Traffic Signal Management Plan

Completed by

Traffic Signal Operations

FY 2014

Agenda

- Who We Are – Traffic Signal Operations Group
- Traffic Signal Operations (TSO) History
- TSO Goal and Objectives
- Traffic Signal Management Plans (MP 1-6)
- Management Plan 1
- Management Plan 3
- Management Plan 4 & 5
- Next Steps

Traffic Signal Operations Group

- Danielle Bolan - Traffic Operations Engineer
- Julie Wotring - Signal Timing Engineer
- Phill Balsley - Traffic Signal Engineer
- Erich Wulfekuhle - Traffic Signal Engineer

History

- FHWA Every Day Counts Initiative – Adaptive Signal Control
- Reorganization of the Traffic Section into Traffic Design and Traffic Operations
- FHWA's Review of Traffic Signal Operations in Montana

History

- 641 Traffic Signals Statewide
  - 464 state maintained
    - 397 state maintained in signal groups
    - 67 isolated state maintained signals
  - 175 city maintained and 2 county maintained
    - 101 city maintained in signal groups (interact with state maintained)
    - 11 isolated; 65 in City of Billings (not necessarily isolated but no interaction with state system)
- Signal Groups
  - 70 Signal Groups
    - 48 are in Cities (Billings, Bozeman, Butte, Helena, Great Falls, Kalispell, Missoula)
    - 22 are in small towns (Whitefish, Columbia Falls, Libby, Polson, Pablo, Ronan, Lolo, Hamilton, Belgrade, Livingston, West Yellowstone, Anaconda, Browning, Havre, Sidney, Glendive, Miles City, Glasgow, Laurel, Lewistown)

Goal & Objectives:

- Goal
  - Provide Safe and Efficient Traffic Signal Operations by Promoting Mobility and Effectively Managing Capacity.

- Objectives
  - Develop and Implement an **on-going** Traffic Signal Management Plan that Links MDT Policies, Design, Operations, Maintenance, Infrastructure, and Resource Needs.

  - Provide Infrastructure with the Capability to Implement Operations and Maintenance Strategies that Maximize the Safety, Efficiency, and Reliability of the Traffic Signal System.

Traffic Signal Management Plan

- (MP1) TSO will align their Management Plan to Map-21, The State of Montana's Tran-Plan 21, and future Map-21's Performance Measures.
- (MP2) TSO will create a Traffic Signal Operations Manual and ensure alignment with the on-going Management Plan.
- (MP3) TSO will prioritize , perform, and implement no fewer than 8 Traffic Signal Analyses and Implementations per calendar year. Current average is 3 per year.
- (MP4) TSO, through a phased approach, will deploy new controllers and an integrated communication system to monitor State supported traffic signals throughout the State of Montana.
- (MP5) TSO will develop a plan and implement appropriate features (Advanced Reporting capabilities, alerts etc.) provided by the new Siemens Software.
- (MP6) TSO will coordinate with Traffic Design to incorporate appropriate design elements to meet operational objectives.

Traffic Signal Management Plan

- (MP1) TSO will align their Management Plan to Map-21, The State of Montana's TranPlan 21, and future Map-21's Performance Measures:
  - Establishes Credibility with the Public
  - Identify Future Funding Sources
  - Gain Support for TSO
  - Alignment and Compliance

- (MP2) TSO will create a Traffic Signal Operations Manual and ensure alignment with the on-going Management Plan:
  - Documentation, alignment, and consistency of Practices and Procedures
  - Provide guidelines to current/future employees and consultants

Traffic Signal Management Plan

- (MP3) TSO will prioritize, perform, and implement no fewer than 8 Traffic Signal Analyses and Implementations per calendar year. Current average is 3 per year:
  - To provide optimal traffic signal timings to meet current traffic conditions
  - Moving towards Industry Guidance and Recommendations

- (MP4) TSO, through a phased approach, will deploy new controllers and an integrated communication system to monitor State supported traffic signals throughout the State of Montana:
  - To phase out DOS-based controllers
  - To provide remote access to signals to monitor and adjust operational parameters, as necessary (signal timings, detection, etc.)
  - Pro-active signal management for Operations and Maintenance
  - Provides data for Performance Measures

Traffic Signal Management Plan

- (MP5) TSO will develop a plan and implement appropriate features (Advanced Reporting capabilities, alerts etc.) provided by the new Siemens Software:
  - Improved response time to fix issues
  - Pro-active signal management for Operations and Maintenance
  - Current system uses an outdated DOS operating system

- (MP6) TSO will coordinate with Traffic Design to incorporate appropriate design elements to meet operational objectives:
  - Alignment and Consistency
  - Pro-active

Management Plan 1

TranPlan21 Alignment – Action # 1

- TranPlan 21 - Overview

  TranPlan21 is Montana's Federally mandated statewide transportation plan. Originally adopted in 1995, TranPlan 21 is an essential component of a continuing statewide planning process that develops and implements MDT policy goals and action in cooperation with the public and Montana's transportation stakeholders.

  See http://www.mdt.mt.gov/pubinvolve/docs/tp21_overview.pdf

Management Plan 1

TranPlan21 Alignment – Action # 1

- TranPlan 21 – Roadway System Performance

  See:

  http://www.mdt.mt.gov/publications/docs/brochures/tranplan21/roadwaysysperf.pdf

  - TranPlan 21 Policy Goal C -Improve the productivity of the roadway system, see page 27.
    - TranPlan 21, Action C.3 – Encourage the MPO areas to include enhanced traffic control and management systems in their long-range plans, see page 28.
    - TranPlan 21, Action C.4 -Strengthen MDT's traffic operations capability to reduce delay and improve travel times through better traffic management, see page 29.
    - TranPlan 21, Action C.5 - Promote efficient system management and operations, and emphasize the preservation of the existing transportation system by implementing strategies that manage travel demand, enhance mobility, and extend the service life of the system, see page 28.

Management Plan 1

TranPlan 21, C.3 TSO Action Steps

Encourage the MPO areas to include enhanced traffic control and management systems in their long-range plans.

- TSO Action C.3.a - Become involved in the Transportation Planning Process and make sure TSO is properly represented to ensure TSO needs are addressed. Provide input and feedback to the Planning Division, MPO, and the Districts.

- TSO Action C.3.b – Provide input and feedback during the development of the Long Range Transportation Plans for the Metropolitan and Urban Areas.

- TSO Action C.3.c -**Provide annual reports to the MPO's and semi-annual (6-months) reports to MDT management on accomplishments, outstanding issues, and plans going forward.**

- TSO Action **C.3.d - Identify and provide a list of TSO needs and needed funding levels.**
  - **Part of the annual report.**

Management Plan 1

TranPlan 21, C.4 TSO Action Steps

Strengthen MDT's traffic operations capability to reduce delay and improve travel times through better traffic management.

- TSO Action C.4.a - Develop and execute the Traffic Signal Management Plan.
- TSO Action C.4.b - Position Number 32011 – Complete reclassification process and post position. This position will perform traffic signal reviews and analyses.
- TSO Action C.4.c - Develop and publish a Traffic Signal Operations Manual.
- TSO Action C.4.d - Implement Central Systems Software for Traffic Signal Operations and Management.
  - Central and/or urban area locations where traffic signal timings and operations are stored.
  - Tool to provide reports on how the traffic signal systems are functioning.
  - Provides a tool for management of traffic signals (traffic, maintenance, etc..).
- TSO Action C.4.e - Upgrade traffic signal controllers and communications to meet current specifications.
  - Replace all DOS-based traffic signal controllers. They are no longer supported.
- TSO Action C.4.f - Identify and provide a list of TSO needs and needed funding levels.
  - Part of the annual report.

Management Plan 1

TranPlan 21, C.5 TSO Action Steps

Promote efficient system management and operations, and emphasize the preservation of the existing transportation system by implementing strategies that manage travel demand, enhance mobility, and extend the service life of the system.

- TSO Action C.5.a - Upgrade traffic signal controllers and communications to meet current specifications.
  - Replace all DOS-based traffic signal controllers. They are no longer supported.
- TSO Action C.5.b - Prioritize, perform, and implement no fewer than eight (8) Traffic Signal Analyses and Implementations per calendar year on traffic signal groups.
- TSO Action C.5.c - Implement Central Systems Software for Traffic Signal Operations and Management.
  - Central location where traffic signal timings and operations are stored.
  - Tool to provide reports on how the traffic signal systems are functioning.
  - Provides a tool for management of traffic signals (traffic, maintenance, etc..)
- TSO Action C.5.d - Identify and provide a list of TSO needs and needed funding levels.
  - Part of the annual report.

Management Plan 1

MAP21 Alignment – Action #2

MAP-21 – Overview

- MAP-21, the Moving Ahead for Progress in the 21st Century Act (P.L. 112-141), was signed into law by President Obama on July 6, 2012, This law provides funding for surface transportation programs at over $105 billion for fiscal years (FY) 2013 and 2014. MAP-21 is the first long-term highway authorization enacted since 2005.

- MAP-21 is a milestone for the U.S. economy and the Nation's surface transportation program. By transforming the policy and programmatic framework for investments to guide the system's growth and development, MAP-21 creates a streamlined, performance-based, and multimodal programs to address the many challenges facing the U.S. transportation system. These challenges include improving safety, **maintaining infrastructure condition, reducing congestion, improving efficiency of the system** and freight movement, protecting the environment, and reducing delays in project delivery.

See http://www.fhwa.dot.gov/map21/

Management Plan 1

MAP21 Alignment – Action #2

- MAP-21 Establishes National Performance Goals for Federal Highway Programs:
  - MAP-21.a - Congestion reduction - To achieve a significant reduction in congestion on the NHS.
  - MAP-21.b - System reliability – To improve the efficiency of the surface transportation system.
  - MAP-21.c - Infrastructure condition – To maintain the highway infrastructure asset system in a state of good repair.

- TSO MAP-21 Action - Establish Traffic Signal Operations Performance Measures that are in alignment with TranPlan21 and MAP-21.

MAP21 Action 21.A

- TSO Action MAP-21.A - Congestion Reduction
  - Develop a Traffic Signal Management Plan.
  - Develop a Traffic Signal Operations Manual.
  - Implement Central Systems Software for Traffic Signal Operations and Management.
    - Central and/or urban area locations where traffic signal timings and operations are stored.
    - Tool to provide reports on how the traffic signal systems are functioning.
    - Provides a tool for management of traffic signals (traffic, maintenance, etc..).
  - Upgrade traffic signal controllers and communications to meet current specifications.
    - Replace all DOS-based traffic signal controllers. They are no longer supported.
  - Identify and provide a list of TSO needs and needed funding levels.
  - Identify funding sources and support to address TSO needs.
  - Prioritize, perform, and implement no fewer than eight (8) Traffic Signal Analyses and implementations per calendar year on traffic signal groups.
    - Position Number 32011 – Complete re-classification process and post this position.

