SIGNALIZATION STUDY

April 2022

Contents

Overview

Traffic congestion is a costly and frustrating issue that all transportation agencies face. While roadway improvement projects that add lanes and increase capacity can provide relief to traffic, they are expensive and can take years to design and construct. Traffic signal upgrades, improved signal timing, and traffic signal system management deliver great benefits in delay savings and improved safety at a much lower cost, and these improvements often can augment or even replace the need for certain capacity enhancements along surface roads

The Killeen Temple Metropolitan Planning Organization (KTMPO) selected Kimley-Horn to perform a Signalization Study for the KTMPO region. This study aims to:

- Review current best practices for signal timing and management
- Evaluate the current state of signal timing and operations within the KTMPO region
- Identify issues caused by deficiencies in traffic signal timing
- Recommend improvements in policy or procedures related to traffic signal system management to increase efficiency and reduce congestion

Background

The Texas Department of Transportation (TxDOT) owns and operates traffic signals along state roadways throughout Texas. Two TxDOT Districts (Waco and Brownwood) manage traffic signals within the KTMPO region. Any municipality with a population greater than 50,000 is required to operate and maintain traffic signals on state roadways that fall within their jurisdiction.[1] This means that the Cities of Killeen and Temple also operate and maintain traffic signals on state roadways in addition to traffic signals they may also own on County or City roadways. Additionally, Fort Hood operates and maintains traffic signals within their installation, and their system interacts with neighboring agencies at their installation's boundary. Based on our agency assessment there are 308 traffic signals within the KTMPO region as shown in Figure 1 and Table 1.

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[1] Texas Administrative Code Title 43, Part 1, Chapter 25, Subchapter A, Rule 25.5 – Installation and Maintenance of Traffic Signals
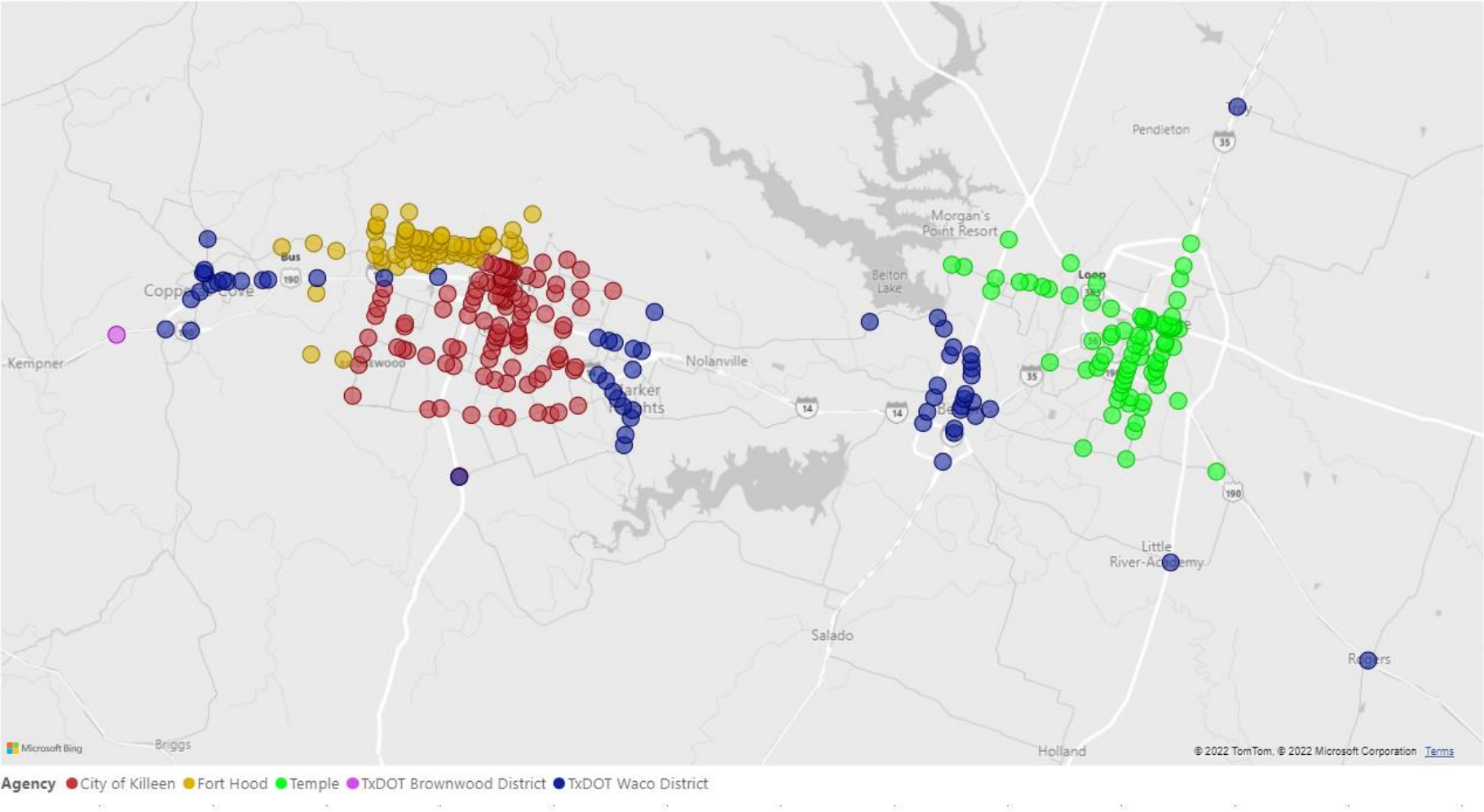
Figure 1. Map of KTMPO Traffic Signal Locations by Agency

Table 1. KTMPO Traffic Signals by Agency

Agency	# of Signals
City of Killeen	103
Fort Hood	67
Temple	76
TxDOT Brownwood District	1
TxDOT Waco District	61
Total	**308**

Best Practices Research

Kimley-Horn conducted research of current best practices within traffic signal management, operations, and maintenance for local and state agencies as well as MPOs.

This signalization study follows FHWA's general outline of the various aspects of traffic signal operations and maintenance as laid out in Traffic Signal Program Management Plans (TSPMP)[2] as shown below:

- Policy and Programs
- Maintenance
- Operations & Safety
- Equipment
- Design
- Funding Opportunities

Each section of this report will outline an aspect of this subject area, including best practices, current assessment within the KTMPO region, and recommendations. A full list of recommendations is then provided at the end of the report.

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[2] *Traffic Signal Management Plans*, FHWA, 2015, FHWA-HOP-15-038

Stakeholder Interviews

Kimley-Horn developed a survey to align with the aspects of TSPMPs and this project's best practices research. Kimley-Horn then administered each survey response during video calls with representatives from each agency that operates and maintains signals within the KTMPO region as listed here:

- City of Killeen
- City of Temple
- TxDOT Waco District
- TxDOT Brownwood District
- Fort Hood

Summarized findings from each portion of the survey are described in each subsequent section of this report. Detailed survey entries are provided in the Appendix for reference.

Policy and Programs

Best Practice

The Guidebook from the Federal Highway Administration (FHWA) entitled *Advancing Metropolitan Planning for Operations*[3] provides an objectives-driven, performance-based approach for integrating management and operations (M&O) strategies into the metropolitan transportation planning (MTP) process. By planning for and investing in M&O strategies, regions can more efficiently and effectively utilize their resources to improve mobility and safety. This approach to M&O at the MPO level is typically incorporated into Congestion Management Plans (CMP). Applicable strategies include:

- Establishing MTP goals and objectives that focus on M&O strategies.
  - Examples related to signalization include:
    - Traffic Incident Management
    - Traffic Signal Coordination
    - Transit Signal Priority
    - Emergency Vehicle Preemption
- Utilizing performance measures to develop, analyze, and recommend M&O strategies
- Monitoring and evaluating system performance and progress toward meeting goals

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[3] *Advancing Metropolitan Planning for Operations*, FHWA, 2010, FHWA-HOP-10-026

Regional Concepts for Transportation Operations (RCTO) are management tools used to plan and implement operations strategies at a regional level[4]. RCTOs can focus on specific functions like traffic incident management (TIM), traveler information, congestion management, or signal operations. RCTOs are a great way to identify operational objectives, strategies, and projects to be included in the MTP process. The Denver Regional Council of Governments (DRCOG) identified the following goals in their RCTO including detailed objectives and operational initiatives to meet those goals[5]:

1. Provide reliable transportation operations for regional travelers
2. Provide safe transportation operations for regional travelers and for public safety and construction/maintenance personnel
3. Provide transportation operations support to non-single occupant vehicle modes of travel

Some MPOs create Regional Traffic Signal Operations Programs (RTSOPs) to address the design, maintenance, management, and operation of traffic signals across multiple jurisdictions. RTSOPs provide for consistency in the management, operations and maintenance of multiple jurisdictions by leveraging regional expertise and facilitating regular forums to discuss technical issues and share good practices.[6]

The North Central Texas Council of Government's (NCTCOG) Regional Traffic Signal Retiming Program (RTSRP)[7] is an example of a RTSOP in the Dallas-Ft Worth metro area. This project retimes traffic signals along critical regional corridors across agency jurisdictional boundaries. While this project is funded by CMAQ grant money which is not available in the KTMPO region, this project is a great example of how an MPO can facilitate traffic signal operations projects and improvements across jurisdictional bounds at a regional level.

Traffic Signal Program Management Plans (TSPMP)
FHWA recommends each agency identify Goals and Objectives within a Traffic Signal Program Management Plan (TSPMP) that integrates into the agency's overall transportation goals and vision. Using the GOST model shown in Figure 2, these goals and objectives can then be used to identify Strategies and Tactics aimed at achieving the overall goals and objectives.

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[4] *Regional Concept for Transportation Operations: The Blueprint for Action,* FHWA, 2007, FHWA-HOP-07-122

[5] *DRCOG Regional Concept for Transportation Operations,* DRCOG, 2012

[6] *FHWA Regional Traffic Signal Operations Programs*, https://ops.fhwa.dot.gov/arterial_mgmt/reg_tso.htm

[7] NCTCOG Transportation Systems Management, https://www.nctcog.org/trans/manage/its/transportation-systems-management

Figure 2. FHWA GOST Model for TSPMPs

In practice however, most agencies do not have a formalized Traffic Signal Program Management Plan as recommended by FHWA. Instead, many transportation agencies have separate traffic signal operations and maintenance goals and objectives that often shift or change from year to year based on areas of greatest need or concern from upper agency management.

Oregon DOT's TSPMP[8] is an example of current best practice. The Oregon DOT TSPMP describes goals and objectives of traffic signal operations and maintenance activities to meet overarching transportation and mobility goals of the agency and provide a basis for sustained planning, operations, and funding for their traffic signal network.

Current Assessment

Currently, the KTMPO CMP[9] calls for the following strategies related to M&O:

- Bluetooth-Based Travel Time Measurement
- Traffic Signal Optimization
- Transit Signal Priority
- Demand-Responsive Signal System
- Pedestrian Signals

Additionally, KTMPO evaluates congestion data along highway segments every two years to update their CMP. This list is used to prioritize projects and evaluate areas in greatest need of congestion relief.

