Harris County Emergency Vehicle Preemption System

GPS VEHICLE EQUIPMENT QUALIFICATION TESTING

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GPS Vehicle Equipment Testing

Executive Summary

Taylor Traffic Systems was contracted by Harris County to evaluate potential vendors for the emergency vehicle priority system. Three vendors responded to the request to provide equipment, perform installation, and be evaluated against the County specification. The responding vendors were: Applied Information, E-views Safety Systems, and Global Traffic Technologies. Each vendor was evaluated using the same set of criteria, and as of February 8th, 2018, all were found to meet the County's specification. The evaluation and testing focused solely on the GPS vehicle equipment, traffic signal cabinet equipment, and communications interface to the traffic signal controller. The central management system for each of the vendors was not evaluated, nor was the traffic signal controller software (apart from the communications interface from the vendors equipment to the signaling software). Each vendor had slight differences in their implementation of the control strategies and hardware, but each performed as designed and met the specification set forth by Harris County.

Project Background

Taylor Traffic Systems was contracted by Harris County to evaluate their Emergency Vehicle Preemption specification, modify it to meet the needs of the NTCIP 1211v0224 protocol, develop testable cases for the specification, and perform equipment evaluation testing of three different manufacturers of NTCIP compatible GPS vehicle equipment. Three manufacturers provided and installed the necessary equipment at five test locations in north Harris County. The intersections selected for the test are indicated in figure 1. The field testing was performed using test Econolite COBALT controllers running version 3.1.18 EOS firmware. The test controllers were not running the intersections, simply simulating the operations that would occur if they were in control. The timings from the actual intersections were converted from D4, so that it would be possible to see the split adjustments that would occur. The focus of this testing was on the GPS equipment to the Econolite controller software and not specifically the way that the EOS software behaved. The attached specification and testing requirements were developed to ensure that all manufacturers were provided the same specification and testing requirements. Care was taken to make sure that each manufacturer was isolated from each other's equipment and field testing. Testing was performed at approximately the same time each day, though it had little effect on the results. As of February 8, 2018, all three manufacturers have satisfied the requirements set forth and have passed field testing.

Three manufacturers provided test equipment, performed their own installations of the equipment, and provided staff to perform testing. It was left solely to each manufacturer to provide the appropriate technical staff to complete the testing.

The following manufacturers were evaluated:

Applied Information (AI)

Global Traffic Technologies (GTT)

E-views Safety Systems (E-views)