MAP21 Action 21.B

- TSO Action MAP-21.B - System Reliability
  - Develop a Traffic Signal Management Plan.
  - Develop a Traffic Signal Operations Manual.
  - Implement Central Systems Software for Traffic Signal Operations and Management.
    - Central and/or urban area locations where traffic signal timings and operations are stored.
    - Tool to provide reports on how the traffic signal systems are functioning.
    - Provides a tool for management of traffic signals (traffic, maintenance, etc..)
  - Upgrade our traffic signal controllers and communications to meet current specifications.
    - Replace all DOS-based traffic signal controllers. They are no longer supported.
  - Identify and provide a list of needs and needed funding levels for our traffic signal systems/infrastructure.
    - Part of annual report.

MAP21 Action 21.C

- TSO Action MAP-21.C - Infrastructure Condition
  - Implement Central Systems Software for Traffic Signal Operations and Management.
    - Central and/or urban area locations where traffic signal timings and operations are stored.
    - Tool to provide reports on how the traffic signal systems are functioning.
    - Provides a tool for management of traffic signals (traffic, maintenance, etc.).
  - Upgrade our traffic signal controllers and communications to meet current specifications.
    - Replace all DOS-based traffic signal controllers. They are no longer supported.
  - Identify and provide a list of needs and needed funding levels for our traffic signal systems/infrastructure.
    - Part of annual report.
  - Identify funding sources and support to address TSO needs.
    - Part of annual report.
  - Establish a communication Process for TSO
    - Establish what is to be included in annual and semi-annual reports.
    - Establish how we will document TSO's roles and responsibilities.
    - Establish and document the process's for working with other groups throughout the department and with local governmental agencies.

MAP21 Performance Measures Alignment – Action #3

- **Action Items:**
  - Once measures are established for the CMAQ program under MAP-21, participate with Planning in the establishment of targets for MDT, specifically for traffic signal operations.
  - Document and establish TSO performance measures in alignment with TranPlan-21 and MAP-21.

Management Plan 3

TSO will prioritize , perform, and implement no fewer than 8 Traffic Signal Analyses and Implementations per calendar year. Current average is 3 per year.

- Established a ranking system to prioritize the review and retiming of traffic signal groups.
- Develop a signal corridor timing schedule for 2014-2016.
- Goal of 8 Analyses per calendar year dependent on filling Position Number 32011.
- Currently 70 signal groups.
  - Includes approximately 500 of the 641 signals in the state.

Management Plan 3

- Ranking System Criteria
  - Volume (AADT)
  - Change in Traffic Patterns
  - Existing Coordination Status
  - Programmed Projects
  - Discretionary

Management Plan 3

- 6 of the 8 analysis determined by established ranking system.

- 2 of the 8 analysis are discretionary.
  - Traffic & Safety Bureau Chief has the discretion to select up to two signal timing reviews per calendar year.
    - Input from Management.
    - Input from Districts.
    - Decided during annual review held in December of each year by TSO.
- Ranking and Schedule.
  - See Handout
  - For 2014, a decision was reached for this year only that certain past promises and current work in progress will be completed, regardless of current rankings.

Management Plan 3

- 8 Traffic Signal Reviews for 2014
  - Billings - King Avenue
  - Great Falls - 3rd St. NW/Smelter
  - Bozeman - 19th South of Main St.
  - Bozeman - 19th North of Main St.
  - Columbia Falls – US 2
  - Missoula – Brooks Street
  - Great Falls – 14th/15th
  - Great Falls - 25th/26th

Management Plan 4 & 5

- TSO's Direction
  - Controller/Software Benefits
  - System Architecture
    - Server Configuration
    - Communication Configuration
  - M50 Controller/Communication Upgrade Implementation Schedule and Funding Plan

Existing Signals

Past/Existing Hardware, Software, and Communications

- DOS-based controller (Traconex) & software (Traconet) no longer supported by manufacture
  - Parts obtained from other State DOT's
- Non-networked laptops not supported by ISD
- 1 PC (networked for printing) limited support by ISD– risk to the State
  - Data (traffic signal timings) stored in multiple locations/laptops or PC
  - No central hub or servers to manage traffic signals State-wide
- Current communications uses closed loop systems. Industry moving to Central Systems platforms.
  - Dial-up modem to field masters
  - Can only communicate with one master at a time
  - No interaction between two closed loop systems
  - Master to intersection controller communication (1200 baud):
  - Do not communicate with isolated intersections
  - Hardwire (copper) with internal FSK modem
  - 900 MHz licensed band serial radio
- Approximately 380 intersections of the 641 have some type of communication currently (59%)

Controller/Software Benefits

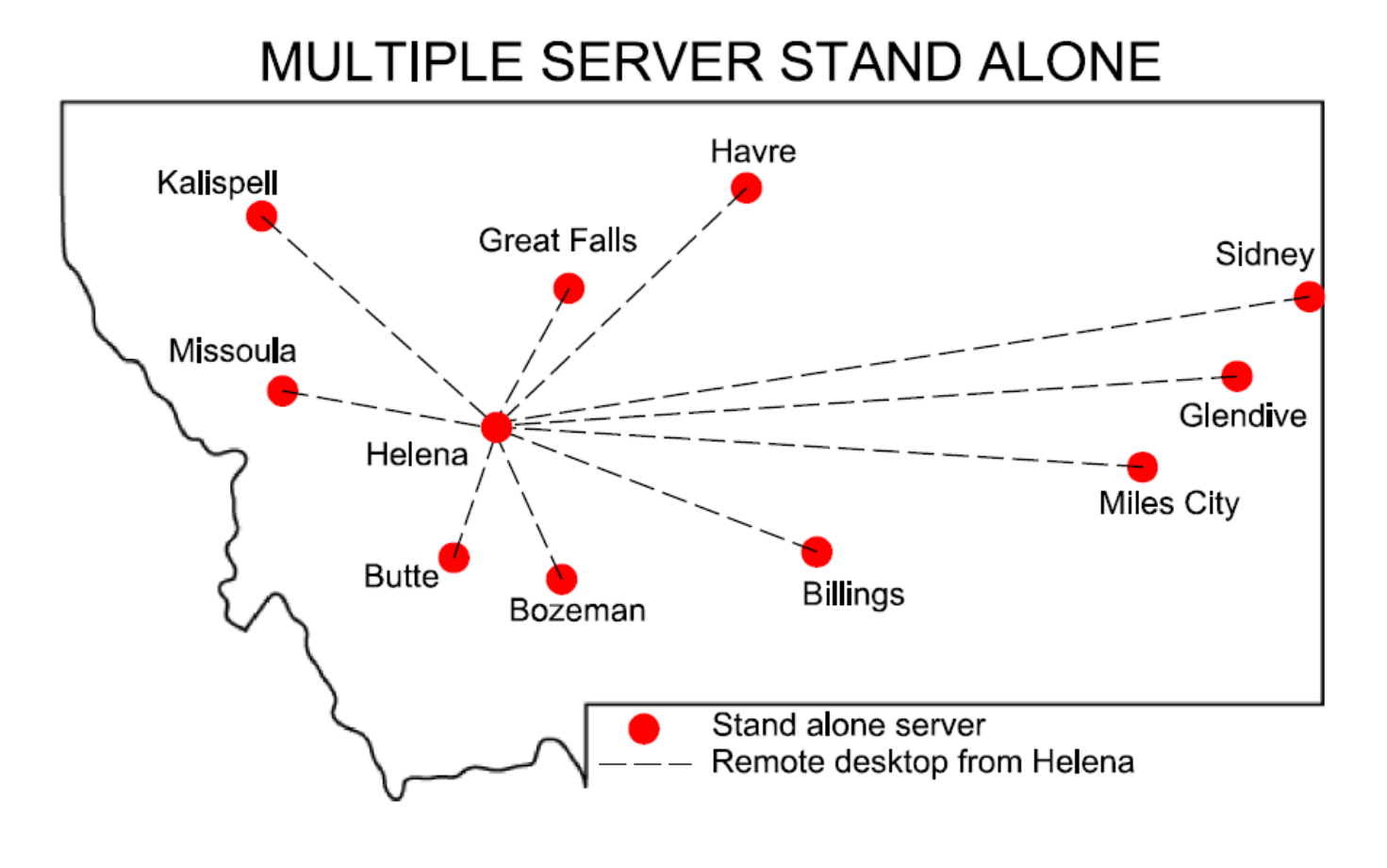
- Upgrade to the Siemens M50 Signal Controllers
  - One Controller Platform once upgrade completed
    - 85% to 90%of statewide intersections
    - 10% to 15% would be within the City of Billings (using a different controller/software)
  - Already Implemented in 22% of STATE/LOCAL intersections
  - By the end of 2015 – plan and funding in place to have 59% of intersections upgraded
  - By the end of 2018 – plan in place to have 82% of intersections upgraded, funding close to 100%
  - Consistency of installation in construction or replacement projects
  - One common controller
    - Training for one system (controller/software)
    - Common knowledge base among signal technician and traffic engineers throughout the state
    - Less equipment to stock for repair or replacement
    - Easier maintenance once new controller/software are learned and understood

- Siemens Tactics Central Software
  - Monitoring of all connected intersections with one software application
    - Software - TSO purchased in 2013 to compliment and align with M50 Signal Controllers
      - Alerts for issues/problems (maintenance)
      - Reports on Performance
      - Server Location for Traffic Signal Timing Data (server database – seven large urban areas)
      - Networked software

System Architecture

- Server Configuration
- Communication Configuration

Server Multiple Stand Alone



Server Multiple Stand Alone

- Pros
  - Access by MDT Helena to each server through existing state network
  - Citrix portal available for non-MDT tech access to the district server
  - Access for each signal tech will be limited to the server with their intersections (Sandboxing)
  - Each connected intersection's data needs only to be transported to the local server
  - If lose network connection in one part of state would not affect other parts of state
- Cons
  - Server back-up and security, redundancy will be required since routine Helena data center functions won't be available
  - A computer will need to be purchased at each district or area server location
    - Secure location but with limited access will need to be determined

