TSM&O Traffic Infrastructure Process

Annual Stakeholder Summit

Bureau of Traffic Operations
September 27, 2016

Summit Agenda

1. Introductions (10 min)
2. TSMO-TIP Overview (35 min)

3a. TSM&O Annual Technology Review Part 1 (50 min)

Break (15 min)

3b. TSM&O Annual Technology Review Part 2 (40 min)

4. Next Steps (5 min)

1. Introductions

Summit Objectives

- Continue integration of the TSM&O Traffic Infrastructure Process
- Obtain additional feedback
- Review TSM&O technologies
- Define which projects must go through TSMO-TIP
- Discuss documentation requirements
- Discuss proposed 2017 deployments

2. TSMO-TIP Overview

Defining TSM&O – MAP-21

- Not just ITS
- MAP-21 revised federal definition of TSM&O (23 U.S.C. § 101(a)(30))
  - Integrated strategies to optimize existing infrastructure performance
  - **Multimodal and intermodal**, **cross-jurisdictional** systems, services, and projects
  - Preserve capacity and improve security, safety, and reliability of transportation system
  - Includes coordinated regional implementation and interoperability
- WisDOT TSM&O State of the State Report adopts MAP-21 definition adding:
  - "Plans to retire system components that no longer provide sufficient benefit to warrant continuation or are technologically obsolete."

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Example TSM&O Traffic Infrastructure Strategies

- Work Zone Management
- Traffic Incident Management
- Service Patrols
- Special Event Management
- Road Weather Management
- Transit Management
- Traffic Signal Coordination
- Surveillance and Monitoring
- Traveler Information
- Ramp Management
- Managed Lanes
- Active Traffic Management
- Integrated Corridor Management
- Truck Parking

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TSM&O History at WisDOT Early ITS Infrastructure

- Ramp Metering
  - Began in 1969 in Milwaukee
- Other infrastructure
  - Loop detectors – 70s
  - Dynamic message signs (DMS) – 90s
- Legacy Problems
  - No “pavement equivalent” method of considering traffic operations and management infrastructure
  - ITS deployments sporadic
  - Legislative issues – No direct ITS funding

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Advancing TSM&O Infrastructure Deployments

- "Low hanging fruit" addressed – where to go next?
- Previous deployments based on old data
- New technologies maturing rapidly
  - Connected vehicle infrastructure
  - Probe-based traffic data
  - In-car travel time displays
  - Multipurpose cameras
  - Smart traffic signals
- System needs to be more flexible to adapt quickly

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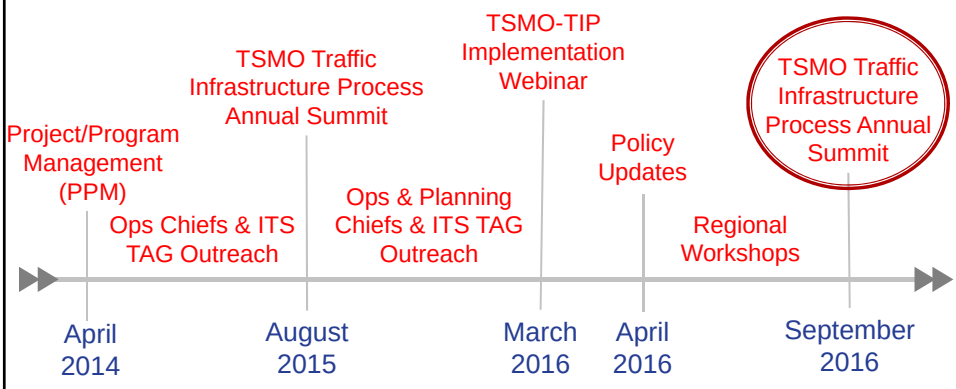
Implementation Timeline



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Recap of Year's Activities

- Program Development Refinements
- Needs Analysis Tool Refinements
- Benefits Tool Refinements
- TSMO-TIP March Webinar
- Regional Workshops

- Annual Report will be available on TSMO-TIP website

TSMO-TIP Objectives

- Develop a traffic infrastructure deployment process focused on:
  - Continuous performance improvement
    - Annual process open to technological advances
  - Current and short-term needs
    - Needs analysis tool to identify system issues
  - Decision making support
    - Process checklist and benefits analysis tool
  - Process documentation
    - Project justification and historical reference
- Support federal requirements

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TSMO-TIP Expectations

- What it is…
  - Provides a defined, consistent process methodology
  - High level evaluation using historical data and numbers
  - Needs data identifies general areas of concern
  - Benefits analysis estimates potential project benefits
  - Documents project information, data and decisions
- And what it isn't…
  - Does not provide a "go or no go" decision
  - Does not identify deployment solutions

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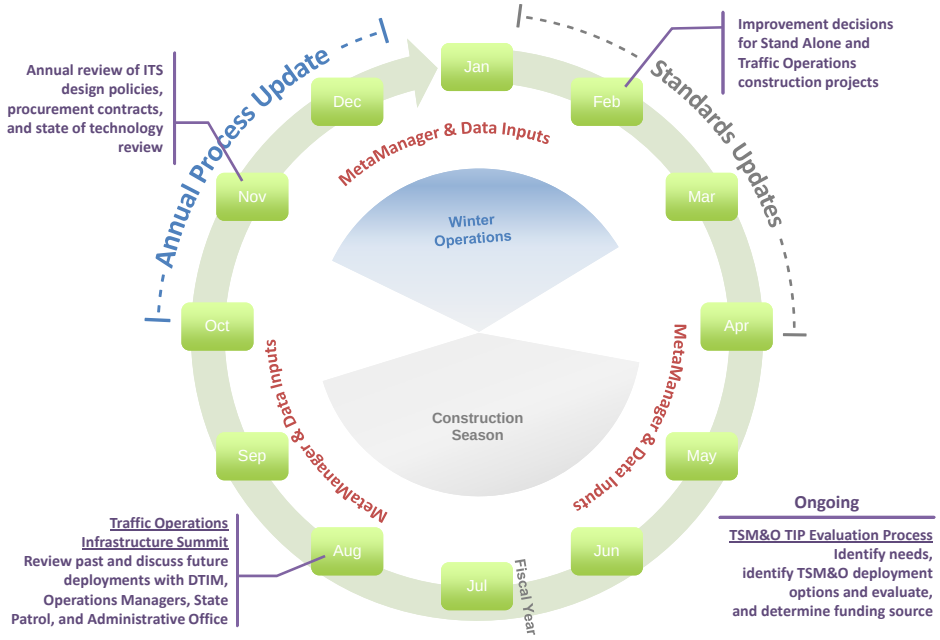
TSMO-TIP Annual Cycle