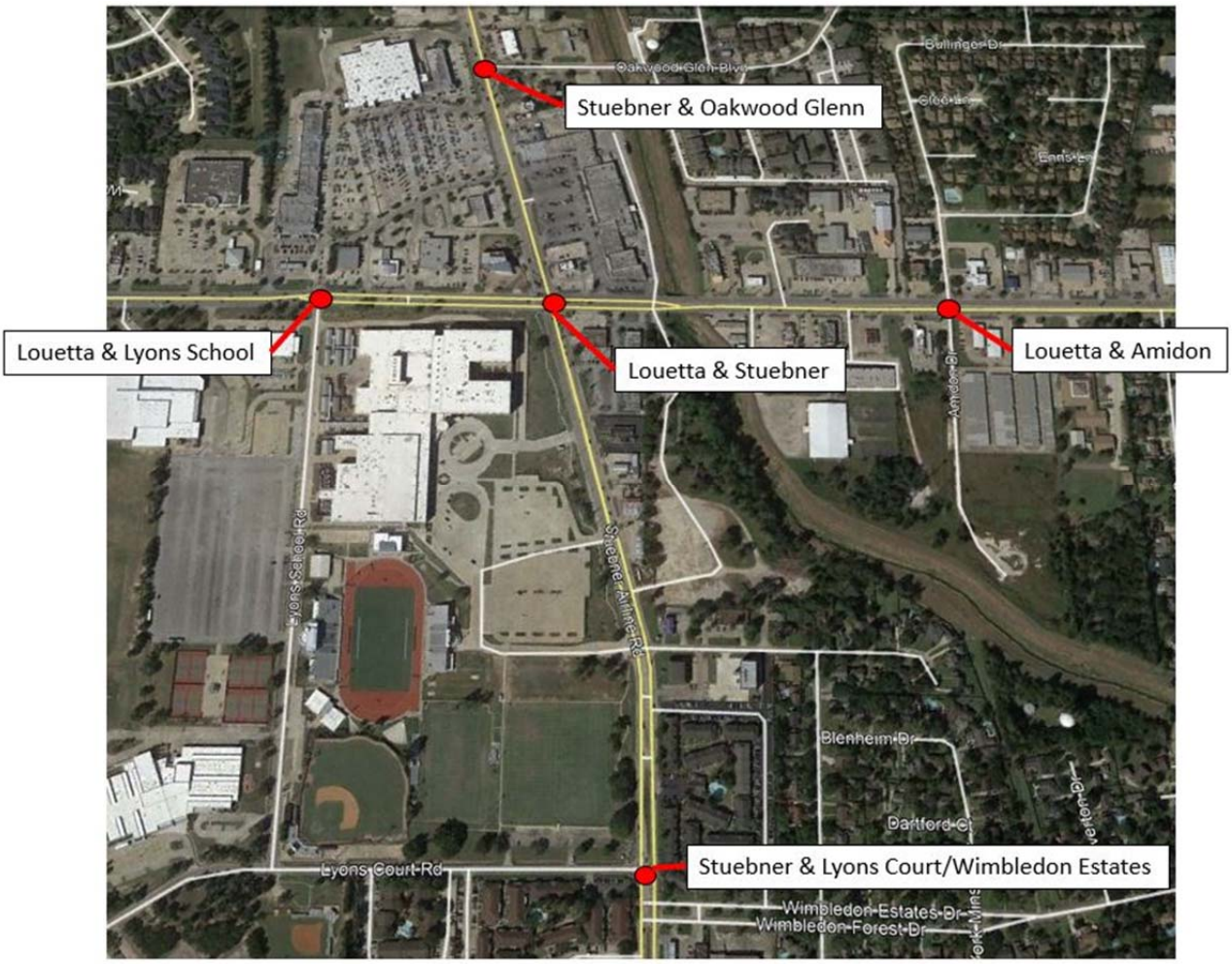

Figure 1 - GPS Test locations

Results and observations from the field testing

Applied Information (AI)

Project Staff

Applied Information - Walter Townsend - performed setup, commissioning and testing

Paradigm Traffic - Bob Coker, Dwayne Brown - performed equipment installation

Observations of staff

The staff from Paradigm Traffic behaved in a professional manner and performed careful and quality installation of the field equipment.

Applied Information's representative was knowledgeable of the equipment, settings, and was able to troubleshoot issues. Software fixes were addressed quickly, and they made sure sufficient testing was performed prior to implementation of any software changes. Field issues were identified, understood quickly and resolutions were generally at the time of the failure or within the same day. Their software development team was committed to providing solutions immediately.

Observations of equipment

The AI equipment appeared easy to service, and the components were of good quality. AI took the time to explain what each component inside the box did, and what the upgrade path for the equipment in the future would consist of. The vehicle kits that were provided for the test were of high quality and were designed so that all features of the system we able to be tested.

Observations of programming software

The settings for the cabinet equipment were capable of being programmed through the central management system, Glance. The one drawback of the current cabinet equipment was that it needed to be disassembled to perform firmware updates, though program settings could be done without opening the unit. Future cabinet equipment will not need to be disassembled and all updates can be done over the air. The actual settings for the intersection approaches seemed reasonably straight forward, as the system is rule based. One item of note is the way that the Glance central interacted with the local cabinet and vehicle kits. The central server sends a message when there is an update available (settings changed) and the local cabinet or vehicle kits would need to recognize this change, download the new settings, implement them, and then notify the Glance system that they were accepted. Through the web interface, this seemed to take an unnecessarily long time. AI explained that the delay was due to the equipment not checking for changes until the top of the minute and then not notifying the system of a change until the next minute.

Observations and performance during testing

The first field test of the equipment encountered virtually no issues. At the completion of their first field test visit, there was only one outstanding spec item that needed to be addressed (left turn latching). This item was resolved, retested, and completed January 31st, 2018.

Global Traffic Technologies (GTT)

Project Staff

GTT – Craig Karis, Glen Klimek, Pat Cosgrove – performed all configuration and field testing

CTC – Fabricio Saenz, Ronnie Gomez – performed all field installations

Observations of staff

The staff from CTC were knowledgeable and capable field technicians. Their GPS antennas were installed at the top of span-wire masts and they were able to quickly identify conduit issues, pathways to the cabinet, and were very safety conscious throughout the installation. They were considerate of the motoring public and aware of the impacts that they would have on traffic. They setup their work zones properly and made sure that the wiring was neat and tied up, even though this was a temporary installation. They were professional, courteous, and easy to work with.

GTT's representatives were knowledgeable of the equipment and settings, and they made sure that they sent staff members that could quickly identify and resolve any issues related to any of the equipment, protocols, or communications equipment. GTT also made their lead developer available for the entirety of the lab and field testing. He was knowledgeable of the changes that were made to the GTT equipment to support NTCIP and was able to resolve any issues or operational changes necessary in the field remotely.

Observations of equipment

The GTT equipment was easy to install and understand. The vehicle kits were of high quality and had the switches necessary to perform all tests. One item of note is the proprietary nature of the cabling and antennas. Users cannot substitute alternate cable or antennas, even though there may be a suitable replacement. The GTT equipment is sold as a package, but this is not necessarily an issue as they will be responsible to installing, operating, and maintaining the system.

Observations of programming software

The on-site software was easy to program and understand. There were no issues running it on any of the computers it was installed on, nor were there any crashes during operation of the software. The central management software was not evaluated during this testing as it was not a direct requirement for the GPS vehicle system.

Observations and performance during testing

The GTT field testing ran into a few issues, but they were able to quickly resolve these as they had dedicated the lead developer to this task. Once the issues were resolved, the testing was completed, though there are still a few operational items that they are working on. Specifically, the ability to display queued vehicles on the controller status screen. Currently the phase selector (cabinet equipment) does not send the second call status message until the conflicting call is completed. The conflicting call is indicated on the phase selector status, and the GPS arrival time is calculated in the background. If the

conflicting vehicle's arrival time changes to become the vehicle with the soonest arrival time, the first call is overridden and queued. It is important that they get this item resolved as we will need to see the conflicting/queued call on the controller status screen for troubleshooting and logging. GTT is currently working on this change.