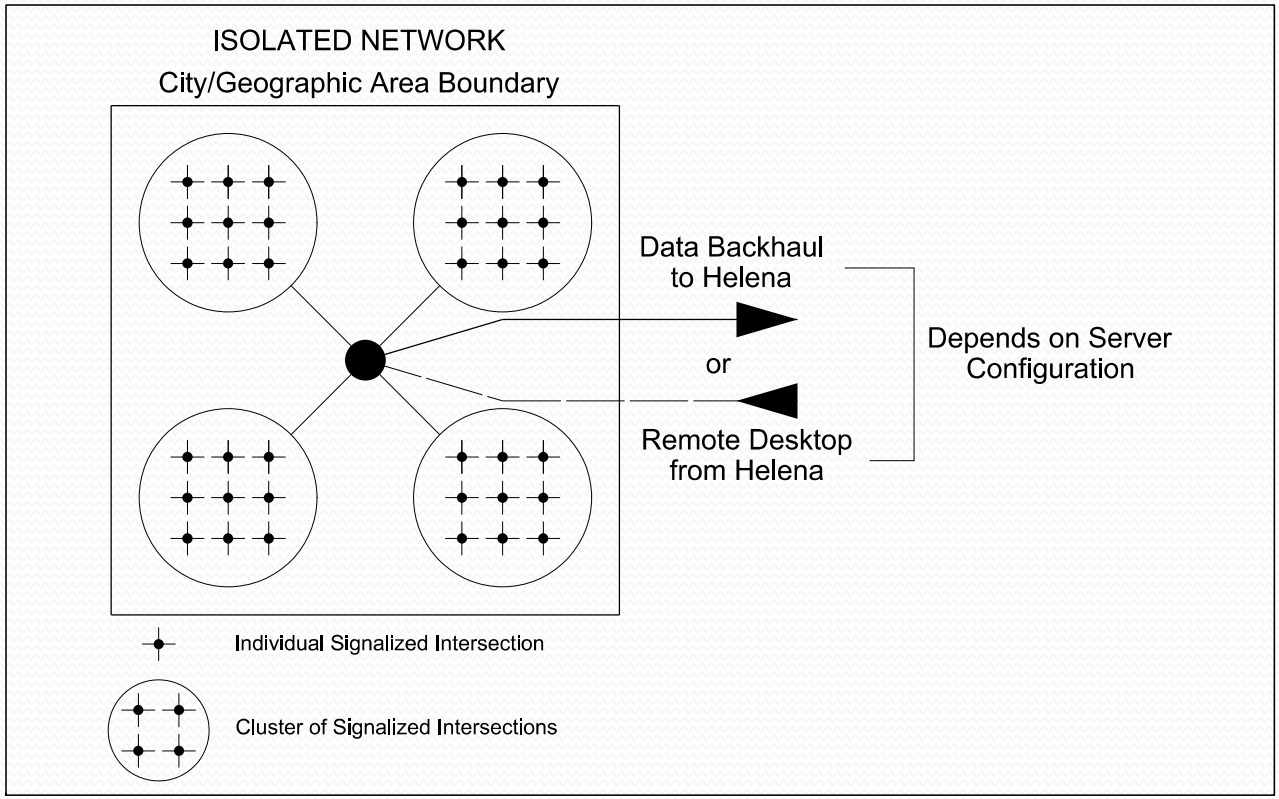
Communication Configuration - Options

- Communication Configuration
  - **Isolated network –Recommended for urban area and some small towns**
  - 1 to 1 network – Option for small towns and isolated locations

Communications

- Communication Median
  - Serial radio – limitations – move towards Broadband radios
  - Broadband radios – provide for more functionality now and in the future
  - Ethernet Access Devices (Ethernet over copper)
  - Cell Modems (isolated locations) – limitations
- Use a combination of the communication medians
  - Large urban areas (7) – Miles City & Glendive (9)
  - Smaller towns
  - Isolated locations

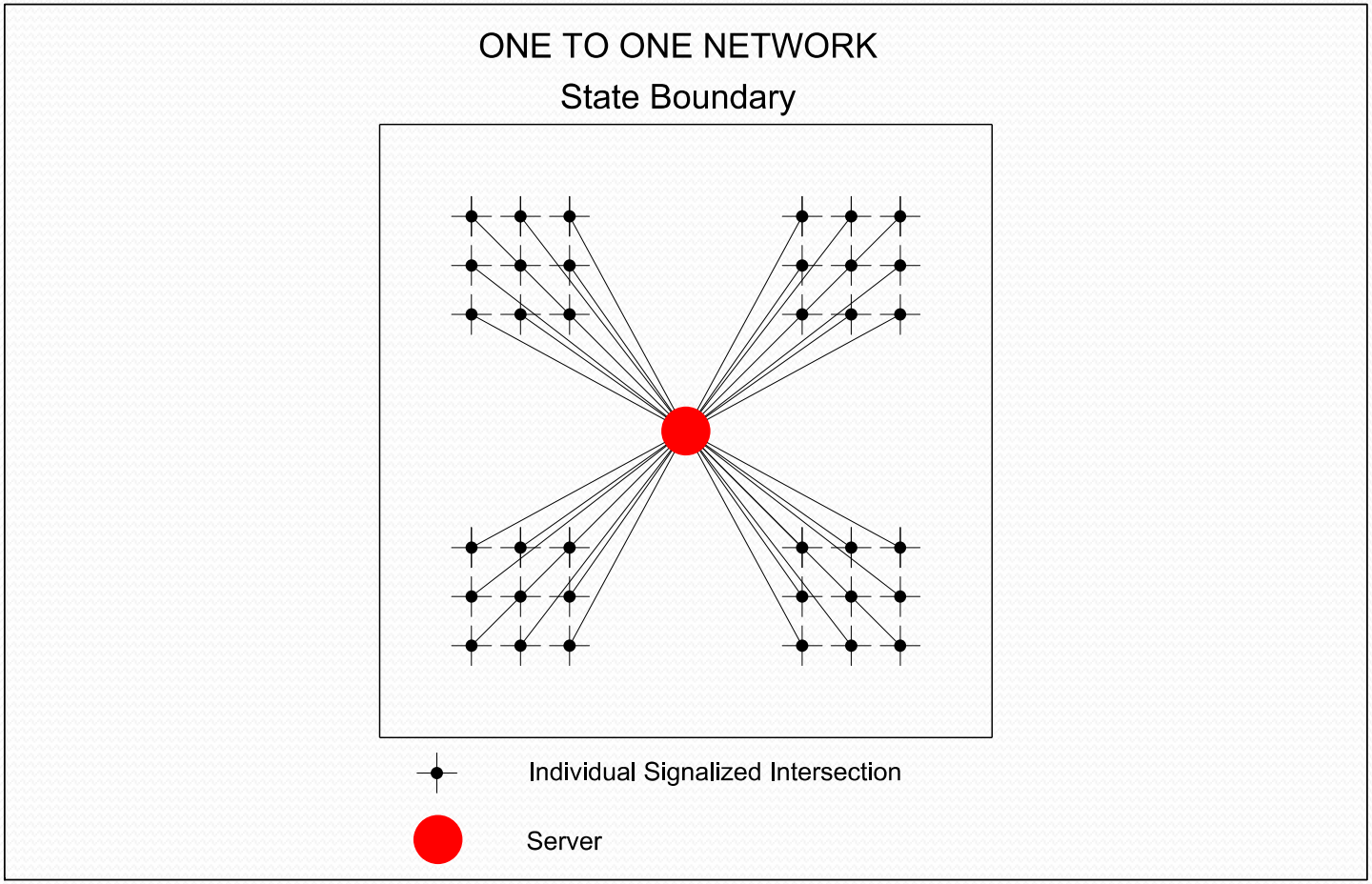
Network - Isolated



Network - Isolated

- Pro's
  - Capitalize on existing comm infrastructure where possible
  - Each system connected back to district server
  - Network can be expanded for future possibilities
  - Capability to connect to other devices in the cabinet
- Con's
  - Less standardized intersection configuration

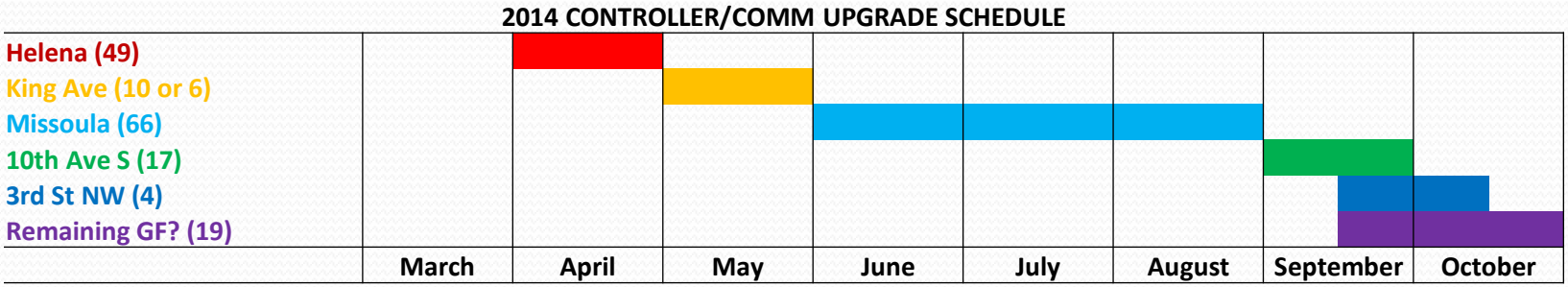
Network – 1 to 1 Network



Network – 1 to 1 Network

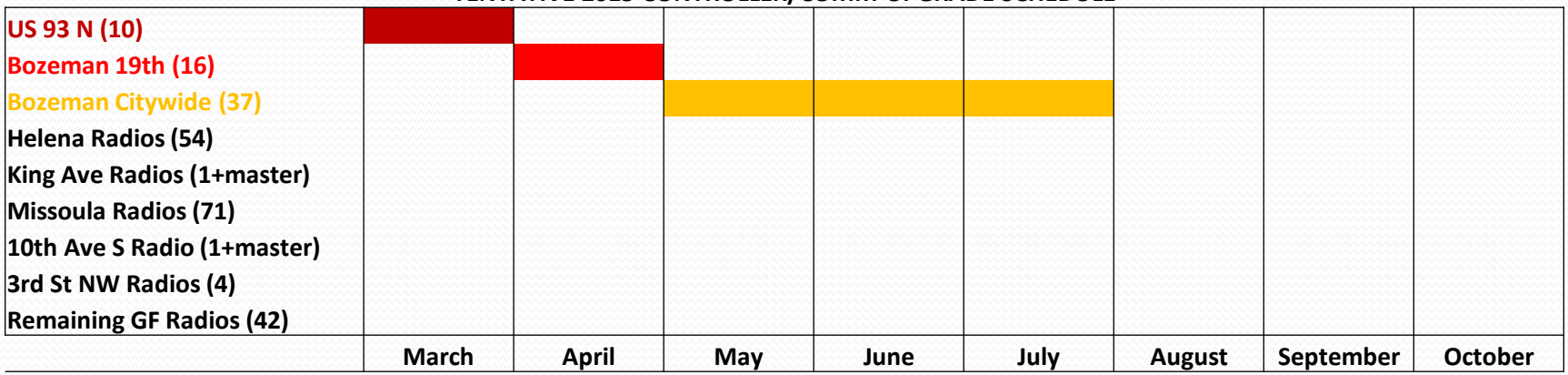
- Pro's
  - Hardware cost would be relatively low
  - Quick to implement
- Con's
  - Would require one cell modem per cabinet
  - Recurring monthly cost ~ $6500/month statewide
  - Can only connect to one device in the cabinet (there may be a solution to this)
  - Limited future expandability