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[8] *Traffic Signal Management Plan,* Oregon DOT, 2020
[9] *Congestion Management Plan,* KTMPO, 2020 Update
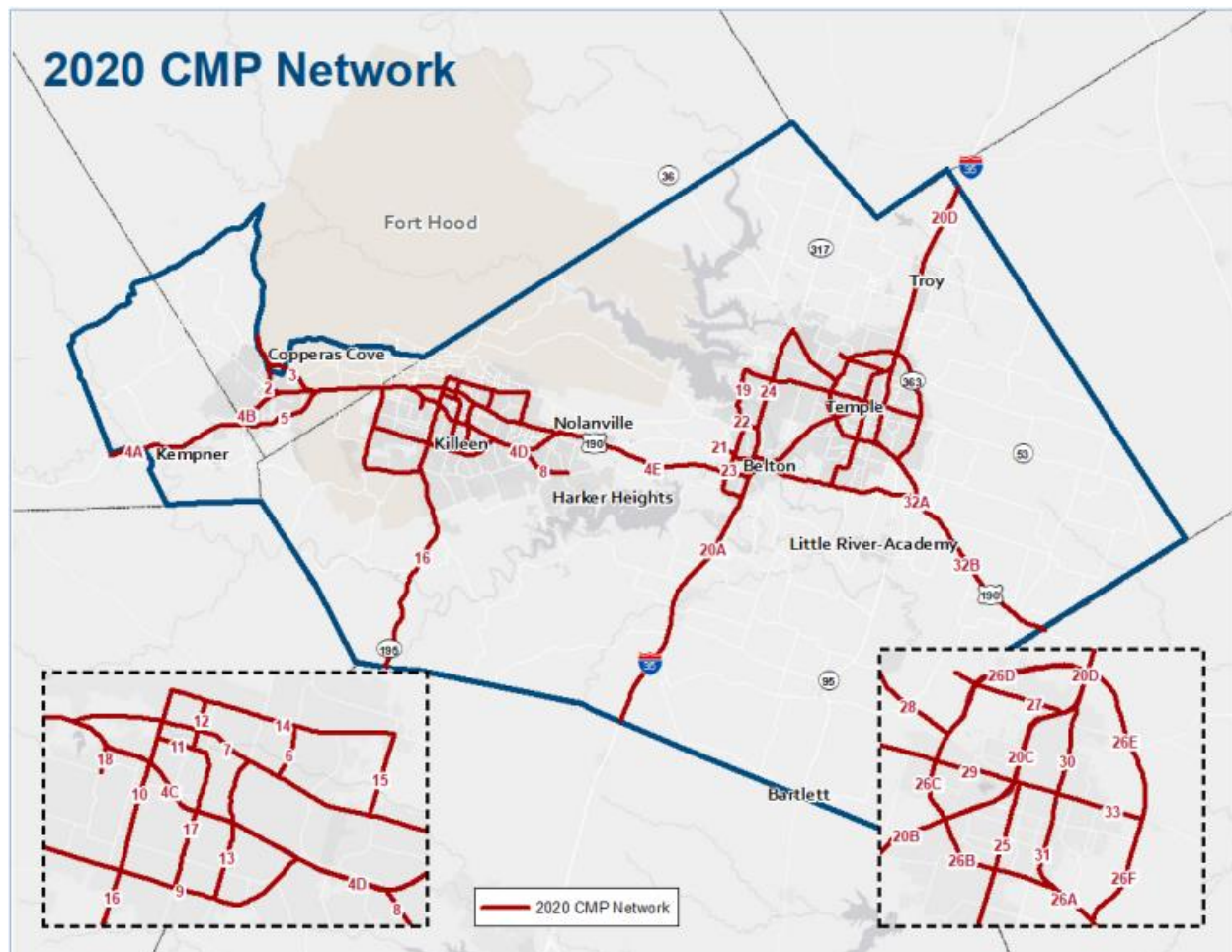
Figure 3: KTMPO 2020 CMP Network

The KTMPO region does not have an RTSOP or equivalent program that coordinates signal operations, maintenance, or management across jurisdictional boundaries.

None of the agencies have TSPMPs or formalized goals for their traffic signal system. However, most agencies had informal goals ranging from minimizing public complaints to modernizing technology. Many of the agencies' primary informal goals were to maintain a state of good repair, replace aging signal infrastructure and equipment, and modernize signal systems (detection, communication, and Advanced Traffic Management Systems [ATMS]). Most agencies stated that budgetary limitations made it difficult to achieve their informal goals. No agencies had formal metrics by which to measure performance toward informal program goals.

Recommendations

Number	Recommendation Description - Policy and Programs
Policy-01	**Create Regional Concept for Transportation Operations (RCTO) and Establish Goals for Management and Operations:** Identify structure and metrics for overarching goals related to traffic incident management, signal coordination, transit signal priority, emergency vehicle preemption, and other operational goals. This effort could be funded through KTMPO's Unified Planning Work Plan (UPWP).
Policy-02	**Adopt Congestion Management Plan (CMP) Performance Measures related to Operations:** Examples include corridor travel time, percentage of operational detection, percentage of signals with Backup Battery Systems (BBS), total number of signals still awaiting Flashing Yellow Arrow (FYA) upgrades, etc.
Policy-03	**Create Regional Committees Focused on Identifying and Resolving Signal Ops Issues:** Identify joint objectives and goals focused on signalization. Provide inter-agency coordination of signal operations staff.
Policy-04	**Create and Fund Regional Traffic Signal Operations Program (RTSOP):** Create processes to review performance measures, identify and analyze issues, and recommend solutions. Provide signal timing and cross-jurisdictional coordination.
Policy-05	**Assist Agencies in Developing Traffic Signal Program Management Plans (TSPMP):** Connect agencies that seek to develop TSPMP to available regional and federal resources to support development. Formalize the MPO's role in this process as part of RCTO development (Policy-01). Consider funding TSPMPs through UPWP.

Maintenance

Best Practice

Traffic signal maintenance is a vital practice for all agencies and requires significant staffing and resources. Maintenance activities generally fall into three categories, 1) Proactive Strategies, 2) Reactive Strategies, and 3) Administrative strategies[10].

Proactive Strategies

Traffic signal preventative maintenance (PM) should be conducted at least annually for all cabinet and signal equipment, including controllers, monitor units, and overhead infrastructure (signal heads, cameras, span wires, etc). Many agencies elect to conduct monthly or bi-monthly cabinet checks to quickly assess signal operations and identify any potential concerns more rapidly. Agencies that conduct cabinet checks typically also conduct a more comprehensive annual or semi-annual PM regimen to cover items that aren't addressed in the cabinet checks. Best practice is to maintain a standard PM checklist and to track activities, findings, and deficiencies using an asset management system.
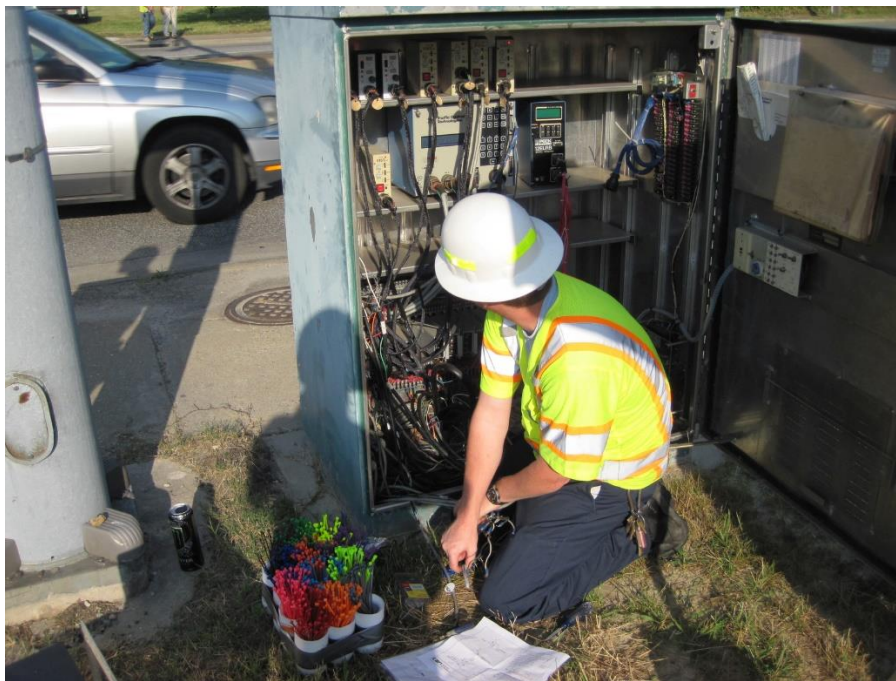

Figure 4. Traffic Signal Technician Performing Preventative Maintenance

Reactive Strategies

Best practice is to maintain adequate spare equipment to restore signal operation in the event of infrastructure being damaged due to crashes or other unexpected events.

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[10] *Traffic Signal Management Plans,* FHWA 2015 – Chapter 4

Some smaller agencies elect instead to retain contractors to provide on-call response services due to inventory expense.

Each agency should keep at least one person responsible for signal operations and maintenance on-call at all times. This often proves challenging for smaller agencies who must rely on a small group of staff to rotate through an on-call schedule, making staff retention challenging due to these staffing demands.

Administrative Strategies

Keeping 'as-built' drawings and records of each signal within each signal cabinet for troubleshooting purposes is standard but maintaining digital records within the agency in addition to in-cabinet as-builts is best practice.

Asset management is crucial to know where infrastructure exists, to understand what types of devices and equipment are located at each signal, and to track work activities for each signal. While logbooks in each traffic signal cabinet are valuable, best practice is to maintain a digital asset management system that integrates with or includes a work event tracking system for record keeping and analyzing previous work history.

It is also best practice to maintain a digital system by which the public can submit work requests and report issues. While not required, it is best if this system is integrated into an asset management system to improve data retention and decrease labor needs and potential errors or omissions.

Current Assessment

Most agencies prioritized Preventative Maintenance (PM) activities and performed bi-monthly cabinet checks in addition to annual or semi-annual complete PMs which aligns well with best practice guidance. Each had some version of a PM checklist and record keeping of those activities in varying degrees of formalization and digitization.

Most agencies had adequate spare equipment to react to damaged infrastructure and/or emergencies. However, each agency expressed interest in being able to coordinate with partner agencies to help one another with emergency needs for equipment that is more rarely needed. This model currently would rely on personal relationships between agency personnel since no formal committee or affiliation of signal operators exists in the region.

All agencies used some form of asset management system to digitally track signal locations and equipment to varying degrees. Most also had Work Order and Service Request tracking integrated into these systems. Some agencies complaints only come via phone or email and are not tracked.

Recommendations

Number	Recommendation Description - Maintenance
Maint-01	**Create Interagency Memorandums of Understanding (MOU) for Signal Resource Sharing During Emergencies:** Create formalized MOU agreements signed by each agency to provide or loan spare equipment if on-hand until replacement equipment can be obtained during emergency situations. This could include the ability for staff to work on partner agency infrastructure in case of emergency need as well.