E-views Safety Systems (E-views)

Project Staff

E-views – Roy McPherson, Randy Lloyd, Johnathan Youngman

Observations of staff

E-views did not have a local presence to perform any of the work necessary to make the system ready prior to arrival on-site to perform the testing. Their technician arrived on Monday February 5th and upgraded the five locations to support NTCIP, installed additional antennas to support the extended distance requirements, and performed pre-testing. This work had more issues than necessary. This was exacerbated by their developer being connected to the units remotely via the internet/Skype.

Observations of equipment

The E-views hardware seems to of good quality. Specifically, the PCB design and circuit protection are engineered well. Having had experience in the field with contractors hooking equipment up incorrectly, their hardware is resilient to mistakes. The vehicle kits performed well and included all necessary switches to perform field testing.

Observations of programming software

The E-views EV Lite software has been significantly updated from the prior version and the user interface is now more intuitive, providing a smoother flow during setup and troubleshooting. That said, it took over 6 hours to get the software properly installed on the test laptop (Windows 10 provided by Taylor Traffic Systems), and the Windows security for prevention of malicious software had to be disabled during install which is a security risk. The laptop software utilizes unsigned driver signatures and Java as their backend. Additionally, manual registry changes had to be made, so the installation package is not automatic. Once the software was properly installed, Windows security was re-enabled with no adverse effects to its operation.

The cabinet equipment upgrade process was able to be done over the air (via 900 MHz radio) on some units (those with the most recent firmware version 3.16 or later), but those with older firmware (the majority of units deployed) require direct connection to the unit and a separate laptop computer with a downgraded driver to perform upgrade. The interface between the laptop software and the cabinet units was intermittent at best, with several issues where the cabinet unit would not respond. Without a direct USB connection to the units, software upgrade will be problematic and time-consuming. Additionally, the user interface built into the cabinet units is not graphically driven, and the required settings are not intuitive or easy to understand. Their developer must program the configuration of the

units manually. This could become a problem in the future as the developer has been difficult to get a hold of during this project.

Observations and performance during testing

The field test was performed on February 8th, 2018 and passed the requirements set forth in the Harris County specification. Of note is the way that the E-views system sends status and request messages to the intersections. For example, if a vehicle has indicated that they are turning left, no messages are sent to upstream intersections. This could be problematic as, operationally, a vehicle may want to send the left turn request to clear out a left turn pocket spilling into the through lane, even though they are going to travel through the intersection. The other manufacturers do provide this operation. Also, there were several observations of the intersections ignoring the vehicle calls for priority during testing. While they were able to demonstrate the 80 second arrival time, if the left turn was requested and the vehicle traveled through the intersection, the call to the next intersection would not be issued until the previous left turn cleared. The arrival time for the next intersection would then be far too short for the intersection to react and thus cause the vehicle to stop. There were also cases where a call would be issued, cancelled, issued again, cancelled, and so on. Their developer witnessed these defects and plans on doing additional testing and software fixes to resolve this. They still do not have a controller available to test with and continue to try to rely on a VPN connection to a computer that Taylor Traffic Systems would have to host for them.

Conclusions and recommendations

While each vendor has satisfied the requirements set forth by Harris County, it is my recommendation that additional use cases be developed by the ESD so that it can be ensured that the vehicle and cabinet equipment meet the operational needs of the ESD.

Applied Information

While they are a small company with a small deployment base, I am confident that they have the ability to provide a working system and support the ESDs. They have an excellent knowledge of implementation of NTCIP, have well versed technical staff, and the ability to rely on their local distributor to deploy, manage, and support the system. Their distributor also adds the bonus of being tied to Econolite (Harris County's new local firmware) and have a technical staff with expertise in setting up and troubleshooting controller software. They have a partnership with Econolite if there are features or operational issues that need addressing, without blaming another competitor's equipment.

GTT

GTT has a wide deployment of GPS equipment installed throughout the United States and has decades of experience with preemption systems. However, this is their first deployment of GPS equipment with NTCIP capability, which creates some risk of additional software bugs being discovered while deploying. I am confident in their technical acumen and their willingness to make this project a success. They also have an excellent working relationship with Econolite, as they have several active projects with them and have their equipment installed at thousands of intersections. They also have a local presence in Harris County (CTC), who are very experienced installing the equipment and making sure that it is done safely and professionally.

E-views Safety Systems

Harris County is the only large-scale deployment of E-views in the country, which creates concern for their growth and development as a company. Their technical staff is limited; there is only one field technician for field support. The developer is in Central America and often unreachable, and their hardware is built to order. As far as I can tell, their staff consists of five people, all residing in different locales, none of which are local. While they demonstrated a commitment to implement NTCIP, they were not timely and took several months to start the development work. It worries me that they appear almost insolvent as a company, and do not seem to be pursuing additional customers or projects. When presented with the idea that the ESDs would no longer like to own any equipment and move to a subscription model, they seemed unable to present any workable solution. The system has been deployed and expanded without proper change management, documentation of deployments, or any on-going preventative maintenance. Significant changes to the overall technical structure of this system should be implemented if the ESDs choose to move forward with this vendor.