Controller/Communication/Software Upgrade Schedule



Controller/Communication/Software Upgrade Schedule

TENTATIVE 2015 CONTROLLER/COMM UPGRADE SCHEDULE



Controller/Communication Upgrade Schedule

Upgrade Schedule

- 2014 Controllers -Communications to follow when get license to use 4.9 GHz (Reserved for public safety)
  - Broadband Radios
  - Ethernet over copper/1 Broadband Radio back to server
  - Cell modem (where needed)
- Maintenance /Communication Involvement
  - Installing Controllers (Signal Techs – MDT and City Contracted Techs)
  - Acquiring Broadband Licenses for our urban areas (Communications Bureau)
  - Installing the broadband radios on signal mastarms and pulling wire back to the cabinet (Signal Techs – Bucket Trucks)

Controller/Communication Upgrade Schedule and Funding Plan

Spreadsheet

- Upgrade Schedule
- Funding
  - Traffic Signal Timings
  - Hardware Upgrades
    - Controller, communications, servers

Traffic Signal Management Plan

What has been Accomplished

- Helena
  - Server has been activated in Helena
  - Tactics Software has been installed
  - Controllers upgraded at the 49 remaining intersections
  - Total of 54 intersections
  - Using existing Serial radios at intersections with current communications until we upgrade communications

Traffic Signal Management Plan

Next Steps (Immediate)

- Billings (King Avenue Corridor)
- Missoula – City-wide
- Broadband Radio's (7 urban areas)
  - IFB or RFP for communication hardware
  - Path Analysis and Licensing for Broadband Radio's

Traffic Signal Management Plan

Next Steps (Future)

- Align Engineering TSO with Maintenance - Communication Bureau/Districts.
  - Document current practices
  - Document Roles and Responsibilities
    - MDT Signal Technicians
    - City Signal Technicians
    - TSO staff
- Timeframe – Start working on this late summer/early fall

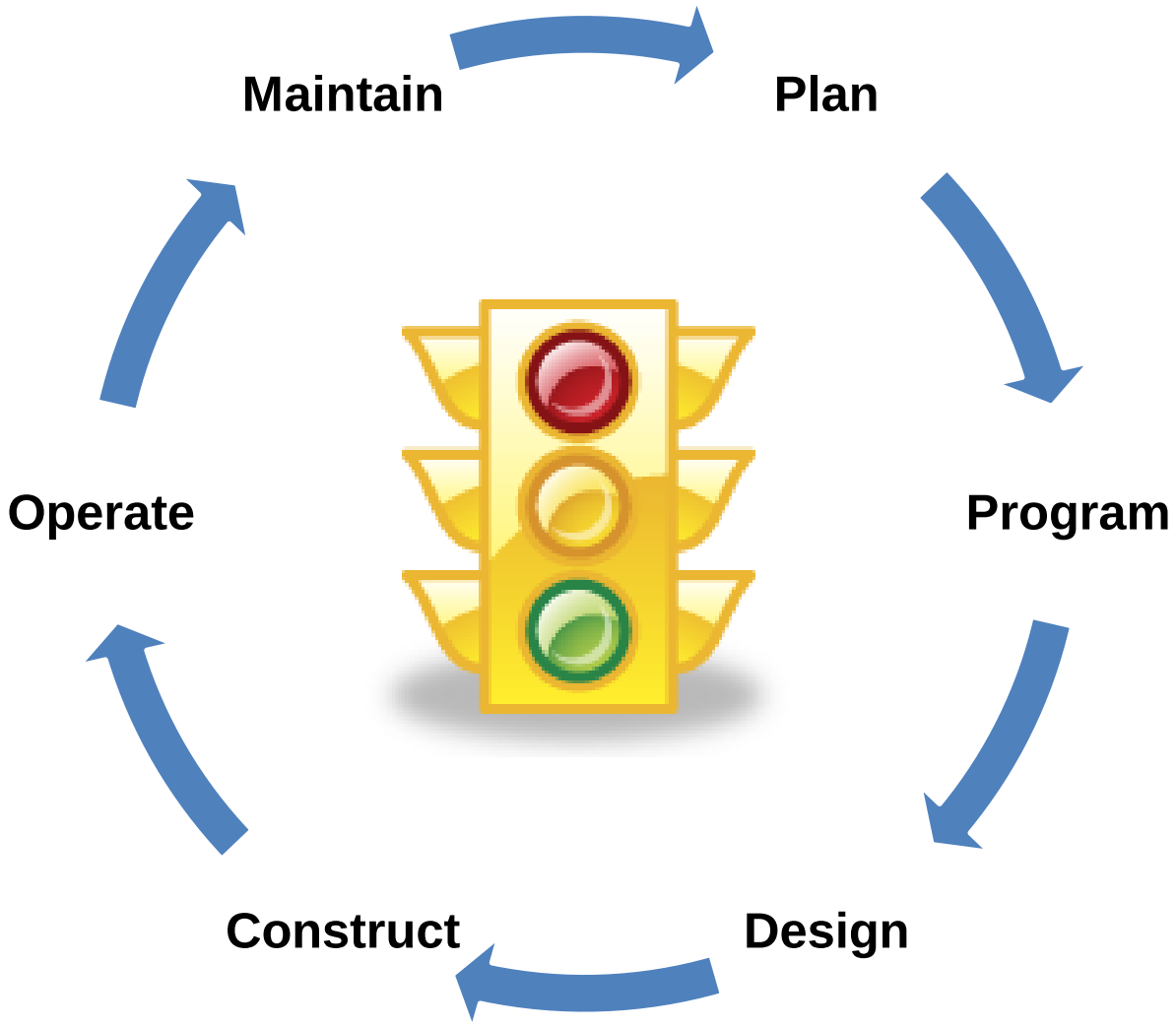
Traffic Signal Management Plan

Questions/Comments

Traffic Signal Management Plan

Annual Report

2014



Goal:

Provide safe and efficient traffic signal operations by promoting mobility and effectively managing capacity.

Objectives:

- Develop and Implement a Traffic Signal Management Plan.
- Provide an infrastructure with the capability to implement operations and maintenance strategies that maximize the safety, efficiency, and reliability of the traffic signal system.

Plan for 2014

- Develop Traffic Signal Management Plan
- Develop Traffic Signal Operations Manual
- Prioritize, perform and implement 8 Traffic Signal Analyses
- Deploy Siemen M-50 controller, central systems software (TATICS), and upgrade communications in a phased approach.
- Coordinate with Traffic Design to incorporate appropriate design elements to meet operational objectives.

Accomplishments for 2014

- Traffic Signal Management Plan
    - Plan was developed and presented to Management, the Districts, City of Missoula, City of Great Falls, and the City of Kalispell.

- Traffic Signal Operations Manual
    - Draft has been completed and is currently out for review. Will be finalized by the end of April.

- Incorporated design elements to meet operational objectives. New traffic signals and upgraded traffic signals will include:
    - detection on all approaches
    - APS push buttons (voice messaging)
    - FYA (flashing yellow arrow)
    - Countdown Pedestrian Indications
    - Retroreflective Backplates
    - P-Cabinets etc…

Accomplishments for 2014

- Completed ranking system and prioritized analysis for signal timing projects – Goal was to Implement 8 new timings in 2014.

King Ave. - Billings Implemented July 2014	Lyndale/Euclid Ave. – Helena Implemented April 2014
3rd St. NW/Smelter Ave. - Great Falls N Implemented Sept. 2014	Custer Ave. – Washington to Montana Ave. – Helena Implemented April 2014
Brooks Street (Dore Lane) - Missoula New traffic signal installed May 2014 Brooks Street timings updated	Columbia Falls – US 2 Implemented Nov. 2014

- Controller and Communications Upgrades

Tactics Central System Software Deployed in Helena, Missoula, Billings; Already deployed in Great Falls	Upgraded Missoula Controllers Completed in 2014
Upgraded Helena Controllers Completed in May 2014	Upgraded 10th Ave. South Controllers and Communications Great Falls – Completed in December 2014
Upgraded King Avenue Controllers and Communications Billings – Completed in July 2014	Upgraded 3rd St. NW Controllers – Great Falls Completed in September 2014

Plan for 2015

- Continue Implementing Traffic Signal Management Plan
    - Present plan to City of Helena and to the City of Bozeman
- Finalize Traffic Signal Operations Manual by the end of April
- Deploy TACTICS software in Kalispell and Bozeman
- Implement new timings on 8 corridors
    - 14th/15th – Great Falls
    - 25th/26th – Great Falls
    - 19th Avenue South of Main – Bozeman
    - 19th Avenue North of Main – Bozeman
    - South Billings Boulevard - Billings
    - Prospect/11th Avenue – Helena
    - West Yellowstone – Canyon Street
    - Main Street (East & West) - Bozeman
- Continue to upgrade controllers & communications
    - Finish upgrading remaining controllers in Great Falls
    - Upgrade Controllers – Bozeman Citywide
    - Upgrade Controller and Communications- US 93 N Kalispell
    - Helena, Missoula, Bozeman, and Great Falls
        - Conduct Path Analysis
        - Obtain License for Broadband Radios
        - Upgrade Communications
            - Broadband Radios
            - Ethernet over copper

Risks/Barriers to Completion of 2015 Plan

- Communications Upgrades
    - Conductiing Path Analysis – Optimum timeframe is during the late spring, summer, or early fall while there is foliage on trees. To complete four areas with the given employees available will be a challenge
    - Obtaining License for Broadband Radios – We can not apply for license until path analysis is complete. However, we can complete each urban area separately.
    - Upgrade Communications – Until a license is obtained, the broadband radios can not be upgraded. Actual installation of radios may not occur until 2016 due to timeframes for path analyis, obtaining licenses, and installaiton of equipment.

U.S. Department of Transportation

Federal Highway Administration

Program Review

FHWA Resource Center
FHWA Montana Division
Montana Department of Transportation

Review of Traffic Signal Operations in Montana

May 2012

MONTANA MDT DEPARTMENT OF TRANSPORTATION

Final Report

U.S. Department of Transportation
Federal Highway Administration

Table of Contents

Executive Summary

The Montana Department of Transportation (MDT) in partnership with eight independent local agencies is responsible for the management, operation and maintenance of over 450 traffic signals distributed widely throughout the state. Sound decisions made two decades ago have served the state well: a robust traffic signal control platform, dedicated staff, supportive partner agencies and responsive maintenance has kept the traffic signal program solvent. To realize the same measure of success over the next two decades MDT must plan strategically to meet agency objectives and needs in a much more complex environment.