Operations & Safety

Best Practice

The basis of good signal operations management at the system level is good signal operation at the local intersection level throughout the system. Building upon that foundation, functional vehicle and pedestrian detection and communications between signals and an Advanced Traffic Management System (ATMS) are modern necessities to operate a signal system to full potential. Only then can signal coordination and advanced applications be utilized properly.
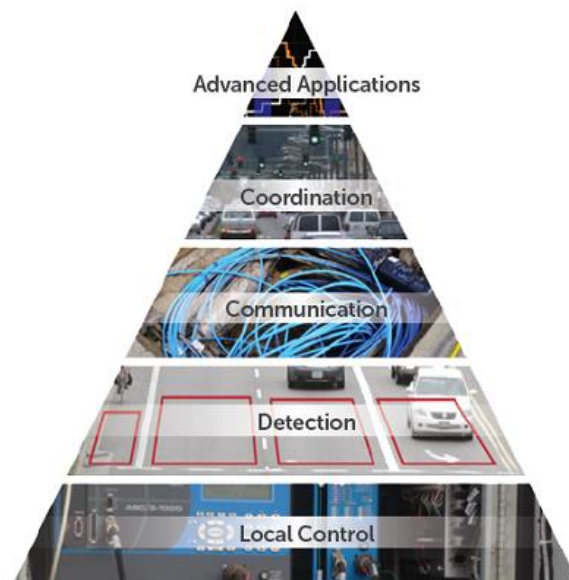

Figure 5. Hierarchy of Signal System Operations[11]

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[11] *Evaluating the Benefits and Costs of Implementing Automated Traffic Signal Performance,* FHWA, 2020, Chapter 2

Advanced Traffic Management Systems (ATMS) and Traffic Management Centers (TMC)

ATMS connect traffic signals and other smart devices to a central system by which agencies can monitor and control their traffic signal network. ATMS can automatically alert staff to critical events and malfunctions, display signal status in real-time, and adjust signal operation remotely.

Traffic Management Centers (TMC) are used by agencies to operate their ATMS and other transportation infrastructure from a centralized location with the aid of other sensing technology like traffic cameras, detection sensors, and other devices. TMCs often focus on either freeway operations or traffic signal system management. Smaller TMCs often only operate through the morning and evening rush hour periods and do not operate overnight, while large TMCs spanning entire regions often operate 24/7.

While smaller agencies with less than 100 may not staff a TMC regularly or have a dedicated facility to operate an ATMS, it is best practice to have all signals connected to an ATMS for the purpose of alerts and signal monitoring on an as needed basis.

Regional TMCs provide the opportunity to leverage shared monitoring and management space and staff. However, it is rare that a TMC operates multiple agencies' signal systems unless they share the same ATMS platform and signal network. For this reason, many Regional TMCs may co-locate staff from multiple agencies and share data, but often don't have fully combined networks and ATMS.

Traffic Signal Timing

The National Cooperative Highway Research Program (NCHRP) Report 812: Signal Timing Manual lays out the methods and means by which signals should be retimed.[12] Elements of successful timing programs should include:

- Effective intra-agency and inter-agency coordination
- Internal champions for support
- External support from elected leaders and stakeholders
- Agency goals and desired outcomes
- Structured programs for tasks (signal timing, performance measures, training, outreach, etc)

Current best practice suggests signal timings should be re-evaluated based on regular reviews of signal and corridor performance measures. Where signal performance measures aren't available, traffic signals should be retimed at least every three years. Successful signal timing programs regularly evaluate corridors for retiming or rotate through a list of corridors based on a set schedule.

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[12] NCHRP 812: *Signal Timing Manual Second Edition,* 2015

Figure 6. Traffic Signal Timing Activities

Additionally, best practice for signal timing includes the development and implementation of incident management and/or event plans to be utilized during extraordinary events and abrupt changes to traffic patterns. Standardizing signal timing pattern numbers allows TMC and ATMS operators to quickly implement these specialized plans for large incidents or special events.

Signal Performance Measures

Signal Performance Measures (SPM) include travel time, delay, arrivals on green, split failures, and other metrics that measure the effectiveness of signal operations through either probe-based connected vehicle data or high-density detector data at each signal. Best practice is to have at least one SPM system in place that is used to assess signal operations, investigate issues, and measure improvements as changes are made. However, SPMs require good working detection and base signal operation to be fully utilized. If agencies are lagging in maintenance, equipment upgrades, and signal timing improvements, SPMs should be implemented as or after remedying those more fundamental issues.

Current Assessment

Most KTMPO member agencies that operate signal systems utilize a vendor specific ATMS to connect most or all of their traffic signals. These ATMS provide automated alerts, remote monitoring capabilities, and the ability to adjust timings remotely as needed.

Most agencies had a small TMC or at least dedicated rooms and workstations for operating their ATMS and viewing system status and camera feeds. None of these facilities were staffed full time with dedicated operators, but rather were home-base for staff adjacent to offices and test equipment.

No agency had a formal signal timing program or regular retiming activities. All signal timing efforts or projects were done on an as-needed basis and/or when funding was available or prioritized. Increases in complaints or scrutiny from agency leadership were the most common reasons to undergo signal retiming activities. The primary reasons for not having a formal signal timing program were due to lack of funding, staff expertise, and staff availability.

KTMPO member agencies desire to use SPMs more, but are instead prioritizing detection improvements, maintenance upgrades, and improving base signal operations first.

Signal Coordination at Agency Boundaries

Agencies didn't provide many locations at jurisdictional boundaries that were experiencing signal coordination issues. The interaction between entry/exit gates of Fort Hood were the most commonly cited locations identified for potential improvement. However, these issues appear to stem primarily from gate security operations and not traffic signal coordination.

When analyzing the locations of all the traffic signals within the KTMPO region, this study identified the following corridors where cross-jurisdictional coordination may be beneficial since they include signals operated and maintained by multiple agencies. These regional corridors are also identified and tracked within the KTMPO CMP.

- SH 201 (Clear Creek Rd) – Killeen & TxDOT Waco District
- US 190 Business (Veterans Memorial Blvd) – Killeen & TxDOT Waco District
- FM 2410 – Killeen & TxDOT Waco District
- SH 317 – Temple & TxDOT Waco District

Safety

None of the agencies mentioned specific processes used to identify locations with incidences of high crashes. These agencies instead rely on ad-hoc safety studies or plans to identify locations warranting further safety analysis. Safety issues and high crash frequency locations are not currently identified through any regular, systematic process due to staff and budget limitations.

KTMPO is in the process of developing multiple data dashboards which will include safety data from TxDOT's state-wide Crash Record Information System (CRIS)

database. This dashboard could be used to identify signal locations with high incidences of crashes for further investigation and project prioritization.

Recommendations

Number	Recommendation Description - Operations & Safety
Ops-01	**Utilize RTSOP to Evaluate and Improve Safety and Operations Within the Region:** In line with Policy-04 recommendation, an RTSOP could provide signal retiming and a mechanism by which to address operational and safety concerns throughout the region and across jurisdictional boundaries.
Ops-02	**Create Process to Evaluate Metrics Along Existing CMP Segments and Identify Corridors for Retiming and Operational Improvements:** This regular process could be a part of the CMP update (Policy-02) or a part of an annual performance review in the proposed RTSOP (Policy-04). By evaluating metrics, resources can be focused to the areas in most need of operational improvements and project funding.
Ops-03	**Create Process to Evaluate Safety Data at Signalized and Un-Signalized Intersections:** Use new KTMPO Data Dashboard to identify both signalized and unsignalized locations that warrant safety studies and potential safety improvements. This can be included as part of the RTSOP (Policy-04) or a separate project in the TIP (Policy-05).
Ops-04	**Establish Long-Term Goal to Use SPMs to Evaluate Signal Performance:** This could be included under the CMP and/or as part of the proposed RTSOP (Policy-04).

Equipment

Best Practice

Traffic signal components can vary in life span and efficacy as they age. Changes in national standards, new technology, and other factors can necessitate changes and upgrades prior to each component's end of life.

Traffic signal controllers should utilize the Advanced Traffic Controller (ATC) platform and support National Traffic Controller Information Protocol (NTCIP) communication. As mentioned previously, traffic signals controllers should be connected to an ATMS and/or

TMC via a fiber optic, wireless, or cellular communication system. Closed Circuit Television (CCTV) cameras are then used at all critical locations (ideally at every intersection) to observe and monitor traffic throughout the signal system.

The standard permissive left turn treatment specified in the Manual On Uniform Traffic Control Devices (MUTCD) is the Flashing Yellow Arrow (FYA). Other previous left turn treatments are still allowed if they existed prior to the advent of FYAs in the 2009 edition of the MUTCD. However, FYAs provide proven safety benefits by mitigating driver confusion and crashes. Best practice for agencies is to upgrade all protected-permissive left turn treatments to FYAs as soon as reasonably able. Some agencies have secured safety related funds to achieve this quickly and systematically while others address FYA upgrades on a case-by-case basis.

Figure 7. Flashing Yellow Arrows

Best practice in pedestrian infrastructure is to provide crossings, ramps, signals, and pedestrian buttons consistent with the Americans with Disabilities Act (ADA) specifications. This includes Audible Pedestrian Signals (APS) devices that provide a tone or message for visually impaired pedestrians.

Critical intersections with high volumes, high-speed facilities, high volumes of pedestrians, or other considerations should utilize battery backup systems (BBS) to provide emergency backup power to signals during temporary outages, which provides a significant safety improvement over a dark traffic signal. Best practice is to specify BBS as a part of any new signal to be constructed and also to programmatically retrofit signals with BBS starting with the most critical locations.

Most agencies have moved away from Bluetooth readers and other roadside units (RSU) in favor of probe-based connected vehicle data from third party vendors to provide travel time data. Probe-based data generally provides greater density and

coverage as compared to RSUs and require no maintenance. They do however require subscriptions. TxDOT currently provides a statewide contract to access roadway travel time data to any public agency, free through their agreement with a third-party data provider.

Current Assessment

Most agencies that operate signals in the KTMPO region have full or nearly complete connectivity to their traffic signal system and utilize an ATMS to alert them to issues. Some agencies are still in the process of rolling out cellular communications to some of their signals to reach this milestone of full integration.

Traffic camera coverage was less than agencies would have liked. Some are using video detection systems to view traffic conditions, but significant traffic camera coverage was a noted desire by all agencies.

The degree to which agencies had retrofit FYAs for permissive left turns varied. Some agencies had already converted all of their eligible signals to FYAs while most were upgrading as able when projects came through to upgrade existing signals. Of the agencies that had not completed their retrofits, none had a program to systemically upgrade to FYAs. Some agencies stated that cabinet configurations limited their ability to retrofit FYAs as it would require significant cabinet improvements or replacement to install, making the upgrade process significantly more costly.

Multiple agencies expressed desire and need to provide pedestrian improvements both at locations that had existing, outdated pedestrian infrastructure and at locations where no pedestrian infrastructure existed currently.

Agencies had very limited number of signal locations that had BBS installed. While all agencies now implement them with all new signal designs and installations, none had programs by which they were retrofitting existing locations with BBS.