Appendix A

Harris County Emergency Vehicle Priority System Requirements

Revised December 6, 2017

INCLUDES UPDATED REQUIREMENTS FOR SUPPORT OF:

- NTCIP 1211v0224 protocol
- Traffic Signal Software Requirements
- GPS Vehicle Priority Request Generator
- Central System Requirements

Objective

To provide emergency vehicles priority service with a minimum disruption to vehicular and pedestrian traffic

Traffic Signal Firmware Requirements

PRIORITY OPERATION

1. The natural controller sequence shall be preserved
2. No phase with demand shall be skipped
3. Left turn signals shall not be served unless specifically requested by the emergency vehicle (by utilization of the left turn signal input to the vehicle transponder)
4. No phase with demand shall be shortened to less than the programmed alternate minimum green
5. Clearance times (yellow clearance and all-red interval) shall not be shortened under any circumstance
6. Pedestrian intervals shall not be shortened less than the programmed alternate minimum times
7. If phase truncation is necessary, the controller shall not arrive at the priority service phase earlier than the specified arrival time (based on testing with demand on all phases)
8. The firmware shall support a minimum of four (4) priority control schemes
9. Each priority control scheme shall consist of the following programming items:
    a. Primary service phase
    b. Secondary service phase (for example a left turn movement)
    c. Alternate minimum green time for each phase in the sequence
    d. Alternate minimum pedestrian walk time
    e. Alternate minimum pedestrian clearance time
10. Emergency vehicle priority requests shall be able to reduce any phase to the alternate minimum green time, including coordinated phases
11. The controller firmware shall prevent a previously accepted priority control scheme from extending its time of arrival beyond the maximum programmed time of arrival (due to reduced speeds caused by excessive traffic)
12. During SCP activation, the controller shall display the following:

a. Phase requested
b. Vehicle classification
c. ETA
d. Status of SCP
e. Vehicle ID

13. The controller shall log the time of request, vehicle ID, phase (SCP) requested, and time of end of request
14. The controller firmware shall log a minimum of 500 events in a circular log, utilizing FIFO

Vehicle GPS Priority Request Generator System

1. The communications protocol between the GPS equipment and the controller shall be NTCIP 1211v0224
2. Travel time shall be passed directly to the controller via NTCIP
    a. Travel time away from the intersection shall be displayed in seconds, up to the maximum of 255 seconds
    b. Minimum 80 seconds advance notice is required – calculated using a constant vehicle speed of 40 MPH (approximately 4700 feet from the intersection)
3. Vehicle ID shall be passed directly to the controller via NTCIP
4. A minimum of 3 messages per direction via NTCIP are required
        i. 1 advance through movement message
        ii. 1 advance left-turn movement message (latched once activated)
        iii. 1 check-out message (sent when vehicle exits the approach)
    b. Advance messages shall not activate until the programmed ETA from the intersection is reached
5. GPS unit shall send a left turn request if the left turn signal is activated (default is no left turn)
    a. Left turn request is provided via NTCIP and must be logged
        i. This message shall be passed on an intersection by intersection basis by default
            1. Closely spaced intersections may necessitate that the left turn message be sent to clear queues and is allowable
        ii. The left turn request is only valid for the next intersection after passing the previous intersection (unless spacing of intersection prevents it)
    b. Left turn inputs shall be a “latched” call wired to the vehicle left turn signal
        i. Left turn signal shall only need to be on for 1 second to latch
        ii. Left turn must not latch to more than one intersection
        iii. Left turn request shall be remembered after passing the previous intersection but have the ability not to pass the call to the controller until the emergency vehicle is the specified travel time away from the intersection
6. In no instance shall raw (wired) inputs in the detector racks be used
7. GPS unit shall have a mechanism in place to prevent increasing ETA (due to slowing or stopping of vehicle) from changing the original ETA more than 20 seconds later.

    a. Hysteresis shall be provided such that if a vehicle is stopped or slowed, the update of the ETA will be delayed to determine if the vehicle can return to the original ETA window (no greater than +10 seconds)
8. GPS unit shall send a check-out request to all downstream intersections (provided there are no other active emergency vehicles on that approach) if the vehicle is in park or there is a communication loss between the vehicle and the PRG
    a. A vehicle in park shall immediately send the check-out request to the controller pending no other active priority request on that approach
    B. GPS shall have a separate time-out value (in seconds) for communication loss configurable on a per approach basis

GPS Central Management System Requirements

Mandatory Items

1. Central system shall be connected to all intersections via communications
    a. Communications shall not be over existing Harris County communications infrastructure
2. Central system shall provide monitoring of all devices currently active in the system
    a. This includes any vehicle in the system that is sending GPS location
3. Central system interface shall provide a GUI that displays all devices currently in the system
    a. GUI shall include a map showing the relative or actual location of all devices in the system
    b. Minimum statuses to be displayed
        i. Online
        ii. Offline
        iii. Responding to code priority/preemption
4. Central system shall monitor all devices and recognize if their configuration has changed
5. Central system shall provide a mechanism to remotely update the field device configuration
6. Central system shall provide a mechanism to remotely upgrade/update field device firmware
7. Central system remote update/upgrade of firmware shall be able to send to multiple devices at a time
8. Central system shall provide user security levels for multiple users
    a. Minimum user levels required – Administrator and User
        i. Administrator level shall be able to make any change to the system and users
        ii. User level shall have view rights and be able to run reports
9. Central system shall provide reporting tools
    a. Minimum reports required
        i. Devices in system
        ii. Devices online
        iii. Devices offline
        iv. Device logs
        v. Device firmware version
        vi. User log on/activity report
10. Central system shall provide automated notification to selected users of failed devices via email