In recognition of critical decisions that must be made in the coming months MDT has partnered with FHWA-MT and FHWA Resource Center Operations Technical Service Team (RC-OPS-TST), to benchmark the current situation and to develop an action plan to direct the future of the program. The FHWA RC-OPS-TST has conducted 17 traffic signal reviews since 2004 involving the participation of over 100 State, local and regional agencies. The outcome of these reviews have ranged from development of documentation to guide management and operations activities to alignment of regional traffic signal operations with the transportation planning process resulting in sustained funding of traffic signal management and operations. The paragraphs that follow provide key background information, summarize the observations of the review team and provide recommended actions, based on information obtained through surveys and interviews of MDT and local agency staff.

MDT is currently responsible for the management, operation and various levels of maintenance for approximately 450 traffic signals. There are approximately 630 signals in the state including the city owned and maintained signals, many of which MDT takes responsibility for retiming The average value of a signal is conservatively estimated at between $200,000 and $267,000 resulting in a total infrastructure investment of $90,000,000 to $120,000,000. Outside of maintenance contracts executed with local agencies to provide various levels of emergency and routine maintenance, no operations or maintenance budget(s) exist to support proactive activities.

Observations & Recommendations –

Observation	Recommendation
#1 A good foundation exists.	#1 Leverage the dedication of the staff, and lessons learned over the last two decades to advance a program that maintains a focus on field infrastructure reliability while establishing and maintaining the performance expected by customers.
#2 Program and Policy Documentation Lacking.	#2 Develop a stakeholder engaged comprehensive traffic signal management and operations program plan, inclusive of a needs assessment, goals, objectives, activities, and performance measures. Must be developed within the resource limitations and capabilities of the existing staff.
#3 Management Controls for Traffic Signal Management is Unclear	#3 Develop specific written documentation of management controls, practices, accountability and reporting. This documentation should be developed in partnership with the local agency partners.
#4 The majority of the existing traffic control equipment, management software and supporting equipment and systems are functionally obsolete.	#4 Undertake a stakeholder-engaged process to evaluate and document the needs and objectives of MDT and its partner agencies to establish minimum functional requirements for traffic signal control equipment. The requirements should be routinely updated to maintain relevance. Development of an asset management program would help tracking this.

#5 Constrained Workforce Presents Challenges	#5 Develop a staffing plan that would include the cross training of others to back up and support the key personnel. Develop mechanisms where these individuals could be promoted and/or otherwise recognized for their contributions to the department.
#6 Geographic Distribution of the Signals Challenges Operations.	#6 Install upgraded technology with the new controllers and potentially cabinets that would allow more detailed remote diagnostics. Again the need for these features should be taken in context with the location, function and relative priority of the signal. They should also be consistent with documented agency needs and requirements.
#7 Budgeting & Funding Sources and Process Unclear.	#7 This should be a major topic of your financial plan. The funding situation must also be sustainable long term.

The observations and recommendations contained in this report must be carefully evaluated and prioritized. While developing program, documentation should be a high priority and is a key to success, it must be developed within the resource limitations and capabilities of the existing staff. Opportunities to utilize guidance, training, technical assistance and peer-to-peer programs available from FHWA should be capitalized upon to minimize redundant activities.

Opportunities to partner with the universities in Montana should also be considered. They could help with the documentation effort but they could also play a key role in data collection, data archiving, performance measurement, performance monitoring and performance reporting. In other states relationships between transportation system operations and the universities has proven extremely valuable and cost effective. There is also the potential for the Universities to expand the effectiveness of MDT staff.

However it will be important that MDT develop the program within current resource constraints. If there are needs that transcend those constraints they should begin to identify and prioritize program elements as well as a time table to mitigate those constraints. Additional sources of funding should also be identified but these should be

carefully considered such that the result is an increase not a replacement of one source with another. Long term stability should also be a key consideration such that it would support the long range vision in a reliable manner.

While the state of traffic signal management and operations in Montana has ample opportunity for improvement, it should be viewed within the context of the state of the practice nationally which rated a D+ score on the 2012 National Traffic Signal Report Card. The score for MDT is consistent with the overall national results at a D- score.

Introduction

The Montana Department of Transportation (MDT) initiated a review of its traffic signal management, operations and maintenance program in partnership with the FHWA MT Division and FHWA Resource Center Operations Technical Service Team (RC-OPS-TST). The motivation for conducting a review developed after MDT participated in an FHWA Every Day Counts Adaptive Signal Control Technology Workshop. During the workshop it became apparent that barriers both technological and institutional could hinder the success of adaptive control deployment in Montana. An outcome of the EDC workshop was placement of a high priority on examining and benchmarking current practices as a starting point for developing a plan of action to improve management and operations practices.

A review team was formed consisting of staff from MDT, FHWA-MT, FHWA-RC-OPS-TST a peer from King County, WA was added to the team to accommodate the need to focus on maintenance. The review team identified several desired outcomes for the review including:

- Benchmark current practices
- A plan to advance traffic signal management, operations and maintenance practices
    - Short-term actions
    - Long-term actions
- Identification of and justification for operations and maintenance resource needs
- Bridge the gap between operations and maintenance
- Transitioning from a reactive to proactive operations and maintenance program

With the outcomes in mind, MDT, assisted by the RC-OPS-TST, developed a survey questionnaire to allow the review team to gain insight on the practices and policies that guide traffic signal operation and maintenance in Montana. Interviews were scheduled between the RC-OPS-TST and maintenance staff within MDT and local agencies responsible for traffic signal maintenance in regions of the state including:

- Billings
- Glendive
- Bozeman

- Butte
- Great Falls
- Missoula
- Kalispell
- Helena

This report documents the information gathered by the review team and summarizes the findings in response to the review objectives. All the information and findings contained in the report have been vetted among the members of the review team and represent a consensus about how these should be presented.

Background

This review is a follow on activity to an Every Day Counts workshop on Adaptive Traffic Signal Control Technology (ASCT) intended to provide MDT staff with a greater understanding of how to apply systems engineering to advanced technology implementation. This workshop was focused on the systems engineering process as it is applied by the FHWA Model Systems Engineering Documents for ASCT. An outcome of the workshop was recognition that significant institutional barriers related to management, operations and maintenance might hinder the success of ASCT implementation should it be implemented without addressing some underlying deficiencies. At that point FHWA offered to return in the future to assist in a systematic review of the traffic signal operations program in Montana.

To gain an understanding of the organizational structure, goals, objectives and policies related to traffic signal management and operations; the review team obtained copies of readily available documents.

MDT Strategic Business Plan
http://www.mdt.mt.gov/publications/docs/brochures/business_plan.pdf

2012-2016 Draft Statewide Transportation Improvement Program (STIP)
http://www.mdt.mt.gov/publications/docs/stip/2012stip_draft.pdf

TranPlan21 Overview http://www.mdt.mt.gov/pubinvolve/docs/tp21_overview.pdf

TranPlan 21, 2007 Amendment – Summary Report
http://www.mdt.mt.gov/pubinvolve/docs/tp21_overview.pdf

Roadway System Performance – Policy Paper – amended in 2007
http://www.mdt.mt.gov/publications/docs/brochures/tranplan21/roadwaysysperf.pdf

Performance Programming Process – A Tool for Making Transportation Investment Decisions. http://www.mdt.mt.gov/publications/docs/brochures/tranplanp3.pdf

2013 Biennium Goals and Objectives
http://www.mdt.mt.gov/mdt/2013goals_objectives.shtml

2010 MDT Infrastructure Needs – 10-year Estimate
http://www.mdt.mt.gov/publications/docs/brochures/needs_study/needs_study2010.pdf

TranPlan 21 Public Involvement Survey 2011
http://www.mdt.mt.gov/publications/docs/surveys/2011_tranplan21_public_involvement.pdf

TranPlan 21 Stakeholder Survey 2011
http://www.mdt.mt.gov/publications/docs/surveys/2011_tranplan21_stakeholder.pdf

See Appendix B for a detailed commentary on these documents.

Purpose and Objective

The purpose of the review is to assess the traffic signal operations program in Montana. The program is primarily the responsibility of the Montana Department of Transportation.

The objective of this review is to provide suggestions, guidance and partnership for improvement of that program.

The review team identified several desired outcomes for the review including:

- Benchmark current practices
- A plan to advance traffic signal management, operations and maintenance practices
    - Short-term actions
    - Long-term actions
- Identification of and justification for operations and maintenance resource needs
- Bridge the gap between operations and maintenance
- Transitioning from a reactive to proactive operations and maintenance program

Scope and Methodology

The methodology for the review began with several teleconferences between FHWA Resource Center, FHWA Division and MDT to discuss the scope and agenda for the review.

The next step in the process was to provide MDT partners with a questionnaire to help them describe their situation and provide information to help evaluate their situation. This questionnaire was developed by the Institute of Transportation Engineers as a Traffic Signal Audit Guide with a couple of minor adjustments to better reflect the MDT situation. The questionnaire as used is in Appendix A.

On site face-to-face interviews were also held in Billings, Helena, and Missoula. The following people attended these interviews:

- John Strub, Billings Signal Technician
- Terry Smith, Billings Traffic Engineer
- Erin Claunch, Billings Staff Engineer
- Jay Harvey, MDT Glendive District Signal Technician
- Steve Keller, MDT Communications Bureau Chief
- David Stillwagon, Butte Signal Technician
- John Van Delinder, Bozeman Street Superintendent
- Steve Robbins, Bozeman Signal Technician
- Bill Moeckel, Bozeman Signal Technician
- Matt Ladenburg, MDT Havre Division Maintenance Chief
- Karl Ryder, Great Falls Signal Technician
- Jerry McKinley, Great Falls Traffic Supervisor
- Dave Dobbs, Great Falls City Engineer
- Roy Peterson, MDT Traffic and Safety Engineer
- Danielle Bolan, MDT Traffic Operations Engineer
- Julie Wotring, MDT Traffic Engineer
- Phill Balsley, MDT Traffic Engineer
- Tim Seelye, MDT Kalispell Division Signal Technician
- Rick Larson, Missoula Communications Supervisor
- Ken Hughes, Missoula Signal Technician

Team Members

Marcee Allen, FHWA Montana Division
Paul R. Olson, FHWA Resource Center Operations Technical Service Team
Eddie Curtis, FHWA Resource Center Operations Technical Service Team
Fred Housman, Retired Traffic Signal Maintenance Manager King County WA

Observations and Recommendations

Observation #1: A Good Foundation Exists

Agency professionals responsible for the management and operation of the traffic signals in Montana are extremely dedicated to keeping the traffic signals operating. Some of them endure long days and inclement weather routinely to keep the traffic signals in Montana working.

In some locations the contracted agencies are going above and beyond their contracted tasks to ensure the traveling public is provided with good service.

Recommendation # 1:

While these folks are working hard to keep the traffic signals working the review team detected frustration with the situation. Several of the local agencies we talked to seemed particularly frustrated with the pace of progress for the replacement of functionally obsolete equipment as well as other operational improvements. The Traconex equipment has and continues to serve the state well, but they recognize that it's beyond its lifecycle and without action in the short-term the remaining number of spares may not serve future needs.