Recommendations

Number	Recommendation Description - Equipment
Equip-01	**Prioritize Equipment Upgrades to Improve Safety:** Update project scoring or assessment process to weigh signal improvements that support safety more heavily. Examples include installing pedestrian equipment, Flashing Yellow Arrows, Battery Backup Systems, etc.

Design

Best Practice

Plan or Project Development Processes (PDPs) are used by agencies to help staff, consultants and contractors successfully deliver design and construction projects. Coordination with stakeholders, partner agencies, and utilities is critical to the process and PDPs often specify how this coordination should take place. While traffic signals may be designed and constructed as stand-alone projects, they are often parts of larger roadway projects as well which can make the signal portion of coordination more complex or overlooked. Local agencies are typically stakeholders in State led projects, but traffic signals can sometimes be a forgotten piece of coordination when Local Agency staff involved in stakeholder meetings may not have a good working knowledge of traffic signal equipment and operational needs.

Current Assessment

TxDOT has a Project Development Process (PDP) used to deliver traffic signal design and construction projects. TxDOT also has specifications that dictate which types of equipment and products should be used for traffic signal construction projects. Local agencies often do not have their own set of special provisions or product specifications but frequently refer to the TxDOT specifications.

Figure 8. TxDOT PDP[13]

Some local agencies cited difficulty getting the specific products and equipment compatible with their system (controllers, detection equipment, etc.) included within TxDOT led projects within the local jurisdiction.

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[13]TxDOT Project Development Process: Local Government Projects Toolkit, https://www.txdot.gov/government/processes-procedures/lgp-toolkit/process.html

Recommendations

Number	Recommendation Description - Design
Design-01	**Facilitate Inter-Agency Coordination to Improve Plan Development Process and Project Delivery:** Use Regional Committees identified in Policy-03 recommendation to improve coordination between agencies for design and project delivery.

Staffing

Best Practice

Recommended practice is to provide one Traffic Signal Engineer per 75-100 signals and one signal technician per 40-50 signals.[14] However, many agencies ideally aim for a ratio of one signal technician per 30-40 signals as modern equipment and increased complexity require additional resources to maintain and operate sufficiently.[15]

As agencies approach having 100 signals or more, the need for increased technical staffing and specialization grows. Agencies should begin starting to employ an ITS Engineer or Communications Specialist around that 100 signal mark as well.

Table 2: Recommended Staffing Levels

Position	1 to 50 Traffic Signals	51 to 100 Traffic Signals	101 to 200 Traffic Signals	201 to 500 Traffic Signals	501 to 1000 Traffic Signals
Traffic Signal Engineer	0 to 1	1	1 to 2	2 to 5	5 to 10
Traffic Signal Analyst/Technician	0 to 1	0 to 1	1	1 to 3	3 to 5
ITS Engineer	-	-	0 to 1	1	1 to 3
Traffic Signal Maintenance Technician	1 to 2	2 to 4	4 to 7	7 to 17	17 to 33
Electronic Specialists	1	1	1 to 2	2 to 4	4 to 9
TMC Operators	-	-	2	2 to 4	4 to 9
Public Relations Coordinator	0 to 1	0 to 1	1	1	2

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[14] NCHRP 812: *Signal Timing Manual Second Edition,* 2015
[15] *Traffic Signal Operations and Maintenance Staffing Guidelines*, FHWA, 2009

Training

Industry best practice is to provide regular traffic signal training to all dedicated signal staff. Signal engineers focused on signal timing should receive signal timing and operations training on a regular basis involving basic and advanced signal timing techniques, SPMs, technology improvements, etc. Signal technician training opportunities are available through consultants or vendors, industry societies like International Municipal Signal Association (IMSA), and agency partners (State DOTs or other large agencies with training programs).

Current Assessment

Each agency stated that it is difficult to find signal engineering and technician staff with proper expertise and experience. While most stated that they had adequate staffing levels to meet basic operations and maintenance needs, each agency desired more staff but would require additional budget resources to create the additional positions.

Each stakeholder agency desired to increase training and coordinate training opportunities with agency partners. COVID 19 impacted the ability of agencies to bring in external resources for training, and many have new staff that only have on-the-job training so far.

Every agency wanted to provide more and improved training for signal technician and signal engineering staff. The TxDOT Waco District identified the following actions within their recent TSMO Program Plan[16]:

- Provide TxDOT Waco District Training Opportunities to Local Staff
- Improve Access to Available Specialized TxDOT Signal Training
- Conduct Quarterly Signal Technician Forums
- Conduct Semi-Annual Regional Traffic Operations Forums

Recommendations

Number	Recommendation Description - Staffing
Staff-01	**Partner with TxDOT Waco and Brownwood Districts to Host Signal Operations and Maintenance Training:** Establish initial and ongoing training programs for technicians and other staff to stay current on signal operations and infrastructure.

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[16] *Transportation Systems Management & Operations Program Plan,* TxDOT Waco District, 2020

Funding Opportunities

One common funding source for traffic signal improvements in Texas is the annually funded Highway Safety Improvement Program (HSIP). While the majority of HSIP funds are dedicated to on-system safety improvements, 10% of the funding that TxDOT receives each year through the federal HSIP program is reserved for off-system safety improvements. HSIP funding for is awarded through a competitive program, and off-system HSIP funds are awarded by District. As a result, candidate projects within the KTMPO region would only be assessed against other projects submitted within the TxDOT Waco or Brownwood Districts.

Projects that are approved for HSIP funding generally require a 10% local funding match for construction costs. In some cases, traffic control signalization projects may be eligible for 100% federal funding of construction dollars through the HSIP "G Match" program. Projects receiving full federal funding for construction are selected as part of each District's finalization of its HSIP program. Other project costs, including design costs, are not covered through HSIP. TxDOT publishes a guide with work codes that correspond to common HSIP project types. Project types related to traffic signals include:

- **107: Install Traffic Signal.** Definition: Provide a traffic signal where none existed previously. This does not include the installation of flashing beacons.
- **108: Improve Traffic Signals.** Definition: Improve existing intersection signals to current design standards.
- **110: Install Pedestrian Signal.** Definition: Provide a pedestrian signal at an existing signalized location where no pedestrian phase exists, but pedestrian crosswalks are existing.
- **111: Interconnect Signals.** Definition: Provide a communication link between two or more adjacent signals in a corridor. Specify all signalized intersections to be included in the interconnection.
- **118: Replace Flashing Beacon with a Traffic Signal.** Definition: Replace an existing flashing beacon at an intersection with a traffic signal.
- **131: Improve Pedestrian Signals.** Definition: Bring existing pedestrian signal units into conformance with current standards.
- **138: Install Flashing Yellow Arrow.** Definition: Improve existing intersection signals by adding a flashing yellow arrow indication and install the LEFT TURN YIELD ON FLASHING YELLOW ARROW (R10-17T) sign.
- **143: Pedestrian Hybrid Beacon.** Definition: Provide pedestrian hybrid beacon at established crosswalk or in conjunction with installation of new crosswalk.

Several other programs and grant opportunities exist to assist with traffic signalization improvements, but applicability to the KTMPO region is limited. The federal Congestion

Mitigation and Air Quality Improvement Program (CMAQ) provides funding opportunities for signalization enhancements that reduce congestion, but the program is only available to regions currently in non-attainment of ambient air quality standards. Several competitive grant programs also award grants to assist in funding transportation technology projects, such as the Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD). Programs like these, however, receive large applicant pools each year and are generally focused toward very large, multimillion dollar project deployments.

For smaller-scale signalization improvements, such as technology upgrades or reconfigurations that do not qualify for HSIP funding, KTMPO may consider identifying a list of potential projects with local support that could be included in the MTP and TIP at low cost as available funding allows. The low cost of signalization projects (compared to road construction projects) could allow for KTMPO to regularly include a different signalization project as part of its annual TIP update as opposed to carrying over that extra funding to the next fiscal year. Selectively including low-cost signalization enhancement projects as part of TIP updates also provides a way for KTMPO to increase the geographic diversity of projects in the TIP from year to year, especially in years where the TIP may be focused largely upon a small number of high-cost projects.

Recommendations

Number	Recommendation Description - Funding
Fund-01	**Consider Adding Traffic Signal Projects to TIP as Funding and Eligibility Allows:** Maintain a list of high-priority spot and corridor signalization enhancement projects related to either improved safety or operations. If funding becomes available and there is MPO support, signal projects may represent an opportunity for relatively low-cost enhancement to the transportation system.
Fund-02	**Assist Agencies in Identifying Funding Opportunities for Traffic Signal Projects:** TxDOT Funding Category 8 can be used by local agencies to fund safety-related traffic signal improvements, and KTMPO can serve as a resource to connect these agencies with information about this and other traffic signal-focused grant and funding opportunities as they are made available.

Recommendations Summary

Number	Recommendation Description - Policy and Programs
Policy-01	**Create Regional Concept for Transportation Operations (RCTO) and Establish Goals for Management and Operations:** Identify structure and metrics for overarching goals related to traffic incident management, signal coordination, transit signal priority, emergency vehicle preemption, and other operational goals. This effort could be funded through KTMPO's Unified Planning Work Plan (UPWP).
Policy-02	**Adopt Congestion Management Plan (CMP) Performance Measures related to Operations:** Examples include corridor travel time, percentage of operational detection, percentage of signals with Backup Battery Systems (BBS), total number of signals still awaiting Flashing Yellow Arrow (FYA) upgrades, etc.
Policy-03	**Create Regional Committees Focused on Identifying and Resolving Signal Ops Issues:** Identify joint objectives and goals focused on signalization. Provide inter-agency coordination of signal operations staff.
Policy-04	**Create and Fund Regional Traffic Signal Operations Program (RTSOP):** Create processes to review performance measures, identify and analyze issues, and recommend solutions. Provide signal timing and cross-jurisdictional coordination.
Policy-05	**Assist Agencies in Developing Traffic Signal Program Management Plans (TSPMP):** Connect agencies that seek to develop TSPMP to available regional and federal resources to support development. Formalize the MPO's role in this process as part of RCTO development (Policy-01). Consider funding TSPMPs through UPWP.

Number	Recommendation Description - Maintenance
Maint-01	**Create Interagency Memorandums of Understanding (MOU) for Signal Resource Sharing During Emergencies:** Create formalized MOU agreements signed by each agency to provide or loan spare equipment if on-hand until replacement equipment can be obtained during emergency situations. This could include the ability for staff to work on partner agency infrastructure in case of emergency need as well.

Number	Recommendation Description - Operations & Safety
Ops-01	**Utilize RTSOP to Evaluate and Improve Safety and Operations Within the Region:** In line with Policy-04 recommendation, an RTSOP could provide signal retiming and a mechanism by which to address operational and safety concerns throughout the region and across jurisdictional boundaries.
Ops-02	**Create Process to Evaluate Metrics Along Existing CMP Segments and Identify Corridors for Retiming and Operational Improvements:** This regular process could be a part of the CMP update (Policy-02) or a part of an annual performance review in the proposed RTSOP (Policy-04). By evaluating metrics, resources can be focused to the areas in most need of operational improvements and project funding.
Ops-03	**Create Process to Evaluate Safety Data at Signalized and Un-Signalized Intersections:** Use new KTMPO Data Dashboard to identify both signalized and unsignalized locations that warrant safety studies and potential safety improvements. This can be included as part of the RTSOP (Policy-04) or a separate project in the TIP (Policy-05).
Ops-04	**Establish Long-Term Goal to Use SPMs to Evaluate Signal Performance:** This could be included under the CMP and/or as part of the proposed RTSOP (Policy-04).