Optional Items

1. Central system shall provide change control management of all intersections and vehicle equipment regardless of whether the devices are currently online or offline
    a. If a device is offline, the user shall be able to view, edit, save, and export the configuration settings
2. Central system shall notify selected users when a change has been detected
    a. Users that are logged into the system shall be notified of configuration differences if detected by the system
    b. Users shall be able to select if they are to be notified via email
3. Central system shall have the ability to roll back configuration changes to devices and firmware updates
    a. System shall save at least one known good configuration to allow for roll back

Appendix B – Original Harris County Specification (local controller)

EXHIBIT A
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Harris County Emergency Vehicle Priority System Requirements
Local Controller Firmware

Objective: To serve emergency vehicle(s) with minimal disruption to vehicular traffic
Traffic Signal Firmware Requirements:

• The natural controller sequence shall be preserved at all times. By default, no phases are skipped and left-turn signals operate as normal unless requested by the emergency vehicle
• No phase with demand shall be shortened to less than the alternate minimum green and the priority shall proportionally truncate all conflicting phases subject to this constraint
• In the instance where phase truncation is necessary (with full vehicular demand on the conflicting movements), the controller shall not arrive on the service phase earlier than the specified travel time for that approach
• The firmware shall have at least 4 emergency vehicle priority modules (one per direction)
• Each module should consist of the following programming items:
o Primary service phase (thru phase)- activated by GPS advance message(s)
o Secondary service phase (left-turn phase)- activated by GPS left-turn message
o Flags with the ability to omit phases or pedestrian movements as necessary for each of the priority modules {no omits by default)
o Travel time parameter for the primary service phase (thru-phase) where the specified movement shall be green by the time the vehicle is that distance away
• Any conflicting walk rest shall be terminated once a conflicting emergency vehicle request is recognized by the controller
• On a coordinated street the opposing direction walk rest shall be terminated only if a conflicting secondary service phase is programmed
• Any walk rest parallel to the emergency vehicle shall rest as normal
o Travel time parameter for the secondary service phase (left-turn-phase) where the specified movement shall be green by the time the vehicle is that distance away
o Check out input- activated by GPS check-out message
o Maximum presence timer where the priority is ignored until the call is dropped
• A conflicting emergency vehicle priority request on the cross street shall be able to force-off the coordinated phases early in order to serve the green by the specified travel time
• The controller firmware shall have mechanism in place to prevent acceptance of increasing travel times from the GPS unit if the emergency vehicle were to encounter reduced speeds
• All phases shall have an alternate priority minimum green (typically greater than the normal minimum green) that will apply if there is demand for a particular phase. This prevents the short timing of phases if short-way transition is required
• Upon check-out the controller shall immediately move onto the next phase if the priority is timing beyond the normal force-off point, subject to the alternate minimum green
• All priority requests and left-turn requests, including Vehicle ID shall be logged by the controller and be brought back to the ATMS (central system) for further analysis

Appendix B – Original Harris County Specification (GPS system)

EXHIBIT A
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Harris County Emergency Vehicle Priority System Requirements
GPS System

Objective: To serve emergency vehicle(s) with minimal disruption to vehicular traffic
GPS System Requirements:
GPS shall report the following to the traffic signal controller for each approach (4 minimum):
• Travel Time away from the intersection (in seconds)
• Minimum 80 seconds advance notice is required
• Travel time must be passed directly to the controller via Ethernet (using a crossover cable if no Ethernet switch is present) and pass the Vehicle JD directly to the controller
• Vehicle ID shall visible from the controller front panel and in the controller logs
o In no instance shall raw inputs in the detector racks be used
o A minimum of 4 messages per direction via Ethernet (16 total) are required
• 2 advance messages (4 preferred)
• 1 left-turn message (latched)
• 1 check-out message (active when vehicle is at the stop-bar)
o Each of the advance messages shall not activate until the specified travel time away from the intersection is reached
• GPS unit shall pass along left-turn requests (default is no left-turn)
o Left-turn request is provided via Ethernet and must be logged
• This message is passed along on an intersection by intersection basis
• The left-turn request is only valid for the next intersection after passing the previous intersection
o Left-turn inputs are a " latched" call linked to the vehicle left-turn signal
• Left-turn signal shall only need to be on for a second to latch
• Left-turn must not latch to more than one intersection at a time
• Left-turn request shall be remembered after passing the previous intersection but have the ability not to pass the call to the controller until the emergency vehicle is the specified travel time away from the intersection
• GPS unit shall have mechanism in place to prevent sending increasing travel times to the local intersection controller
• GPS unit shall send a check-out request to all downstream intersections (provided there are no other active emergency vehicles on that approach) if the vehicle is in park or there is a communication loss between the vehicle and the controller (in seconds)
o A vehicle in park shall immediately send the check-out request to the controller pending no other active priority requests on that approach
o GPS shall have a separate time-out value (in seconds) for communication loss configurable on a per approach basis

Appendix C – Test Results (GPS System) Applied Information

DOT Date of test - 1/31/2018

Activation Test Plan - GPS System – All items must "Pass" prior to the system being certified as meeting Harris County acceptable standards