As a minimum developing a clear program of when the systems would be upgraded, particularly if the program is developed with input from those partners would go a long way toward strengthening those critical relationships. Commitments of when this would occur would help enhance the relationships but also provide the push some partners may need to program upgrades to their own signals off of the state systems that must be coordinated.

These partners are generally donating significant amounts of their own time and money which is a plus for MDT. However, that could end at any time particularly if partners' concerns are not promptly managed and this could have a major negative impact to the state. Building and managing these relationships and expectations is a low cost way to multiply the department's limited resources.

Observation #2: Program and Policy Documentation Lacking

In our interviews with traffic signal operations and maintenance people we were unable to find a well-defined program or policy documentation to support an operational policy. Montana Transportation Department does have a Traffic Engineering Manual as well as a Maintenance Manual; neither of which clearly defines operational policy.

We also did not find documentation or links to the state long range planning effort (TranPlan21) that would directly address the operations of the traffic signal infrastructure. Much of the traffic signal system is functionally obsolete so it would seem reasonable to find entries in the long range plan for projects to fund system replacements. In the typical 20 year plan there should be policy goals for one or two major upgrade/replacement projects. The probability of having resource allocations available for this critical asset replacement is much more likely when it is recognized in the long range transportation policy plan.

The infrastructure has a finite life span which due to the rapid advancement of computer and telecommunications technology is getting shorter. The life cycle is commonly quite different for various hardware components of these systems and is different from the software components. Today's traffic signal management systems rely on common office grade desk top computers and software operating systems which typically have a 3 to 5 year lifecycle. The telecommunications equipment also has a short lifecycle of between 3 to 5 years. The traffic signal controllers themselves, particularly the NEMA variety, are currently running a 10-year life span but this depends heavily on the vendor and their policies. Therefore, there should be policies in place to provide funding to anticipate this evolution.

While more modern traffic signal controllers have been selected and purchased, there is no written program to prioritize deployment. There is also no salient discussion or program to update the existing communications technology to take full advantage of the functionality of the new traffic signal controllers. The program appears to rely upon replacement of the obsolete Traconex equipment as a part of the normal cycle of roadway improvement projects. In our opinion this is a risky proposition that may take a considerable amount of time.

The team detected high levels of frustration from several of the partner local agencies that wish to move forward, having made considerable investments to upgrade their systems. However only one (Great Falls) has actually made considerable investments to upgrade their system and offered MDT a low cost licensing option for their advanced central system software. As a result in Great Falls the old MDT signals are inhibiting their ability to coordinate signals in the entire area.

We found no clear documentation detailing preventative maintenance programs or one for monitoring, reviewing and readjusting the signal timing settings on any cyclical basis. The people we interviewed indicated that much of the preventative maintenance was ad hoc. In some cases people did indicate that they were testing conflict monitors yearly but this too did not appear to be universal or documented.

The program plan for traffic signal operations should be directly linked to and address the implementation of the action items presented in TranPlan 21. In particular the action items presented in ***Policy Goal C. Improve the productivity of the roadway system*** can be leveraged to support operations and maintenance of signal systems

Recommendation # 2:

The traffic signal program in Montana needs a plan that provides clear guidance to everyone involved both within MDT, with MDT partner agencies and the public and stakeholders. The plan should cover a wide variety of topics to include:

- Overall program vision
- Implement the Policy Goals and Actions presented in TranPlan 21
- Program accountability and responsibilities
- Program organization and staffing
- Staffing knowledge skills and abilities, including development & training
- Overall system performance expectations
- Performance and Program Reporting
- Financial Plan
- Plan of action and time table for completion and implementation of the resulting program

Overall Program Vision
This would be the overall guide to traffic signal operations in Montana. The foundation for this vision could be the FHWA publication "Improving Traffic Signal Management and Operations: A Basic Service Model"[1]. The vision should also clearly state agency operational objectives.

Implement the Policy Goals and Actions presented in TranPlan 21
MDT traffic signal operations and the operations of ITS elements such as weather stations and dynamic message signs appear to be captured in the statewide planning

[1] http://www.ops.fhwa.dot.gov/publications/fhwahop09055/index.htm

process. However, the tenets of the TranPlan21 plan do not appear to have been put into practice.

Program Accountability and Responsibilities
The plan should clearly define the individual roles and responsibilities for everyone that has contact with the traffic signals in Montana. It should also clearly define the qualifications and credentials for those approved to access the traffic signal control systems and traffic signal controller field equipment.

Program organization and staffing
Included here should be the organization structure and within that identify particular functions performed by staff and partners. It should identify the arrangements for staff provided by local agencies and contractors. It should help answer the question "if XX happens who is responsible" then identify the mechanism to ensure a known, well-planned response is mounted according to written agency policies.

The plan should also indicate the depth of each position or how many other people within the organization can take over and fill that position if needed.

Staffing, knowledge, skills, and abilities including development & training.
The plan should include details of the expected knowledge and skill set for each position. It should also include the expected training that each position would have to undergo and when it would happen during an individual's tenure in that position. The training and qualifications of individuals authorized to access to the signal systems software and the traffic signal controller hardware should also be detailed.

Overall system performance expectations
System performance expectations could be based upon the following statements:

- If we have to stop vehicles we don't want to stop them long.
  We should seek to reduce the number of times a vehicle has to stop and the stops should be short.
- When vehicles do have to stop it should be clear to the operator why they are being stopped.
  While the vehicle is stopped the operator should see other vehicles or pedestrians moving through the intersection.

The performance objectives should also be closely linked to clearly stated operational objectives.

The single most limited resource at an intersection is time. MDT should seek to maximize and monitor the use of this resource. Measurement and tracking of the

utilization of green time (e.g. are vehicles flowing at the maximum rate for the duration of the green time) should replace the complaint call as the primary performance metric. Newer traffic signal systems can provide highly detailed and highly automated reports of system performance[2]. These reports can be quickly reviewed and will provide sufficient information to fine tune signal operations without having to perform costly traffic counting and analysis.

Performance metrics should also be developed. Parameters such as the mean time to complete repairs, mean time for notification of failures, and number of repeat occurrences are examples.

Performance and Program Reporting
MDT should regularly provide management and the public with reports of how the traffic signal systems are operating and how well they are maintained. This could be in the form of quarterly or yearly reports.

The reporting could also be instantaneous via the internet. Many agencies are broadcasting real time arterial traffic conditions graphically on maps along with the conditions of the freeways and Interstates. This information is also being presented by commercial services such as Google Maps. This could be totally focused on several of the key routes in the major Montana cities, an example could be Reserve Street

Many of the more recent traffic signal systems are capable of automatically generating information needed to populate interactive arterial traffic condition maps. Agencies around the country are using these internet based maps to gain additional public support for traffic management efforts. They could also be a subset of the existing Montana Road Conditions web presence.

Financial Plan
A well constructed financial plan is critical to the survival of traffic signal operations in Montana. Funding for operations and maintenance should be clearly stated for everyone to see. It should also be mapped to overall system performance much like how MDT's performance programming process shows the influence of funding allocations on pavement performance.

This plan should span the long range planning horizon so MDT is prepared to fund replacement of systems before they are functionally obsolete, begin to fail and are no longer supported by their manufacturers.

---

2 http://rebar.ecn.purdue.edu/ltap1/multipleupload/Signals/Signal%20System%20Performance%20Measure%20Report.pdf and http://docs.lib.purdue.edu/jtrp/1490/

We also asked the interviewees if there was any form of accounting of the cost of the current investment in these systems. The best we could do was a crude estimate of replacement costs at $200,000 per intersection for total replacement. So given the 450 existing traffic signals at $200,000-$267,000 each, MDT has an asset worth between $90,000,000 to $120,000,000.

The financial plan should include discussion of funding for day to day operations plus the regular replacement of obsolete equipment. This plan should be based upon the well recognized asset management programs MDT has developed for other parts of the highway infrastructure.

Plan of Acton
The final plan should be a plan of how all this would be accomplished. It would include accountability for actions including specific achievable deadlines for completion of the actions identified.

Observation #3: Management Controls for Traffic Signal Maintenance is Unclear

It is unclear which section or which individuals are responsible for actually delivering the operations and maintenance of the traffic signals in the state. It is, however, clear that actions were being undertaken to keep the systems operational but to what level is unclear. The individuals we interviewed seemed to know these relationships but could not point to documented lines of authority and accountability. We were told that these relationships are changing due to several organizational changes.

It also wasn't clear who had authority over access to traffic signal controller cabinets and traffic signal control systems. Nor was it clear what qualifications and credentials are required of persons working with this equipment.

For the most part we were told that the traffic signal maintenance technicians did have IMSA certification. While this information may exist we couldn't find anyone who could produce a hard copy of the policies.

We feel that it is important that only people with tested and recognized skills, and qualifications be allowed to access these systems. Without this there is the potential for damage to expensive electronic systems and equipment and greater potential for personal injury.

We also found that there appears to be few controls for or accounting of the maintenance spare parts. One district reported having an over-abundance of some components but not others. This is a result of purchasing controller cabinets that have

every component slot filled with a device whether it is needed or not. This is a legacy practice where construction funds are plentiful and maintenance funds are not.

MDT has contracted much of its signal maintenance to the local agencies. In the past the contracts have called for emergency and preventative maintenance. In some jurisdictions the preventative maintenance work has been removed from the agreement. In these locations it isn't clear if the preventative maintenance work is being done. The agencies seemed to think that preventative maintenance was not taking place. The maintenance technicians indicated that they record visits to the traffic signal controller in log books in the controller cabinet as well as their own diary, though no other records appear to be kept. This information doesn't appear to be forwarded to a central depository for analysis.

Several of the local partner agencies stated that the means and methods for funding various items needed to keep the signal systems operating at the most minimal levels was not clear. They were perplexed that no one seemed to know if there are any set budgets for maintenance repair materials or documented process for obtaining the funds.

We also understand that each state highway district has a traffic engineer on staff. Yet we were lead to believe that they do not participate in traffic signal operations in their districts. It isn't clear to us why this is so but it may be based partly upon inconsistencies between each district and legacy management decisions. In our opinion this is a missed opportunity for additional local support.

MDT, as is typical nationwide, relies on complaints to drive the program. This is often not a very good indicator of system performance. We as an industry have, through our practices, desensitized the public to the point that poor traffic signal performance is the expected norm. Then when a complaint is received it can be difficult to verify the veracity of the complaint and in many cases an expensive field trip is required which could very well result in wasted time, money and energy as things "look normal". In the end MDT has little to justify the expenditure.

We also heard stories from several individuals of traffic signals that had been "on flash" for several weeks before signal maintenance was alerted. There could be several possible explanations for this:

- The signal really isn't needed. In this case remove it and reallocate its operations funds elsewhere.

- The public doesn't know who to call. Make the process of submitting a complaint easier and more transparent.