Number	Recommendation Description - Equipment
Equip-01	**Prioritize Equipment Upgrades to Improve Safety:** Update project scoring or assessment process to weigh signal improvements that support safety more heavily. Examples include installing pedestrian equipment, Flashing Yellow Arrows, Battery Backup Systems, etc.

Number	Recommendation Description - Design
Design-01	**Facilitate Inter-Agency Coordination to Improve Plan Development Process and Project Delivery:** Use Regional Committees identified in Policy-03 recommendation to improve coordination between agencies for design and project delivery.

Number	Recommendation Description - Staffing
Staff-01	**Partner with TxDOT Waco and Brownwood Districts to Host Signal Operations and Maintenance Training:** Establish initial and ongoing training programs for technicians and other staff to stay current on signal operations and infrastructure.

Number	Recommendation Description - Funding
Fund-01	**Consider Adding Traffic Signal Projects to TIP as Funding and Eligibility Allows:** Maintain a list of high-priority spot and corridor signalization enhancement projects related to either improved safety or operations. If funding becomes available and there is MPO support, signal projects may represent an opportunity for relatively low-cost enhancement to the transportation system.
Fund-02	**Assist Agencies in Identifying Funding Opportunities for Traffic Signal Projects:** TxDOT Funding Category 8 can be used by local agencies to fund safety-related traffic signal improvements, and KTMPO can serve as a resource to connect these agencies with information about this and other traffic signal-focused grant and funding opportunities as they are made available.

Appendix A: List of Signal Locations

Agency	County	Intersection	Latitude	Longitude
TxDOT Waco District	Bell	SH 95 & FM 436	30.980483	-97.341689
TxDOT Waco District	Bell	FM 439 / Lake Rd & FM 2271	31.102136	-97.476961
TxDOT Waco District	Bell	FM 439 / Lake Rd & Dunn's Canyon Rd	31.096756	-97.473431
TxDOT Waco District	Bell	FM 93 / 2nd Ave & Loop 121	31.062603	-97.479053
TxDOT Waco District	Bell	FM 93 & FM 817 / Blair St	31.060386	-97.456592
TxDOT Waco District	Bell	Loop 121 & Avenue D	31.055414	-97.483014
TxDOT Waco District	Bell	Loop 121 & Sparta Rd	31.083567	-97.469822
TxDOT Waco District	Bell	Loop 121 & FM 439	31.087503	-97.467883
TxDOT Waco District	Bell	SH 317 & FM 93/ 2nd Ave	31.058275	-97.463056
TxDOT Waco District	Bell	SH 317 & FM 93/ 6th Ave	31.061836	-97.4617
TxDOT Waco District	Bell	SH 317 & Sparta Rd	31.080356	-97.457586
TxDOT Waco District	Bell	SH 317 & FM 439	31.083831	-97.457578
TxDOT Waco District	Bell	SH 317 & Industrial Park Rd	31.073431	-97.457386
TxDOT Waco District	Bell	SH 317 & 22nd Ave	31.076972	-97.457147
TxDOT Waco District	Bell	US 190 & Loop 121 / Frontage Rd	31.049805	-97.485444
TxDOT Waco District	Bell	Loop 121 & I-35 Frontage Rd	31.03059	-97.473986
TxDOT Waco District	Bell	SH 317 & US 190 WB Frontage Rd	31.047074	-97.467273
TxDOT Waco District	Bell	FM 436 & I-35 Frontage Rd	31.044838	-97.467416
TxDOT Waco District	Bell	FM 93 & I-35 Frontage Rd	31.056773	-97.446623
TxDOT Waco District	Bell	Central Ave & I-35 Frontage Rd	31.053376	-97.454909
TxDOT Waco District	Bell	FM 439 & Sparta Rd	31.100113	-97.516434
TxDOT Waco District	Bell	SH 317 & 9th Ave	31.064237	-97.460779
TxDOT Waco District	Bell	SH 317 & Central Ave	31.056392	-97.463785
TxDOT Waco District	Bell	Loop 121 & MLK	31.06849	-97.477061
TxDOT Waco District	Coryell	BUS 190 & FM 116 / Georgetown Rd	31.111303	-97.910597
TxDOT Waco District	Coryell	BUS 190 & FM 116 / Leonhard St / Main St	31.115078	-97.905406
TxDOT Waco District	Coryell	BUS 190 & Robertson Ave	31.118597	-97.899031
TxDOT Waco District	Coryell	BUS 190 & Elm St	31.119686	-97.894931
TxDOT Waco District	Coryell	BUS 190 & FM 1113 / Avenue D	31.120108	-97.889636
TxDOT Waco District	Coryell	BUS 190 & Martin Luther King Jr Dr	31.120369	-97.881447
TxDOT Waco District	Coryell	BUS 190 & Constitution Dr	31.120825	-97.869028
TxDOT Waco District	Coryell	BUS 190 & Robert Griffin lll Dr	31.121042	-97.865758
TxDOT Waco District	Coryell	FM 1113 & Main St	31.123922	-97.902489
TxDOT Waco District	Coryell	FM 1113 & Wolf Rd	31.120758	-97.891975
TxDOT Waco District	Coryell	FM 116 & Lutheran Church Rd	31.124294	-97.903583
TxDOT Waco District	Coryell	FM 1113 & FM 116 / 1st St	31.125986	-97.902811

TxDOT Waco District	Coryell	FM 116 & FM 1113/ Avenue B	31.096422	-97.925319
TxDOT Waco District	Coryell	US 190 & FM 2657	31.09578	-97.910721
TxDOT Waco District	Coryell	US 190 & FM 3046	31.121883	-97.837279
TxDOT Waco District	Coryell	US 190 & Clarke Rd / Frontage Rd	31.14128	-97.900933
TxDOT Waco District	Bell	US 190 & SH 201 Frontage Rd (Clear Creek Rd)	31.121988	-97.798374
TxDOT Waco District	Bell	US 190 & BUS 190	31.122408	-97.767169
TxDOT Waco District	Bell	BUS 190 & Roy Reynolds Dr	31.092244	-97.674369
TxDOT Waco District	Bell	BUS 190 & Harley Dr	31.090764	-97.668017
TxDOT Waco District	Bell	BUS 190 & Ann Blvd	31.089794	-97.664636
TxDOT Waco District	Bell	BUS 190 & FM 3423 / Indian Trl	31.086736	-97.653697
TxDOT Waco District	Bell	BUS 190 & FM 3219	31.085643	-97.648831
TxDOT Waco District	Bell	FM 2410 & Ann Blvd	31.073756	-97.674092
TxDOT Waco District	Bell	FM 2410 & Millers Crossing	31.065375	-97.665494
TxDOT Waco District	Bell	FM 2410 & Wampum Dr	31.061958	-97.662864
TxDOT Waco District	Bell	FM 2410 & Mountain Lion Rd	31.058122	-97.659633
TxDOT Waco District	Bell	FM 2410 & FM 3481 / Verna Lee Blvd	31.056253	-97.654103
TxDOT Waco District	Bell	FM 439 / Rancier Ave & FM 3219	31.105056	-97.641458
TxDOT Waco District	Bell	US 190 & Indian Trail / Frontage Rd EB	31.076337	-97.654086
TxDOT Waco District	Bell	US 190 FR & FM 2410	31.070788	-97.669621
TxDOT Waco District	Bell	FM 3481 / Stillhouse Lake Rd & Prospector Trl	31.052359	-97.655279
TxDOT Waco District	Bell	FM 3481 & Vineyard Trl / Cedar Knob	31.043887	-97.658275
TxDOT Waco District	Bell	SH 36 & FM 437	30.931674	-97.227052
TxDOT Waco District	Bell	FM 3481 & Chaparral Rd	31.038799	-97.65919
TxDOT Waco District	Bell	SH 195 & Chaparral Rd	31.023045	-97.75487
TxDOT Waco District	Bell	I-35 Frontage Rd & FM 935	31.206965	-97.302941
City of Killeen	Bell	2nd & B	31.12258887	-97.72965633
City of Killeen	Bell	2nd & C	31.12174733	-97.72998192
City of Killeen	Bell	2nd & D	31.12086793	-97.73021627
City of Killeen	Bell	38th & Atkinson	31.1142033	-97.69916477
City of Killeen	Bell	60th & Westcliff	31.12610666	-97.68419569
City of Killeen	Bell	38th & Westcliff	31.13094699	-97.69209502
City of Killeen	Bell	8th & B	31.12175727	-97.72611447
City of Killeen	Bell	Elms & Robinett	31.09782173	-97.7865981
City of Killeen	Bell	Edgefield & Robinett	31.09939379	-97.78628385
City of Killeen	Bell	FM 3470 (E Stan Schlueter Loop) & Chantz	31.07424978	-97.70630747
City of Killeen	Bell	FM 3470 & Cunningham	31.06890008	-97.7149405
City of Killeen	Bell	FM 3470 & Little Rock	31.08333387	-97.77398095
City of Killeen	Bell	FM 3470 & MLK	31.08159795	-97.6963788
City of Killeen	Bell	FM 3470 & Robinett	31.08743962	-97.79081207
City of Killeen	Bell	FM 3470 & Trimmier	31.07312827	-97.74037966