	PASS	FAIL	Requirement	Test procedure/verification - expectations
1	X		GPS system shall support programming for at least 4 intersection approaches	Prospective equipment shall demonstrate ability to configure a minimum of 4 approaches
2	X		GPS system shall send travel time away from the intersection to the controller (in seconds)	Verification to be done both on the GPS cabinet equipment and controller status screens. GPS and controller ETAs should match within +/- 3 seconds
3	X		GPS system shall be capable of sending travel time at least 80 seconds in advance (once in route)	Verification will be done using Stuebner Airline & Cypresswood as the entry point headed towards Louetta & Stuebner Airline intersection (approximately 4700 feet away). Test vehicle shall start at FM1960 & Stuebner Airline and travel at a constant speed of 40 MPH north towards Louetta & Stuebner. Once test vehicle enters Cypresswood & Stuebner Airline approach zone, status of approx 80 seconds ETA shall be displayed on controller status screen.
4	X		Travel time shall be passed directly to the controller via Ethernet (in no instance shall raw inputs in the detector racks be used)	Verify travel time is displayed on controller status screen using ethernet communications
5	X		GPS system shall pass the Vehicle ID directly to the controller	Verification of vehicle ID display shall be on the controller screen
6	X		A minimum of 3 messages per direction via Ethernet (12 total) are required	See items 7,8,9 below
7	X		1 primary phase request message	Verification - if no left turn is requested, the primary phase shall be displayed in the phase requested status on the controller (example - phase 6)
8	X		1 secondary phase request message	Verification - if left turn is requested, the primary phase shall display the left turn phase requested on the controller status screen (example - phase 1). The controller shall be programmed so that queue clearance phases will be called and will be serviced during left turn request (example - phases 1 & 6)

9	X		1 check-out message (active when vehicle has cleared the stop bar and no other emergency vehicles are present on that approach)	Verification - once vehicle has passed through the intersection, the priority request shall be completed/cancelled after the hold over timer has expired (not greater than 10 seconds)
10	X		The primary phase message shall not activate until the specified travel time away from the intersection is reached	Verification - the priority request shall not have any effect on the controller until the programmed ETA is reached
11	X		GPS unit shall pass along left-turn request via Ethernet when the vehicle left-turn signal becomes active (default is no left-turn)	Verification - left turn phase shall be displayed as the primary service phase on the controller status screen
12	X		Left-turn request is a latched input for the current intersection only, remembered once the left-turn signal is active for at least 1 second. If the vehicle continues straight through the intersection, the left turn request should clear and not re-latch until another left turn input is received	Verification - test will be performed where a left turn signal indicator will be cycled to ON for 1 second, then turned back to OFF. The GPS unit shall not drop the left turn call until the vehicle clears the intersection immediately ahead of it (the nearest test intersection)
13	X		Left-turn request shall not be sent to more than one intersection at a time	Verification - using the test setup for the 80 second travel time, a left turn request will be made for the nearest location (latch) and then verified at downstream locations (no left turns requested). Configuration will be such that zones will not overlap (causing left to be passed to multiple intersections)
14	X		If the emergency vehicle turns left, all intersections that were called by advance detection but are no longer part of the priority request shall be released	Verification - traveling NB on Stuebner Airline, a request to turn left at Lyons School will be initiated. Once the vehicle turns left and exits the intersection, verification that Louetta & Stuebner Airline's call for priority is dropped.
15	X		An emergency vehicle in park shall immediately send a check-out message to downstream intersections provided there are no other active priority requests on that approach	Verification - while on approach to an intersection, the test vehicle shall pull safely off the roadway and place the vehicle in park. All priority requests shall be cancelled as verified on the controller status screen
16	X		GPS unit shall have a unique time-out value for each approach in the event of a communications loss with the priority vehicle(s)	Demonstrate programmatic compliance and demonstrate loss of communication timeout.
17	X		The GPS system shall have a separate max presence time per approach (in seconds) that will ignore future priority requests on the affected approach(es) until the current request becomes inactive	Verification - in the GPS equipment, set the max presence timer to less than the ETA to the intersection and verify that the timeout occurs by verifying status on the controller (dropped priority call)

18	X		GPS equipment shall have the ability to send vehicle classifications 1-10 to controller	Verification: Programmed vehicle classification displayed on controller status screen

PASS	FAIL	Additional testing performed	
X		Multiple vehicles on same approach with different arrival times	Verify both vehicles are in the controller queue and service does not end until last vehicle is cleared
X		Multiple vehicles on the same approach with different SCP requests (one through and one left turn)	Verify both vehicles are in the controller queue and service does not end until both vehicles clear
X		Multiple vehicles on same approach with different arrival times. Lead vehicle cancels.	Verify that the call for second vehicle is not cleared until complete
X		Multiple vehicles on same approach. One latches left turn after two intersections have "heard" the call.	Verify second intersection cancels call for left at second intersection once vehicle with left clears.
X		Multiple vehicles on different approaches.	Verify vehicle with soonest arrival time is serviced first (arrives first)
X		Multiple vehicles on different approaches. Lead (first in queue for arrival) vehicle slows down so that second vehicle is now arriving first.	Verify request for second vehicle is moved up in the queue based on new arrival time

Appendix C – Test Results (GPS System) GTT

DOT Date of test - 2/2/2018

Activation Test Plan - GPS System – All items must "Pass" prior to the system being certified as meeting Harris County acceptable standards