We also collected and reviewed the maintenance agreements with the local agencies. We found them inconsistent and lacking of any standards of performance. Most of the agreements attempted to provide details of the work covered but again weren't complete and were inconsistent, other than the standard "Time of Essence" clause. For example, there is no clear definition of response times to complete emergency repairs, much less the maximum time allowed before a failure requiring emergency response is identified. Some things need to be repaired immediately, e.g. within minutes of being reported, while other things could wait. Events that could wait effectively are in violation of the "Time of Essence" clause of the agreement.

Agreements that covered preventative maintenance did not clearly identify tasks or schedules for their completion. Neither did they present defined reporting and record keeping procedures.

The agreements lack specific focus on the training and qualifications of the maintenance personnel that are allowed to work on MDT owned traffic signals. Nor do the agreements require strict control over who is allowed into the controller cabinet and systems.

They quite simply state if it breaks they fix it and send MDT a bill. There is very little accountability in this process.

Recommendation # 3:

Develop specific written documentation of management controls, practices, accountability and reporting. This documentation should be developed in partnership with the local agency partners.

Engage the local district traffic engineers in the operations and maintenance of traffic signals within their districts. They could become a force multiplier for the limited Headquarters staff. The roles and responsibility of each district engineer need to be documented to clearly define it as it relates to operations. These engineers should be provided with appropriate training and supervision to assist in the management of the traffic signal systems.

Implement a performance measurement, management and reporting program. Consider a key element of the program to track the effective usage of green time at each intersection.

The maintenance and repair agreements with the local agencies should be revisited and made more uniform to include better accountability for the work actually being done.

Observation #4: Technology is Functionally Obsolete

While the traffic signals in Montana operate as designed the traffic signal control equipment, Traconex Model 390 controllers, have been out of production for many years. The last software update occurred more than 15 years ago. The manufacturer has also been out of business for many years.

The management software also relies on the Microsoft DOS operating system. This operating system has also been discontinued and will not operate on current PC hardware. In effect MDT must maintain a computer museum to keep the signal systems operating.

MDT has had an unbelievable run of fortune with this equipment. The only other traffic signal controller platform with a similar life has been the NYSDOT/Caltrans Model 170. As long as the vendor supports the platform it would still be viable however new replacement equipment may not be able to coexist in arterial systems with older equipment. Support for the superseded platform is then dropped within a year or two. Often there is limited inter platform compatibility. Given the rapid pace of technology evolution we doubt that such a run will occur again.

Key to this discussion is that MDT needs to develop a clear set of operational objectives that would lead to the development of needs and requirements that can be used to evaluate both current and future traffic signal system functionality. These needs and requirements can be documented using a Systems Engineering process and should be revisited on some regular frequency.

MDT has sought and contracted for newer traffic signal controllers, the Siemens/Eagle M50 model. MDT needs to ensure that these controllers meet the documented needs and requirements and that they have significant life left at the time of installation. However, MDT should determine what the potential end of lifecycle for this equipment is and begin planning for that eventuality in the near future.

MDT began replacements of the Traconex Controllers in May 2010. Since then 70 city and state controllers have been replaced as part of construction projects to rebuild the entire intersection or with other related projects. However, we must also recognize that controller replacement has been tied to construction projects due to funding constraints. At this rate, assuming that the construction projects continue on this same pace (35 signals a year based upon experience so far), it will take at least 13 years to complete the replacements of the remaining 380 controllers. We are not confident that the existing equipment will last that long. We are also concerned that with this pace the new equipment will be at or near the end of its lifecycle when all the replacements have been completed.

The current systems architecture is also rapidly being abandoned by the industry. The field master architecture was developed to minimize expensive leased telecommunications connections. In this architecture a local master controller is installed on each corridor and connected to each local intersection controller and serves as a gateway for a dial up telephone link to a central office. The field master is typically connected to the local controllers using agency owned multi-drop (aka Party Line) copper cable plant.

With the advent of inexpensive ubiquitous broadband communications the field master is no longer needed. Broadband communications using Internet Protocol over an Ethernet connection will also allow multiple users to access a single controller or system. This would provide the ability for multiple people in different locations to troubleshoot and monitor system operations simultaneously. For example, it would allow the traffic signal timing staff in Helena to view signal operations in real time with a technician in the field.

Internet Protocol over Ethernet will also allow for a much wider variety of connections such as via a cellular phone data circuit. This has the potential to provide an inexpensive connection to some of the more remote signals in the state which could reduce the need to travel to them.

Our understanding of the current replacement plan is to update the controllers in conjunction with construction projects (i.e. MACI, safety and other reconstruction projects). In the future there is an intention to program projects that will focus on upgrading only the controller. What isn't clear is the time table for completion of the upgrades. How much longer will the Traconex equipment be in the field and where will the replacement technology be in its lifecycle at the completion of the program?

Recommendation # 4:

The replacement of the Traconex traffic signal controllers should be accomplished according to a well-designed migration plan with a clear time table for completion. Currently these controllers appear to be failing one or two at a time, but given their age they could begin to fail in large numbers which could cause considerable disruption to traffic flow and public outcry particularly if it happens on a heavily traveled route. This would become an extreme problem if the replacements are tied to construction projects.

The controller replacement plan should consider assigning each signal a priority based upon the context of its location. For example state signals on major congested routes or those that must operate in coordination with upgraded city signals should be upgraded first. Signals on major congested routes that could benefit from the advanced features of the new controller may be next. The local partner agencies should be given firm dates on when the replacements would occur.

In general the time table for the replacements should be well before the current controllers fail and before the "new" controllers become functionally obsolete. The timetable should also recognize the reality of overall agency funding constraints. However, there is some urgency to completing this task so the timetable will have to be relatively short.

We recommend that the current rate of controller replacements be accelerated. To accomplish this replacement of the controllers will have to be decoupled from construction projects. A separate program should be dedicated to this task. This will also require additional staff time to prepare updated signal operational parameters for installation in the new controllers.

Observation #5: Constrained Workforce presents challenges

The staff assigned to operating and maintaining the traffic signal systems in Montana is at best minimal. In many cases, such as for traffic signal timing, there is only one person and there is no back up or understudy for this individual. The team believes the state is vulnerable to a single point failure if these individuals are incapacitated or no longer employed in those positions. The people in these positions require an extensive set of highly technical skills and are not easily or quickly replaced. This also more or less pigeon-holes that individual and effectively eliminates them from all promotional opportunities within the organization.

At least one of the traffic signal maintenance technicians has been promoted to a maintenance supervisor and supervises the work of an entire district. In this case traffic signals take a minor role. This individual told us that these tasks needed to be transferred to someone else that is more qualified.

In many cases the assessment of traffic signal operations currently requires that the engineers and technicians travel to the field site. Given the large geographic area of the state this reduces their productivity.

Recommendation # 5:

Develop a staffing plan that would include the cross training of others to back up and support the key personnel. Develop mechanisms where these individuals could be promoted and/or otherwise recognized for their contributions to the department.

Install technologies that are capable of reducing the need for traveling to the field. These technologies should include automated data collection and performance reporting. The goal would be to have the system provide sufficient information so that traffic signal timing updates could be made without costly labor intensive manual field

data collection. These technologies should also include continuous performance measurement and reporting to tell how well signal timing parameters are performing but also when major updates are needed. This should also allow the timings to be optimized for all hours of the day/week not just during the peak periods.

Observation #6: Geographic Distribution of Signals Challenges Operations

In some districts travel to a single intersection could be four hours or more. Then if the maintenance person doesn't have the needed part a whole day could be wasted.

Recommendation # 6:

Install upgraded technology with the new controllers and potentially cabinets that would allow more detailed remote diagnostics. Again the need for these features should be taken in context with the location, function and relative priority of the signal. They should also be consistent with documented agency needs and requirements.

Upon receiving the trouble call, the maintenance technician should be able to perform remote diagnostics from any convenient location; this could be home, office, another controller cabinet or any location with an internet connection. This could include the ability to query the major traffic signal controller and cabinet modules such as detectors and the conflict monitor.

Along with this would be a hierarchy of responses and notifications of materials needed so the technician can make intelligent choices about how to respond. Before they embark on that long trip they should have as much knowledge of the problem as possible to gather the materials needed to make the repair the first time.

Observation #7: Budgeting & Funding Sources and Process Unclear

Several of the people we interviewed were clearly frustrated by the lack of clarity in the budgeting and funding for traffic signal operations. They also were frustrated with the difficulty in getting small repair and maintenance items funded. We were told that there was a process but were provided no documentation of it.

Recommendation # 7:

This should be a major topic of your financial plan. It should be clear to everyone what funds exist and how to obtain and account for them. It should also be more clearly described in the agreements with the local agencies.

Conclusion

The practices for operations, maintenance and management of traffic signals in Montana face some very significant challenges. The "do more with less" myth has reached the end of the road and has morphed in to one of "how much less can we do before total breakdown". The current situation is one where small events could yield catastrophic system breakdown. This situation should be addressed with a considerable amount of urgency.

There does exist within the current long range planning process and documentation (TranPlan 21) well-formed policy goals and actions that would, if implemented, substantially improve the situation.

The primary recommendation of this review is that MDT should develop and put into action a plan to address the deficiencies noted including the policy goals and actions contained in the approved long range plan and associated policy documents.

This will not be an easy task given the numerous constraints that exist. Nonetheless, it is important to provide all stakeholders meaningful and credible justifications for needed expenditures to support the program as well as the potential impacts of not doing so.

MDT has stockpiled Traconex signal controllers to offset its inability to purchase new spares; the manufacturer is out of business. MDT staff and local agency partners are extremely dedicated and proficient at keeping systems operating in spite of not receiving adequate levels of training. Differences in the state of repair are evident

between adjacent signals in many locations because of deferred maintenance. Operations and maintenance needs are deferred due to a lack of funding; new projects are the standard mechanism used to address ongoing maintenance needs. A single traffic operations engineer develops and implements updated signal timing for the entire state which given the large geographic distribution of the infrastructure may not be meeting the needs of the roadway users.

However, these relationships and the local commitment are being severely strained. Many of the local partners are donating significant amounts of their own funds to keep things running. MDT staff is also stretched thin. People we interviewed voiced extreme frustration with the pace of system upgrades. Most of them are under intense local pressure to improve traffic signal operations. This situation is close to breakdown. The loss of a single staff member or loss of the donations from the local agencies could easily push this situation over the edge.

Actions to keep the systems operating are being done on an ad hoc basis; there is no documented comprehensive plan to guide activities. There is no vision or direction for the program or any connection to policy goals and actions documented in the TranPlan 21 statewide long range planning activities. We were informed that such a plan is available, but were unable to verify this.

Recently MDT has begun to reorganize and develop an organization dedicated to traffic signal operations. We think that this is a step in the right direction. While this is a good thing it is an isolated action without linkage to an overarching vision and plan of action. This reorganization to our knowledge is focused on traffic signal systems, which is good but consideration should be given to including the active operations of all Intelligent Transportation Systems infrastructure within Montana within a single point of accountability.