City of Killeen	Bell	FM 3470 & WS Young	31.06959612	-97.7271583
City of Killeen	Bell	FM3470 & Bunny Trail	31.08579488	-97.785028
City of Killeen	Bell	FM3470 & Jake Spoon	31.08652456	-97.78754796
City of Killeen	Bell	FM3470 & Oak Valley	31.07159401	-97.70951049
City of Killeen	Bell	FM 3470 & LCP (Lions Club Park)	31.07128714	-97.73418926
City of Killeen	Bell	FM 3470 (W Stan Schlueter Loop) & SH 201 (Clear Creek)	31.09228919	-97.80770677
City of Killeen	Bell	FM3470 & FM 440	31.07946376	-97.76245649
City of Killeen	Bell	Ft Hood & K-Mart	31.11248904	-97.74621304
City of Killeen	Bell	Hallmark & 10th	31.11139732	-97.72870536
City of Killeen	Bell	Hallmark & Florence	31.11286052	-97.73317784
City of Killeen	Bell	Hallmark & Gray	31.11220925	-97.73056277
City of Killeen	Bell	Hood & Elms	31.08650462	-97.75567537
City of Killeen	Bell	Hood & Hallmark	31.11593247	-97.74492302
City of Killeen	Bell	Hood & Jasper	31.10337702	-97.74986967
City of Killeen	Bell	Hood & VMB (Veterans Memorial Blvd)	31.12087269	-97.74296974
City of Killeen	Bell	Hood (TX 195) & Chaparral	31.02331485	-97.75472773
City of Killeen	Bell	Lowes Blvd & WalMart	31.09204131	-97.72970457
City of Killeen	Bell	MLK & Scott & White	31.08369426	-97.69726703
City of Killeen	Bell	MLK (FM 2410) & Zephyr	31.0960871	-97.69467292
City of Killeen	Bell	MLK (FM2410) & Rosewood	31.07763595	-97.68733696
City of Killeen	Bell	Old FM 440 & Elms	31.08749775	-97.75932774
City of Killeen	Bell	Rancier & 10th	31.12533029	-97.72332171
City of Killeen	Bell	Rancier & 2nd	31.12662671	-97.72837839
City of Killeen	Bell	Rancier & 38th	31.11860545	-97.69841037
City of Killeen	Bell	Rancier & 4th	31.12630261	-97.72721816
City of Killeen	Bell	Rancier & 8th	31.12565153	-97.72491165
City of Killeen	Bell	Rancier & Alexander	31.12309877	-97.71564629
City of Killeen	Bell	Rancier & College	31.12728135	-97.73061019
City of Killeen	Bell	Rancier & Gilmer	31.12863606	-97.73552142
City of Killeen	Bell	Rancier & Gray	31.12601353	-97.72612563
City of Killeen	Bell	Rancier & Hood	31.12965979	-97.73967419
City of Killeen	Bell	Rancier & Roy Reynolds	31.11553999	-97.66555159
City of Killeen	Bell	Rancier & Twin Creek	31.1161479	-97.6844969
City of Killeen	Bell	Rancier & Valley	31.12752945	-97.7318123
City of Killeen	Bell	Rancier & WS Young	31.12133798	-97.70939734
City of Killeen	Bell	Roy J Smith & Twin Creek	31.1072455	-97.68402944
City of Killeen	Bell	SH 201 (Clear Creek Rd) & Bell Tower	31.11186428	-97.80022719
City of Killeen	Bell	SH 201 & Desert Willow	31.10662503	-97.80223756
City of Killeen	Bell	SH 201 & Elms	31.10307262	-97.80354239
City of Killeen	Bell	SH 201 & Mowhawk	31.0786998	-97.813201
City of Killeen	Bell	SH 201 & Watercrest	31.11650247	-97.79843175

City of Killeen	Bell	SH 201 & Chet Edwards/Airport	31.06336413	-97.816736
City of Killeen	Bell	SH 201 (Clearcreek) and Campus	31.05661987	-97.77280355
City of Killeen	Bell	SH 201 (Clear Creek Rd) & Golden Gate Dr	31.08390704	-97.81095697
City of Killeen	Bell	Stagecoach & Featherline	31.05241677	-97.72694247
City of Killeen	Bell	Stagecoach & WS Young	31.05321119	-97.73229863
City of Killeen	Bell	Stagecoach & Rosewood	31.05849366	-97.68585463
City of Killeen	Bell	Stagecoach & Chantz	31.05520143	-97.69719387
City of Killeen	Bell	Stagecoach & E. Trimmier	31.05387551	-97.70181203
City of Killeen	Bell	Stagecoach & W. Trimmier	31.05381763	-97.7478013
City of Killeen	Bell	Stagecoach & Cunningham	31.05502694	-97.70910987
City of Killeen	Bell	Trimmier & Bacon Ranch	31.08999829	-97.7341856
City of Killeen	Bell	Trimmier & Bryce	31.11040174	-97.72845346
City of Killeen	Bell	Trimmier & Elms	31.08155194	-97.73750017
City of Killeen	Bell	Trimmier & Jasper	31.09829447	-97.73113079
City of Killeen	Bell	Trimmier & Lowes	31.09254552	-97.73324136
City of Killeen	Bell	Trimmier & Terrace	31.10769917	-97.72761509
City of Killeen	Bell	Trimmier & Weiss	31.08572453	-97.73591373
City of Killeen	Bell	VMB & 10th	31.11673385	-97.72657485
City of Killeen	Bell	VMB & 20th	31.1146121	-97.72311506
City of Killeen	Bell	VMB & 28th	31.11149163	-97.71938682
City of Killeen	Bell	VMB & 2nd	31.11786314	-97.73115443
City of Killeen	Bell	VMB & 38th	31.10406738	-97.70484381
City of Killeen	Bell	VMB & 4th	31.11759629	-97.72997783
City of Killeen	Bell	VMB & 8th	31.11699008	-97.72762704
City of Killeen	Bell	VMB & College	31.11836639	-97.73348467
City of Killeen	Bell	VMB & Gilmer	31.11971459	-97.73872162
City of Killeen	Bell	VMB & Gray	31.11743902	-97.72880146
City of Killeen	Bell	VMB & Twin Creek	31.09833393	-97.69420374
City of Killeen	Bell	VMB & WS Young	31.10894483	-97.7144106
City of Killeen	Bell	Watercrest & Willow Springs	31.10639297	-97.76416028
City of Killeen	Bell	WS Young & Elms	31.07727472	-97.72403673
City of Killeen	Bell	WS Young & Grandon	31.0948076	-97.72103172
City of Killeen	Bell	WS Young & Illinois	31.09601132	-97.72093391
City of Killeen	Bell	WS Young & Lake	31.12953921	-97.70633607
City of Killeen	Bell	WS Young & Lowes	31.08833079	-97.72029113
City of Killeen	Bell	WS Young & Mall Dr	31.09274596	-97.72023766
City of Killeen	Bell	WS Young & Terrace	31.10520303	-97.71814039
City of Killeen	Bell	CTE (Central Texas Expy) & Fort Hood St	31.10903844	-97.7475698
City of Killeen	Bell	CTE (Central Texas Expy) EB & Trimmier Rd	31.09471808	-97.73239529
City of Killeen	Bell	CTE (Central Texas Expy) & WS Young	31.09117082	-97.72020433
City of Killeen	Bell	FM 3470 (Stan Schlueter) & Fort Hood St	31.07807819	-97.75808904

City of Killeen	Bell	CTE (Central Texas Expy) & FM 3470 (E Stan Schlueter)	31.08049705	-97.69867641
City of Killeen	Bell	SH 201 (Clear Creek Rd) & S Fort Hood St	31.05714602	-97.7655275
City of Killeen	Bell	CTE (Central Texas Expy) & Rosewood Dr	31.07608879	-97.68816371
City of Killeen	Bell	CTE (Central Texas Expy) & Jasper Dr	31.10066205	-97.74039021
City of Killeen	Bell	CTE (Central Texas Expy) & Willow Springs Rd	31.11407249	-97.76161758
City of Killeen	Bell	WS Young & Zephyr	31.1018038	-97.71917064
TxDOT Brownwood District	Lampasas	US 190 & Big Divide Rd	31.093732	-97.95379
Fort Hood	Bell	E Tank Desroyer Blvd & S 27th St	31.13231559	-97.74887915
Fort Hood	Bell	E Tank Desroyer Blvd & S 37th St	31.13440246	-97.75706088
Fort Hood	Bell	E Tank Desroyer Blvd & S 24th St	31.13124005	-97.74516954
Fort Hood	Bell	761st Tank Battalion Ave & S TJ Mills Blvd	31.13835724	-97.76596765
Fort Hood	Bell	Legends Way & TJ Mills Blvd	31.13986127	-97.76570216
Fort Hood	Bell	E Tank Destroyer Blvd & 31st St	31.13382606	-97.75367304
Fort Hood	Bell	E Tank Destroyer Blvd & Casa Blanca Rd	31.13309549	-97.76072281
Fort Hood	Bell	E Legends Way & 37th St	31.13872215	-97.75787521
Fort Hood	Bell	E Legends Way & 31th St	31.13803897	-97.75293146
Fort Hood	Bell	E 761st Tank Battalion Ave & S 31st St	31.13658651	-97.7531918
Fort Hood	Bell	W Legends Way & 72nd St	31.1426337	-97.78638497
Fort Hood	Bell	W 761st Tank Battalion Ave & S 62nd St	31.13993343	-97.77786731
Fort Hood	Bell	W Legends Way & 62nd St	31.14143736	-97.77755298
Fort Hood	Bell	Santa Fe Ave & Wratten Dr	31.12837104	-97.77263371
Fort Hood	Bell	W Tank Destroyer Blvd & S 72nd St	31.13571531	-97.78758413
Fort Hood	Bell	W Tank Destroyer Blvd & Hood Stadium Rd	31.13327946	-97.80371142
Fort Hood	Bell	Support Ave & S 58th St	31.13653126	-97.77520831
Fort Hood	Bell	W Tank Destroyer Blvd & S 58th St	31.13419436	-97.7755986
Fort Hood	Bell	Santa Fe Ave & S 58th St - S 62nd St	31.12978145	-97.77784654
Fort Hood	Bell	Santa Fe Ave & Bluffs Ave (Hospital)	31.12887697	-97.77595843
Fort Hood	Bell	Tank Destroyer Blvd & S TJ Mills Blvd	31.13309369	-97.76700045
Fort Hood	Bell	W Tank Destroyer Blvd & S 62nd St	31.13461277	-97.77932898
Fort Hood	Bell	E Legends Way & 21st St & Central Drive	31.13902059	-97.74111893
Fort Hood	Bell	E Legends Way & 24th St & 25th St	31.13783348	-97.7446343
Fort Hood	Bell	Support Ave & S 62nd St	31.13750899	-97.77868214
Fort Hood	Bell	Support Ave & S 72nd St	31.13862586	-97.78709291
Fort Hood	Bell	E Old Iron Sides Ave & N 19th St	31.14263564	-97.73804135
Fort Hood	Bell	E Hell on Wheels Ave & N 19th St	31.1431844	-97.73796275
Fort Hood	Bell	E Legends Way & N 27th St	31.13749291	-97.74864877
Fort Hood	Bell	W 761st Tank Battalion Ave & S 72nd St	31.14092796	-97.78669402
Fort Hood	Bell	E 761st Tank Battalion Ave & S 37th St	31.13727849	-97.75814746