	PASS	FAIL	Requirement	Test procedure/verification - expectations
1	X		GPS system shall support programming for at least 4 intersection approaches	Prospective equipment shall demonstrate ability to configure a minimum of 4 approaches
2	X		GPS system shall send travel time away from the intersection to the controller (in seconds)	Verification to be done both on the GPS cabinet equipment and controller status screens. GPS and controller ETAs should match within +/- 3 seconds
3	X		GPS system shall be capable of sending travel time at least 80 seconds in advance (once in route)	Verification will be done using Stuebner Airline & Cypresswood as the entry point headed towards Louetta & Stuebner Airline intersection (approximately 4700 feet away). Test vehicle shall start at FM1960 & Stuebner Airline and travel at a constant speed of 40 MPH north towards Louetta & Stuebner. Once test vehicle enters Cypresswood & Stuebner Airline approach zone, status of approx 80 seconds ETA shall be displayed on controller status screen.
4	X		Travel time shall be passed directly to the controller via Ethernet (in no instance shall raw inputs in the detector racks be used)	Verify travel time is displayed on controller status screen using ethernet communications
5	X		GPS system shall pass the Vehicle ID directly to the controller	Verification of vehicle ID display shall be on the controller screen
6	X		A minimum of 3 messages per direction via Ethernet (12 total) are required	See items 7,8,9 below
7	X		1 primary phase request message	Verification - if no left turn is requested, the primary phase shall be displayed in the phase requested status on the controller (example - phase 6)
8	X		1 secondary phase request message	Verification - if left turn is requested, the primary phase shall display the left turn phase requested on the controller status screen (example - phase 1). The controller shall be programmed so that queue clearance phases will be called and will be serviced during left turn request (example - phases 1 & 6)
9	X		1 check-out message (active when vehicle has cleared the stop bar and no other emergency vehicles are present on that approach)	Verification - once vehicle has passed through the intersection, the priority request shall be completed/cancelled after the hold over timer has expired (not greater than 10 seconds)

10	X		The primary phase message shall not activate until the specified travel time away from the intersection is reached	Verification - the priority request shall not have any effect on the controller until the programmed ETA is reached
11	X		GPS unit shall pass along left-turn request via Ethernet when the vehicle left-turn signal becomes active (default is no left-turn)	Verification - left turn phase shall be displayed as the primary service phase on the controller status screen
12	X		Left-turn request is a latched input for the current intersection only, remembered once the left-turn signal is active for at least 1 second. If the vehicle continues straight through the intersection, the left turn request should clear and not re-latch until another left turn input is received	Verification - test will be performed where a left turn signal indicator will be cycled to ON for 1 second, then turned back to OFF. The GPS unit shall not drop the left turn call until the vehicle clears the intersection immediately ahead of it (the nearest test intersection)
13	X		Left-turn request shall not be sent to more than one intersection at a time	Verification - using the test setup for the 80 second travel time, a left turn request will be made for the nearest location (latch) and then verified at downstream locations (no left turns requested). Configuration will be such that zones will not overlap (causing left to be passed to multiple intersections)
14	X		If the emergency vehicle turns left, all intersections that were called by advance detection but are no longer part of the priority request shall be released	Verification - traveling NB on Stuebner Airline, a request to turn left at Lyons School will be initiated. Once the vehicle turns left and exits the intersection, verification that Louetta & Stuebner Airline's call for priority is dropped.
15	X		An emergency vehicle in park shall immediately send a check-out message to downstream intersections provided there are no other active priority requests on that approach	Verification - while on approach to an intersection, the test vehicle shall pull safely off the roadway and place the vehicle in park. All priority requests shall be cancelled as verified on the controller status screen
16	X		GPS unit shall have a unique time-out value for each approach in the event of a communications loss with the priority vehicle(s)	Demonstrate programmatic compliance and demonstrate loss of communication timeout.
17	X		The GPS system shall have a separate max presence time per approach (in seconds) that will ignore future priority requests on the affected approach(es) until the current request becomes inactive	Verification - in the GPS equipment, set the max presence timer to less than the ETA to the intersection and verify that the timeout occurs by verifying status on the controller (dropped priority call)
18	X		GPS equipment shall have the ability to send vehicle classifications 1-10 to controller	Verification: Programmed vehicle classification displayed on controller status screen

PASS	FAIL	Additional testing performed	
X		Multiple vehicles on same approach with different arrival times	Verify both vehicles are in the controller queue and service does not end until last vehicle is cleared
X		Multiple vehicles on the same approach with different SCP requests (one through and one left turn)	Verify both vehicles are in the controller queue and service does not end until both vehicles clear
X		Multiple vehicles on same approach with different arrival times. Lead vehicle cancels.	Verify that the call for second vehicle is not cleared until complete
X		Multiple vehicles on same approach. One latches left turn after two intersections have "heard" the call.	Verify second intersection cancels call for left at second intersection once vehicle with left clears.
X		Multiple vehicles on different approaches.	Verify vehicle with soonest arrival time is serviced first (arrives first)
X		Multiple vehicles on different approaches. Lead (first in queue for arrival) vehicle slows down so that second vehicle is now arriving first.	Verify request for second vehicle is moved up in the queue based on new arrival time

*Note - The way that the firmware in the phase selector is currently operating, they do not pass the second call to the controller until the first has completed, but it is in the queue for service in the phase selector.
**Note - Test of multiple vehicles on same approach and conflicting approaches should be retested when the phase selector can send them to the controller queue.

