 840 is a relatively small sample size for measuring performance against the FTE writeback specification of 99.9%. For a producer's risk probability (test significance) of 5%, the baseline test could have up to 3 failures. We are allowing up to an additional 3 failures for the 5G test, also because of small sample size. Write back only relates to the

IAG and SeGo transponders (6C transponders do not support write back). A passing result for this criterion will be if there are three or less write failures beyond the results of the baseline.

6. Next Steps

Once the tests are complete the test data will be compiled and it will be reviewed with the FTE Technical Team, FTE/FDOT Management and also shared with the Carriers that participated. Data will not be immediately available during the testing process but will be available a couple days following. A public workshop, currently scheduled for TBD, will be held to discuss the results, any additional collaboration or testing, next steps, and rule language.

It is anticipated that in the event of a failed test, equipment would be relocated, and another round of testing (phase 2) would be run. The intensity of radio waves follows an inverse square law for power density: the power density is proportional to the inverse square of the distance. Every time you double the distance from the source, you receive only one-fourth the power. Given this, it is proposed that if additional testing is needed, a distance of 100 feet away from the antenna would be used.

If interference is still seen, then the 5G equipment will need to be moved further and tested until a passing result is achieved. This will help determine a safe distance between the tolling systems and 5G systems for proper non-interfering operations.