Fort Hood	Bell	S Clear Creek Rd and Comerce Dr	31.1293748	-97.79965521
Fort Hood	Bell	W 761st Tank Battalion Ave & S 58th	31.13955823	-97.77509001
Fort Hood	Bell	W Legends Way & 58th St	31.14107485	-97.77481461
Fort Hood	Bell	W Legends Way & 50th St	31.14022307	-97.76834952
Fort Hood	Bell	W Legends Way & Pleiku Dr	31.14195668	-97.78127221
Fort Hood	Bell	W Old Iron Slides Ave & N 72nd St	31.14532787	-97.7858961
Fort Hood	Bell	W Hell on Wheels Ave & N 72nd St	31.14588942	-97.78577419
Fort Hood	Bell	S Clear Creek Rd & Dakota Dr	31.13807583	-97.80237893
Fort Hood	Bell	S Clear Creek Rd & W Legends Way	31.14488746	-97.80366847
Fort Hood	Bell	W Tank Destroyer Blvd & S Clear Creek Rd	31.13240547	-97.80021364
Fort Hood	Bell	W Tank Destroyer Blvd & S 79th St	31.13338955	-97.79192228
Fort Hood	Bell	W Tank Destroyer Blvd & Wratten Dr	31.13374268	-97.77218609
Fort Hood	Bell	Santa Fe Ave and S 79th St	31.12739603	-97.7907115
Fort Hood	Bell	TJ Mills Blvd & Old Iron Sides Ave	31.14255613	-97.76523325
Fort Hood	Bell	N TJ Mills Blvd & Hell on Wheels Ave	31.14309166	-97.7651118
Fort Hood	Bell	Central Dr & Rifles Ln (Fort Hood Street)	31.13780762	-97.73511116
Fort Hood	Bell	Warrior Way & Martin Dr	31.14077093	-97.72565576
Fort Hood	Bell	E 761st Tank Battalion Ave & 24th St	31.13572482	-97.74436639
Fort Hood	Bell	Warrior Way & Bank	31.13927722	-97.72260742
Fort Hood	Bell	Warrior Way & Commissary	31.1356483	-97.72010208
Fort Hood	Bell	Warrior Way & 10th St	31.13266906	-97.71970648
Fort Hood	Bell	72nd St & Warehouse Ave	31.13088896	-97.78656049
Fort Hood	Bell	E 761st Tank Battalion Ave & 52nd St	31.13889686	-97.77026649
Fort Hood	Bell	W Tank Destroyer Blvd & Muskogee St	31.13540557	-97.82627717
Fort Hood	Bell	S TJ Mills Blvd & Phantom Warrior Dr	31.13517645	-97.76659423
Fort Hood	Bell	W Tank Destroyer Blvd & N Clark Rd	31.13912269	-97.8393414
Fort Hood	Bell	N Clear Creek Rd & Turkey Run Rd	31.15453846	-97.80127261
Fort Hood	Bell	Tank Destroyer Blvd & New Railhead Dr	31.13725637	-97.85783092
Fort Hood	Bell	Martin Dr & E Murphy Rd	31.14569703	-97.72382412
Fort Hood	Bell	S Clark Rd & Clement Dr WRH	31.11438965	-97.83779735
Fort Hood	Bell	S Clark Rd & Mohawk Dr WRH	31.08393986	-97.84082967
Fort Hood	Bell	S Clear Creek Rd & W Hell on Wheels Ave	31.14819718	-97.80284235
Fort Hood	Bell	S Clear Creek Rd & W Old Ironsides Ave	31.147645	-97.80297225
Fort Hood	Bell	Mohawk Dr & Gray Eagle Rd	31.08133582	-97.82203384
Fort Hood	Bell	West Range Rd & Spearhead Rd MTC	31.15472625	-97.78394746
Fort Hood	Bell	East Range Rd & Tedesco Rd	31.15360994	-97.71230897
Temple	Bell	1st & G	31.089962	-97.344761
Temple	Bell	1st & H	31.088988	-97.345153
Temple	Bell	1st & M	31.084307	-97.34688
Temple	Bell	1st & R	31.079695	-97.348591
Temple	Bell	1st & U	31.076465	-97.349798

Temple	Bell	1st & Marvin Felder	31.072779	-97.350605
Temple	Bell	1st & Loop 363	31.068675	-97.349422
Temple	Bell	2nd & Adams	31.097406	-97.339835
Temple	Bell	3rd & Adams	31.098242	-97.34278
Temple	Bell	3rd & Central	31.097192	-97.343164
Temple	Bell	3rd & A	31.096237	-97.343521
Temple	Bell	3rd & French	31.102846	-97.340924
Temple	Bell	3rd & Nugent	31.110941	-97.33795
Temple	Bell	3rd & Zenith	31.12152	-97.336244
Temple	Bell	5th & R	31.080168	-97.350366
Temple	Bell	5th & Temple College (ped crossing)	31.074927	-97.352311
Temple	Bell	5th & Marlandwood	31.060284	-97.357709
Temple	Bell	5th & Canyon Creek	31.057421	-97.358773
Temple	Bell	5th & Waters Dairy	31.049827	-97.361619
Temple	Bell	5th & FM 93	31.031863	-97.367507
Temple	Bell	8th & Adams	31.09658	-97.33696
Temple	Bell	MLK & H	31.087624	-97.340264
Temple	Bell	9th & Adams	31.099009	-97.345725
Temple	Bell	9th & Central	31.098021	-97.346101
Temple	Bell	25th & Adams	31.101262	-97.353821
Temple	Bell	25th & Central	31.100253	-97.354218
Temple	Bell	25th & H	31.092293	-97.357177
Temple	Bell	25th & M	31.087648	-97.358891
Temple	Bell	25th & R	31.082672	-97.359496
Temple	Bell	31st & Adams	31.102227	-97.357292
Temple	Bell	31st & Central	31.101227	-97.357701
Temple	Bell	31st & H	31.09323	-97.360574
Temple	Bell	31st & M	31.088579	-97.362298
Temple	Bell	31st & R	31.083905	-97.363932
Temple	Bell	31st & Scott	31.078783	-97.365913
Temple	Bell	31st & Scott ER exit	31.076316	-97.366906
Temple	Bell	31st & Loop	31.0734962	-97.36789194
Temple	Bell	31st & Mall	31.070796	-97.368936
Temple	Bell	31st & Azalea	31.068871	-97.369714
Temple	Bell	31st & Marlandwood	31.064947	-97.371181
Temple	Bell	31st & Canyon Creek	31.061335	-97.372554
Temple	Bell	31st & Waters Dairy	31.053656	-97.375532
Temple	Bell	31st & 93	31.037303	-97.3925
Temple	Bell	57th & Gen. Bruce	31.09426658	-97.37583904
Temple	Bell	57th & Scott	31.083559	-97.380069
Temple	Bell	57th & Loop	31.08018628	-97.38241408

Temple	Bell	57th & M	31.092655	-97.376481
Temple	Bell	Adams & Apache	31.106754	-97.376325
Temple	Bell	Adams & Ermine/West Loop	31.109787	-97.387475
Temple	Bell	Adams & Old Waco/Research Pkwy	31.117545	-97.416253
Temple	Bell	Adams & Kegley	31.113277	-97.400285
Temple	Bell	Adams & Wal-Mart	31.116426	-97.412536
Temple	Bell	Adams & Westfield	31.119718	-97.423654
Temple	Bell	Adams & Pea Ridge	31.119913	-97.429348
Temple	Bell	Adams & 317	31.121697	-97.443384
Temple	Bell	Adams & Lakewood	31.127437	-97.461757
Temple	Bell	Adams & 2271	31.128508	-97.468758
Temple	Bell	Canyon Creek & Lowes	31.059492	-97.365999
Temple	Bell	317 & Tarver	31.11550733	-97.44595057
Temple	Bell	Adams/Central/Airport & General Bruce	31.102794	-97.358973
Temple	Bell	Main & Adams	31.097645	-97.34086
Temple	Bell	Main & Central	31.096662	-97.34119
Temple	Bell	Marlandwood & Lowes	31.062484	-97.365139
Temple	Bell	Midway & Gen. Bruce	31.07996	-97.411812
Temple	Bell	Midway & Hickory	31.07618	-97.390514
Temple	Bell	South Loop & IH 35	31.09061531	-97.38711499
Temple	Bell	North Loop & I35	31.13898598	-97.329928
Temple	Bell	Thornton & Oakdale	31.077328	-97.384176
Temple	Bell	Loop & MLK	31.060819	-97.337313
Temple	Bell	Loop & Hwy 36	31.11906664	-97.38470288
Temple	Bell	Airport & Research	31.129278	-97.399749
Temple	Bell	Spur 290 & General Bruce	31.127968	-97.334139
Temple	Bell	Prairie View & SH 317	31.141009	-97.43576
Temple	Bell	Ave H & General Bruce	31.095762	-97.368638
Temple	Bell	FM 95/FM 93 & Loop 363	31.025657	-97.315105
Temple	Bell	S 5th Street & Temple Park (ped crossing)	31.04575995	-97.36310556

Appendix B: Stakeholder Survey Responses

Please enter the name of your agency name	TxDOT Brownwood	City of Killeen	TxDOT Waco District	Ft Hood	City of Temple
Primary contact name and title/position	Eric Lykins (Director of Operations)	Andrew Zagars	Chris Pruitt - District Traffic Engineer	Philip Bryce - Paving Program Manager (standing in as traffic engineer)	Jason Deckman - Transportation Sr Planning
Primary contact email	eric.lykins@txdot.gov	later	chris.pruitt@txdot.gov	philip.bryce.civ@army.mil	jdeckman@templetx.gov
Please enter any other individuals assisting completion and their contact if applicable	Blake Stembridge (blake.stembridge@txdot.gov)	Dwayne, Billy	none	Luis Colon	Kenny Henderson - Transportation Director overseeing street, drainage, traffic signals
How many signals does your agency currently manage?	65 signals in the Brownwood district with a few overlapping in KTMPO (Eric to send KH a map of signal locations)	100	150 total. can provide list	67	71
Are your signals integrated into an ATMS? If so, which one?	Coordinated Signals in Lampasas on US 183 Corridor Coordinated Signals in Brownwood	Tactics, SEPAC (Siemens)	Centracs	Not at this time. Siemens controller software	Trafficom - Naztec since 2003 all Naztec Building TMC

What kinds of communication are currently used in your agency's signal system? How many signals have a means of communication? Please identify a percentage with each type of communication used.	Cell modems coming online as part of the statewide initiative	Wireless Radio, 80% online. cell modems for school flashers	100% cell modem	no comm currently	50% Radio, 50% cellular. includes school zones. 2012 all online
What kinds of detection are currently used in your agency's signal system? Please identify a percentage with each type of detection used.	All video detection	some old loops (not many), 90% video (VIVIDS) also used for CCTV), one radar/video	75% video, 25% radar, some others	56 camera, 10 loop	95% video, some loops and radar. everywhere there is coordination, run gridsmart or iteris
What other types of ITS devices do you have installed at signals (ex: BBS, CCTVs, other sensors, etc.)?	One signal in Goldthwaite with pods/pucks (Trafficware). Otherwise, no - just detection.	6 PTZ CCTVs, 6-10 BBS (required on new installs)	not many CCTVs, roughly 50-60% have BBS		yes. forthcoming

Please list any overarching goals or objectives your agency has related to signals and signal systems.	In the process trying to identify locations for battery back-ups (at primary intersections). Otherwise, trying to keep the signals up in running. Looking to get connection to signals in more remote locations (big divide intersection) in order to service and respond to issues quicker.	1) Upgrading spanwire to mast arm, replacing old cabinets 2) new conduit for ped enhancements, new cameras, etc 3) Video detection to all ints 4) comms to all intersections 5) coordinated timings along corridors	Improved illumination at signals, FYAs (especially at box diamonds), infrastructure improvements etc.	Increase funding. currently only get $1M per year. frequently have knockdowns or damage from vehicles. Can't keep up unless it is a big emergency Like to target an ITS system and connect the signals. Upgrading systems	worked hard to have 100% communication. Worked to have a couple of trained employees to time signals. Send them to training at TrafficCom. Standardizing equipment and detection (5 new gridsmart per year). Update coordination on two corridors per year. Good funding.
Do you use any performance measures to support/track your goals and objectives? If so, please summarize the performance measures used and which goal or objective it supports.	Not at the moment. Currently have a service now system that contains a database of the signal equipment and locations. TxDOT is working on gathering that information.	working to stay up to date with newest equipment (controllers) with controller upgrade program, SPMs on a few intersections, just a start, on WS Young	Program level: Asset Uptime primarily	none	not formalized really. target 2 coordination updates per year.