As the system has aged, the resources and staffing dedicated to the management, operation, and maintenance of traffic signals have become victims of their own success. As the number of traffic signals has steadily grown over the last two decades the resources and staffing dedicated to operation and maintenance has not increased commensurately, in fact it has dramatically declined. Equipment that has and continues to operate reliably has become functionally obsolete and is beginning to hinder innovation. For years people have been operating under the “do more with less” myth and have reached the point where this is no longer possible. The overall situation is rapidly approaching the point of complete breakdown. There are several critical single points of failure that have the potential to significantly compromise the safety of signalized intersections.

These discussions must be commensurate with the cumulative size of the investment in traffic signals. To date there has been no detailed accounting of the expenditure for the infrastructure. We can therefore only make a rough estimate.

As with everything the systems, facilities, structures and roadside devices do not have an infinite life. This is a significant investment in infrastructure and is a valuable asset that must be carefully, systematically and sustainably managed. The failure to effectively monitor and manage this investment and the absence of a well formed and documented program is contrary to the documented MDT Strategic Business plan[3]. Without a plan MDT cannot verify that investments being made in Traffic Signals and, for that matter ITS, comply with this business plan. The plan states:

> *Ensure investment decisions consider policy directions, customer input, available resources, system performance and funding levels.*

The MDT TranPlan 21[4] long-range planning program includes an excellent discussion on the need for quality traffic signal operations. As such it is actually one of the few long-range plans in the nation to present this discussion. The plan identifies goals to improve the productivity of the roadway system. These goal statements are well formed and provide an excellent basis for the development of a program to address the need for improved traffic signal operations in Montana. We recommend that MDT actively implement a program to address what they have already committed to in this planning document.

The most important recommendation being made is MDT should undertake a program to develop and document a long term vision to guide the operations of traffic signal systems in the state. This plan should implement the policy goals and actions presented in the existing TranPlan 21 documents as well as other agency policy documents. We believe that it is important that an agency's actions be supported by and driven by written operational goals and targets. The team believes this should be approached with a sense of real urgency and should be completed within the next 12 months.

[3] http://www.mdt.mt.gov/publications/docs/brochures/business_plan.pdf
[4] http://www.mdt.mt.gov/publications/docs/brochures/tranplan21/roadwaysysperf.pdf

Appendix A Review Questions

Review of Traffic Signal Operations Programs
MDT Traffic Signal Technician Review Questions

Date
Name
Agency

Number of State signals you maintain
Number of City signals you maintain

Approximately what percentage of your work time is devoted to the maintenance of traffic signals and how much of that time is spent maintaining state signals versus city signals?

What types of training does your agency provide for traffic signal personnel? What certifications are required (e.g., PE, IMSA, PTOE, etc.)?

How are you kept aware of innovations in signal system equipment and operations? Is there support for your involvement in professional groups and conferences?

What does traffic signal management and operations mean to you?

Do you feel that the value of effective traffic signal management and operations is understood by the decision makers that dictate your budget, what is your relationship with them, could it be improved, why or why not? What control do you have over your budget?

What type of policy, program, or process does your agency have in place to receive, assess, and accommodate requests for special pedestrian needs (e.g., people with disabilities or elderly pedestrians) at signalized intersections?

Do you track citizen complaints and comments? Do you have a policy for responding to complaints, both in terms of the form of the response (written, verbal, email, etc.) and the timeliness of the response? Who is responsible for communicating with citizens in response to a complaint? Do you have a policy for communication outside your agency?

To what extent does your agency have an inventory of signal phasing and timing settings for each intersection? How often is the inventory updated? Do you have a policy for maintaining

consistency between official and actual timings in controllers? Do you routinely check field timings, or do you wish you did?

Does your agency have established policies and processes and committed resources (in-house or contracted) to respond to critical malfunctions that are reported? For example, how are you informed and how do you respond if the police place a signal on flashing mode? How long might it take to find out? How often does this occur?

Do you have a policy of reporting the results of signal operation activities to elected officials and policy makers, particularly in writing? What sorts of activities interest them? If so, attach one or two examples of recent written reports.

What percentage of your agency's detection is operating as designed? How do you know if the detection has failed or isn't operating properly? How do you monitor the condition of the system?

Is there an up-to-date equipment inventory that identifies the location, make, model, model number, and serial number of all equipment in the system (including spares)?

What process does your agency have in place for performing regular preventative maintenance and operational reviews to assess the condition of the traffic control system? How do you assess if the detection systems are operating properly?

What purchase specification does your agency use to procure LED signal modules, what is the typical warranty period and is a program in place to monitor and ensure that minimum light intensity specifications are maintained?

Does your system tell you when faults occur? What types of faults are monitored? How often do they occur?

Does your agency have battery backup or a plan for power outages? Do you have provisions for lightning protection?

What kinds of traffic signal technology and software would you like to have demonstrated?

What other ITS innovations are being considered for your traffic control system? What is your wish list?

How can the Federal Highway Administration best assist you with your traffic signal system?

How can the State best assist you with your traffic signal system?

Do you have any other concerns or requests?

Appendix B Commentary on MDT Planning Documents

Roadway System Performance Policy Paper

Part I Background – Roadway System Performance in Montana

Section 3 on Roadway Congestion, there is very little mention of the performance of facilities within urban boundaries. Facilities such as Reserve Street in Missoula experience significant peak hour congestion to the point of oversaturated conditions. This route is designated as I-90 Business Route as well as State Highway 93. We suspect that there are other routes in urban areas with similar problems.

A root problem here is that the performance of traffic signal systems in Montana is not measured or reported in any continuous and systematic way. Therefore it is difficult to make salient conclusions about congestion of urban arterial facilities.

Part II Key Roadway Performance Issues

Section B, Continued Need to Set Informed Priorities for Roadway System Performance. This discussion should also include the measurement and monitoring of traffic signal performance. Without this there can be no informed discussion and decisions relative to these critical roadway systems.

Section E, Existing Reconstruction Practices. While these sections appear to be primarily directed toward pavement reconstruction they should also be applied to the operations of traffic signal systems. A key to doing so is to measure and report on systems performance and tie system performance to the need for reconstruction. In addition particularly in the growing urban areas of Montana it may very well be that improvements in traffic signal system performance could reduce or significantly delay the need for major roadway widening. It should also be recognized that in terms of the operations of signalized arterials adding lanes can have significant negative impacts.

Part III Policy Goals and Actions

Policy Goal A First Priority – Preservation of Montana's Existing Highway System
This policy goal states the following:

The first priority is treatments that reduce the lifecycle of Montana roadways because roads that are not preserved in this way will result in:

Large increases in repair costs

Operating cost increases for road users
Increases in accident rates
Increases in environmental damage
Increase in travel delays

Ineffective management and operations of the traffic signals in Montana result in all of these issues for every traveler on Montana roadways. This policy goal should greatly reinforce the need to develop and document a clear vision for traffic signal operations.

There are currently no "action statements" associated with this policy goal. Consideration should be given to adding one to reflect the need and importance of well managed and operated traffic signal systems, particularly those in urban areas.

Second Priority – Capacity Expansion and Mobility Improvement

Again this statement maps directly to the need to get the most from the state's traffic signal systems. Inefficient and ineffective operation of those systems can significantly impact mobility. While these systems will not add capacity they do directly impact the utilization of existing capacity.

Action A.1 Enhance the Performance Programming Process (P^3) to strengthen the link between policy planning goals and project selection.

The traffic signal operations program should undertake a program of systems performance reporting to support this action item. The selection of projects and programmatic actions should be prioritized according to the well defined system performance measurements. Performance should also include the performance of the system software and hardware which should also be reflected in the long range planning process.

Action A.2. Provide and disseminate transportation system performance information.

The recommended program of systems performance reporting should be reported. With newer systems the bulk of this can easily be automated and could be instantly displayed on web based maps.

Policy Goal B – Preserve mobility for people and industry in Montana within available resources.

Development of a vision and program for traffic signal operations directly addresses and supports this policy goal. The needs and demand for resources required for traffic signal operations should be identified so that they are intelligently addressed within given constraints and against other competing needs.

Policy Goal C. Improve the productivity of the roadway system.

Action C.2. Identify and deploy cost-effective Intelligent Transportation Systems application to improve safety and system productivity.

Traffic Signal Systems were the very first Intelligent Transportation Systems and are indirectly included as a part of this action item. The measurement of system performance and the management of system assets should be more actively addressed in order to respond/comply with this action item.

Action C.3. Encourage the metropolitan planning organization areas to include enhanced traffic control and management systems in their long-range plans.

Nationally this action item hasn't been voiced. It is encouraging to see it already identified in the Montana long-range plan. However, it doesn't appear as if it has been actively acted upon.

Action C.4 Strengthen MDT's traffic operations capability to reduce delay and improve travel times through better traffic management.

This is a very important action statement already embraced by the long range planning process. It is apparent that this action has not been actively acted upon.

Action C.5. Promote efficient system management and operations and emphasize the preservation of the existing transportation system by implementing strategies that manage travel demand, enhance mobility and extend the service life of the system.

Action C.6. Utilize P^3 to establish objectives and performance levels for preserving the condition of the existing system and addressing growing congestion.

To date operational objectives and performance levels have not been established. MDT has yet to embrace this action item.

2013 Biennium Goals and Objectives

The following statements in this document provide guidance that should be being followed for this program area.

Human Resources Division
Expand the succession planning process identifying critical positions; establish a key talent pool and provide effective development tools and programs.

Administration Division

Continue to strive to maintain a stable and well-trained workforce
Continue to identify opportunities for career growth
Provide management with sound financial information to make operational and investment decisions
Continuously monitor department finances, trends and revenue data to project budgetary needs and fund stability.

Transportation Planning Program
Utilize the Performance Programming Process to improve planning and programming decisions.

Based upon these departmental goals and our interviews it doesn't appear as if they have been applied to the business practice of traffic signal operations.

TranPlan 21 Surveys

It isn't clear that the public and stakeholders are being asked questions that directly map to the quality of traffic signal operations in Montana. Although traffic congestion appears to be concern #3 or #4 in these surveys.

In future surveys questions that directly map to the operations of urban arterial facilities should be asked.

2010 MDT Infrastructure Needs – 10-year Estimate

There is currently a considerable amount of the existing traffic signal infrastructure that needs replacement as soon as possible and should be reflected in this estimate. In addition the lifecycle of today's traffic signal system component is typically 10 years; there should be consideration for at least one replacement cycle reflected in this estimate.

U.S. Department of Transportation
Federal Highway Administration

Report prepared by:

Office of Technical Services
12300 West Dakota Avenue
Suite 340
Lakewood, CO 80465:

FHWA Montana Division Office
585 Shepard Way, Suite 2
Helena, MT 59601
Phone: (406) 441-3900

For additional copies of this report, contact us.