Appendix C – Test Results (GPS System) E-views

DOT Date of test 2/8/18

Activation Test Plan - GPS System – All items must "Pass" prior to the system being certified as meeting Harris County acceptable standards

	PASS	FAIL	Requirement	Test procedure/verification - expectations
1	X		GPS system shall support programming for at least 4 intersection approaches	Prospective equipment shall demonstrate ability to configure a minimum of 4 approaches
2	X		GPS system shall send travel time away from the intersection to the controller (in seconds)	Verification to be done both on the GPS cabinet equipment and controller status screens. GPS and controller ETAs should match within +/- 3 seconds
3	X		GPS system shall be capable of sending travel time at least 80 seconds in advance (once in route)	Verification will be done using Stuebner Airline & Cypresswood as the entry point headed towards Louetta & Stuebner Airline intersection (approximately 4700 feet away). Test vehicle shall start at FM1960 & Stuebner Airline and travel at a constant speed of 40 MPH north towards Louetta & Stuebner. Once test vehicle enters Cypresswood & Stuebner Airline approach zone, status of approx 80 seconds ETA shall be displayed on controller status screen.
4	X		Travel time shall be passed directly to the controller via Ethernet (in no instance shall raw inputs in the detector racks be used)	Verify travel time is displayed on controller status screen using ethernet communications
5	X		GPS system shall pass the Vehicle ID directly to the controller	Verification of vehicle ID display shall be on the controller screen
6	X		A minimum of 3 messages per direction via Ethernet (12 total) are required	See items 7,8,9 below
7	X		1 primary phase request message	Verification - if no left turn is requested, the primary phase shall be displayed in the phase requested status on the controller (example - phase 6)
8	X		1 secondary phase request message	Verification - if left turn is requested, the primary phase shall display the left turn phase requested on the controller status screen (example - phase 1). The controller shall be programmed so that queue clearance phases will be called and will be serviced during left turn request (example - phases 1 & 6)
9	X		1 check-out message (active when vehicle has cleared the stop bar and no other emergency vehicles are present on that approach)	Verification - once vehicle has passed through the intersection, the priority request shall be completed/cancelled after the hold over timer has expired (not greater than 10 seconds)

10	X		The primary phase message shall not activate until the specified travel time away from the intersection is reached	Verification - the priority request shall not have any effect on the controller until the programmed ETA is reached
11	X		GPS unit shall pass along left-turn request via Ethernet when the vehicle left-turn signal becomes active (default is no left-turn)	Verification - left turn phase shall be displayed as the primary service phase on the controller status screen
12	X		Left-turn request is a latched input for the current intersection only, remembered once the left-turn signal is active for at least 1 second. If the vehicle continues straight through the intersection, the left turn request should clear and not re-latch until another left turn input is received	Verification - test will be performed where a left turn signal indicator will be cycled to ON for 1 second, then turned back to OFF. The GPS unit shall not drop the left turn call until the vehicle clears the intersection immediately ahead of it (the nearest test intersection)
13	X		Left-turn request shall not be sent to more than one intersection at a time	Verification - using the test setup for the 80 second travel time, a left turn request will be made for the nearest location (latch) and then verified at downstream locations (no left turns requested). Configuration will be such that zones will not overlap (causing left to be passed to multiple intersections)
14	X		If the emergency vehicle turns left, all intersections that were called by advance detection but are no longer part of the priority request shall be released	Verification - traveling NB on Stuebner Airline, a request to turn left at Lyons School will be initiated. Once the vehicle turns left and exits the intersection, verification that Louetta & Stuebner Airline's call for priority is dropped.
15	X		An emergency vehicle in park shall immediately send a check-out message to downstream intersections provided there are no other active priority requests on that approach	Verification - while on approach to an intersection, the test vehicle shall pull safely off the roadway and place the vehicle in park. All priority requests shall be cancelled as verified on the controller status screen
16	X		GPS unit shall have a unique time-out value for each approach in the event of a communications loss with the priority vehicle(s)	Demonstrate programmatic compliance and demonstrate loss of communication timeout.
17	X		The GPS system shall have a separate max presence time per approach (in seconds) that will ignore future priority requests on the affected approach(es) until the current request becomes inactive	Verification - in the GPS equipment, set the max presence timer to less than the ETA to the intersection and verify that the timeout occurs by verifying status on the controller (dropped priority call)
18	X		GPS equipment shall have the ability to send vehicle classifications 1-10 to controller	Verification: Programmed vehicle classification displayed on controller status screen

*Note: E-views does not pass the though request once left is activated, so queue clearance does not happen at upstream locations like AI & GTT

**Note: there is still some odd behavior of intersections ignoring the E-views call. One intersection will receive it and the other will ignore it completely.
***Still seeing so very intermittent behavior of the vehicle calls. Drops of calls, TTL errors, intersection ignores. They need to do more work to make this more resilient.

PASS	FAIL	Additional testing performed	
X		Multiple vehicles on same approach with different arrival times	Verify both vehicles are in the controller queue and service does not end until last vehicle is cleared
X		Multiple vehicles on the same approach with different SCP requests (one through and one left turn)	Verify both vehicles are in the controller queue and service does not end until both vehicles clear
X		Multiple vehicles on same approach with different arrival times. Lead vehicle cancels.	Verify that the call for second vehicle is not cleared until complete
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X		Multiple vehicles on different approaches.	Verify vehicle with soonest arrival time is serviced first (arrives first)
X		Multiple vehicles on different approaches. Lead (first in queue for arrival) vehicle slows down so that second vehicle is now arriving first.	Verify request for second vehicle is moved up in the queue based on new arrival time