What are the agency's top issues/needs when it comes to signals and signal-related services?	Man power response time (2 techs and 65 signals); response time is tough since signals are sometimes a 1.5+ hour drive.	all the aforementioned and also ADA DOJ transition plan, lots of upgrades coming	Up to date agreements with City partners (must be updated any time there is a new or swapped signal).	Increase funding	A few key locations that struggle with congestion, particularly at Dodgen & IH 35; W Adams; 3rd

Coordination with TxDOT over safety issues, speed limits, signal warrants. |
Are up to date as-built records for traffic signal elements kept in an accessible form?	There should be schematics and layouts in every cabinet. TxDOT has an online system (TxDOTNow) for plans (sometimes challenging remembering what set of plans and where to find them).	Schematic in cabinet. New projects provide as-builts	TxDOT digital database, skematic in cabinets	only for recent ones. do have overall utility plan that is useful	
What is your preventative maintenance schedule?	During the summer months, clean the cabinets and replace outdated/old equipment.	Cabinet checks and PM every 3 months (often every month with quick checks)	Signal supervisor makes schedule, PM at least once a year	Monthly cabinet checks	Monthly "C" maint cabinet check, clean cameras. "B" maint each year. "A" maint. every 2 years
Do you have a standard preventative maintenance checklist? If so, what does it include or exclude? Please share a copy with our team if you can.	Eric to check and see	Yes, have a checklist for the PM checks. hit about 4 or 5 each day.	Definitely have checklist. will share	Keep cabinet logs and internal log	yes, will share

Who performs the signal infrastructure maintenance? In-house or contracted out?	Will call contract (with American Signal currently). Can use them or do in-house. All preventative maintenance done in house.	in-house	Maintenance - 2 or 3 district on-calls for primarily knockdowns, resetting foundations	2 In house signal technicians and general techs who can help when needed	in-house
Do you track signal equipment inventory and other field assets? If so, how?	Tracked in the TxDOT online system and will have information on hardware and configuration items.	CityWorks for WO tracking. Use ATMS (Tactics) as signal inventory for controllers.	ServiceNow. Use Centracs for more Signal asset	Excel list	Yes. CityWorks. helps with PM schedule
How old is most of your signal infrastructure?	10 - 15 Years	5 - 10 Years	10 - 15 Years	> 15 Years	5 - 10 Years
How would you rate the condition of your agency's current signal infrastructure? **(1 = Poor and 10 = Excellent)**	8	5	7	6	9
How do you approach adoption of latest signal technology? Which new technologies do you prioritize?	Wanting to get the remote signal locations online to help do more things remotely	Working to bring oldest technology up to speed. Upgrading critical path/limiting factor issues/infrastructure/equipment Look to bring in the really new stuff with new installations or full upgrades	Prefer to really understand the newest technology. Maintenance is a higher priority than adopting new technology.	trying to catch up	Care more about equipment standardization, but do adopt new technology

How is traffic signal staff organized? (Please include number of managers, technicians, etc. and roles/responsibilities)	1 Director of Operations 1 Traffic Engineer 2 Signal Techs Each county has a contact person that has access to the cabinets and can do some basic work through calls with the Brownwood staff.	Engineer - Andrew Traffic Engineer - hoping to hire one! Transportation Superintendent - Billy Signal Supervisor - Dwayne Technicians - 3	Traffic Engineer Signal Supervisor 2 SR techs per area (Bell, McLendon) 6 other techs	2 techs, 1 super, some general techs	1 - Signal Manager 1 - Signal Supervisor 1 - Sr Tech/ITS/Coordination 3 - Techs
Do you feel that your agency has enough signal technicians on staff?	Not at the moment. Able to keep up with 2 techs, but could use more.	Traffic Engineer is a key need/desire Signal techs stay very busy, but are meeting PM goals, etc Traffic counts, utility locates, other bucket truck work for PW overburdens tech staff	Could always use another one or two. Don't have the FTEs allocated currently	yes, but that is recent	yes, but hoping to add another tech soon as signals grow
How are complaints and service requests handled? Does your agency have a tracking system for these?	ServiceNow	SeeClickFix integration is coming soon. will integrate that to CityWorks	Plan to move to ServiceNow. Currently through email, phone, etc	ICE Comment complaint system. Most are related to timing, could be due to construction	CityWorks

39

Does your agency currently have any training programs for new or existing staff members? If so, what kind of training?	Some formal training. Over the last 2 years though, it's been non-existent. Have seen some effort to get internal TxDOT training rolling again. Also doing trainings with ITERIS.	Previously had IMSA, but financially tough to continue especially with COVID. Could use MMU training.	Vendors come in for training (Centracs, controllers, detection)	Newer more experienced techs helping train the general guys. Has had Iteris come give training in past pre-COVID.	Send to TrafficCon training with Naztec. Some in house
How often does your agency review or update signal timings?	Irregular frequency	dependent on funding, projects/upgrades, corridor need/complaints	Irregular frequency	Irregular frequency	2 corridors per year
Are signal timings currently modified for special events? If so, what kind of events and how frequently do they occur?	No	none	Adjust ad hoc for construction. not so much events now.	No	Christmas Parade; Blooming Temple
Do you have a process or program for implementing FYAs?	Currently all but one signal has FYAs	None now, but considering a bigger focus on it.	Cat 8 work code they use to finish converting all of them in the distrct. (about 10 left in the district) and coordinating with the Cities	No	Ad hoc as projects come along and on any new installations. Limited by cabinet outputs.
What kind of signal infrastructure or treatments do you implement for pedestrian safety?	No formal program. Through TRF, there is a HSIP program. Starting to look at updating signal equipment per those standards.	ADA compliance	through Cat 8 improvements. handled through HSIP	No programs currently	starting to add PHBs

Does your agency currently coordinate any signal timings across jurisdictional boundaries? Examples: Operating all signals on one system; coordinating patterns across boundaries by synchronizing ...	No. No cities over 50,00 people. Across TxDOT districts, contact info is mainly used.	Want to coordinate with Ft Hood around gates, especially the main gate. Coordinate some with TxDOT but could create improved traffic signal coordination across the boundary.	Not aware of any issues currently.	In the past have coordinated with TxDOT when having large functions to adjust signal operations.	no
Which design specifications does your agency refer to for signal design?	TxDOT;	refer to txdot for some standard details;	TxDOT;	Specs can be mixed but typically follow TxDOT with a mix of Corps details;	primarily txdot, but have own special specs for unique products;
Does your agency experience any issues, challenges, or positives related to signal design?	No	TxDOT plans are a bit more schematic rather than site plan oriented (don't take grade into account, ADA, etc) so that often requires change orders	Try to add two ground boxes next to controller (especially at diamonds).	Communications needing years of review and inspection from IT due to security concerns and require.	Good TxDOT coordination, but don't always get the type of video detection they want
What type(s) of detection do you prefer?	Video - happy with video detection. Have some issues with buildings/shadows based on time of year, but looking into other solutions.	Video and radar on high speed areas	whatever is easiest ot maintain	video	Video, Gridsmart

Question					
Can you describe your agency's current plan development approval process? Is there anything you'd like to see changed about the current process?	Everything is going well	Other project types don't include signal impacts. Often with developers or other agency projects. Plans need to project further out into the future "future-proofing" TIA requirement hopefully coming	none	Design goes out through Corps of Engineers then contracted out.	most are TxDOT roadways
Does your agency have an existing policy for clearance intervals? If so, what is it?	Eric to check on this	Iteris implements signal timing and keeps that. appear to follow ITE calcs	use ITE guidelines	No	ITE
What standards does your agency use to calculate phase clearance times and pedestrian walk/clearance times?	Eric to check on this	same as above	ITE	MUTCD	ITE, MUTCD
Does your agency have an existing policy for left-turn treatments? If so, what is it? If flashing yellow arrows (FYA) are part of that policy, please describe.	No variation by time of day. Unsure of when it has to be protected only (Eric to check on this).	no formal policy. study it case by case	Left turn cross product to warrant prot movement. Look at crashes.		no

Does your agency have formal or informal signal timing strategies you employ? **Examples: Maximum cycle lengths, left-turn phasing treatments (lead/lag), etc.**	Not to Eric's knowledge, but he will check on this. Look at signal design manual.	Cycles are typically kept in the 100-120s range. leave most of it up to consultant help 4-phase operation at interchanges for safety	Vary max times by TOD. keep them low at diamonds during off peak		none
What are your agency's biggest challenges when it comes to signals and signal systems?	Man power and geography (lack of remote access)	Upgrades of aging infrastructure timing & coordination LOTS of equipment knockdowns Enforceable hands-free ordinance	Keeping the agreements together Making sure to assist Cities with training and support Would like to coordinate with partner agencies more, but COVID has made it tough	Funding, expertise of personnel, building a system,	Capacity issues in certain locations. Staffed well now, but can have gaps due to departures. Safety and pushing to decrease speeds and get signals installed due to safety concerns.
What are your agency's biggest needs when it comes to signals and signal systems?	Online communication for remote access	Budget to do these projects to meet those needs!! A few additional staff would help get over the hump and tackle backlog	upgrading infrastructure: span wire to mast arm, FYAs, BBS, illumination	Funding, expertise of personnel, building a system, lack of technical ability	

Does your agency currently experience reoccurring issues in certain geographical areas or in certain parts of the overall signal system?	Gets lots of feedback on US 183 corridor in Lampasas (mostly related to traffic increase issues). Eric thinks they have maxed out on what they can do in terms of delay reduction, but it has tough for the minor streets experiencing higher delay.	Schleuter from 195 to Bunny Trail (needs timing improvements) (also requested speed limit lower from TxDOT) Ft Hood gates Veterans Memorial CTE is TxDOT, but aiming for improvements at WS Young	Hamilton County - poor cell connectivity	All gates. TJ Mills	West Temple is really growing
Does your agency currently experience any issues near your agency's boundaries?	No	Ft Hood/TxDOT	none that they're aware of	yes. at the gates	no
What do you consider your greatest strength or accomplishment in regards to signal operations & maintenance?	When there are complaints on the signals, Eric and the techs really try to troubleshoot the issue. Always keeping an open mind when it comes to the average traveler. Do a good job at being responsive and resolving issues.	Response time, dedication to truly solving problems and addressing them quickly TMC staff manage the system really well	ability to integrate Centracs ATMS very quickly District wide	Contracting and programming new intersections. Very adaptable and resourceful.	Have really modernized, great maintenance program (no lingering maint issues), rarely need any help to solve an issue, can handle almost everything in-house. Did all of this during a period of massive growth.

| Is there any other information you wish to share? | Backplates will be updated to reflective backplates within the next 12 months (TRF recommendation) | really want to be kept in the loop by KTMPO with grant opportunities or coordination opportunities | School zone flashers now connected via cell. Interested in coordinating with MPO on joint trainings. | | |