TSMO-TIP Flowchart – Process Tasks

- **A** • **Statewide Needs Inventory** | BTO Traffic Systems Unit with stakeholder support
- **B** • **Regional Project List w/ Priority Ranking** | BTO and Regional ITS Coordinators
- **C** • **Draft Statewide Deployment List** | BTO and Regional ITS Coordinators
- **D** • **Finalize Statewide Deployment List** | BTO and Operations Managers
- **E** • **Identify Funding Sources and Obtain Support Documentation** | ITS TAG et al.
- **F** • **Final Review and Approval of Statewide Deployment List** | ITS TAG
- **G** • **Implement Projects** | BTO and Regional ITS Coordinators

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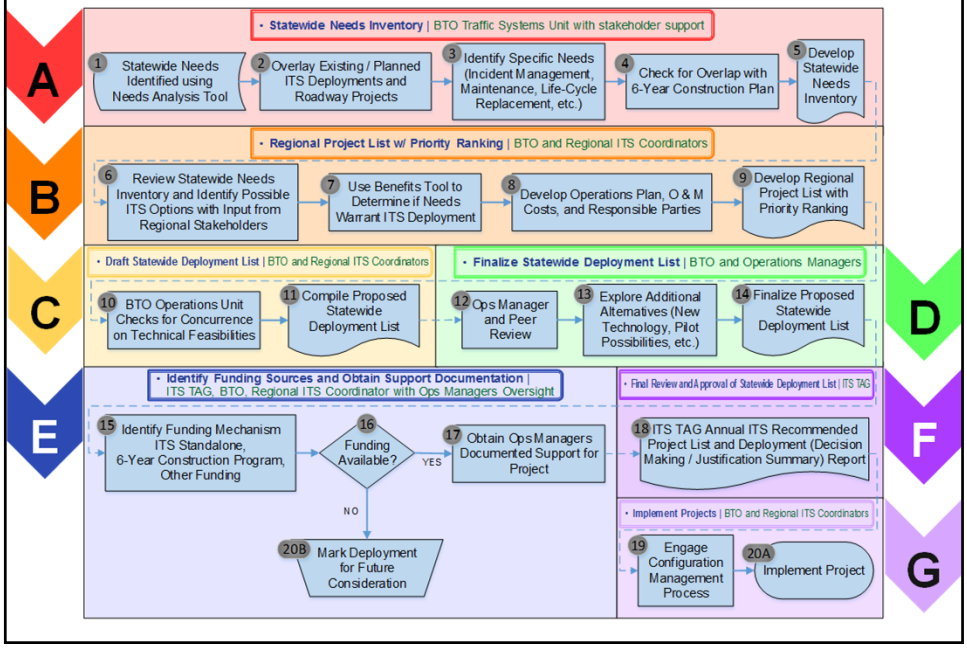
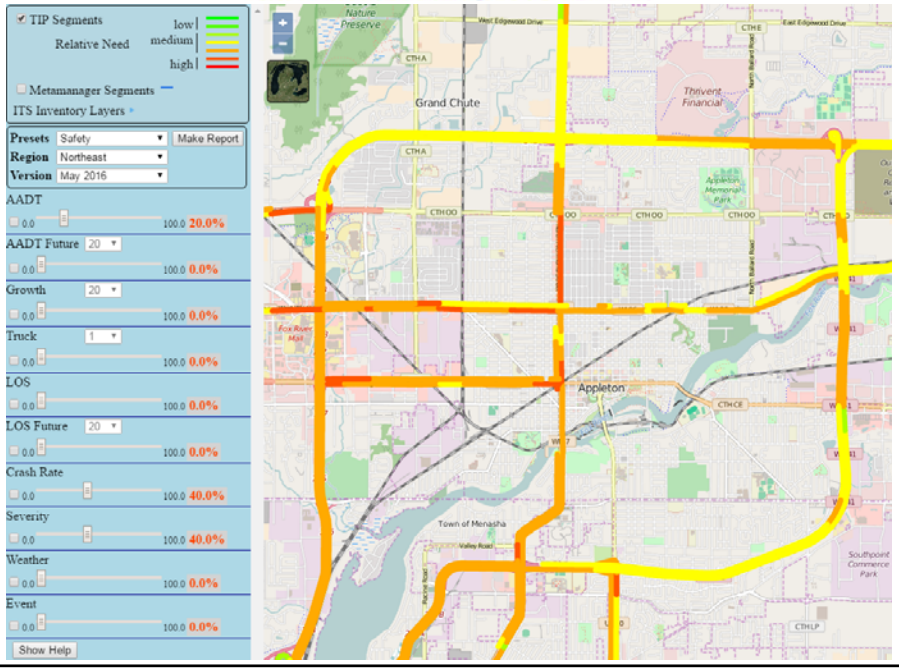
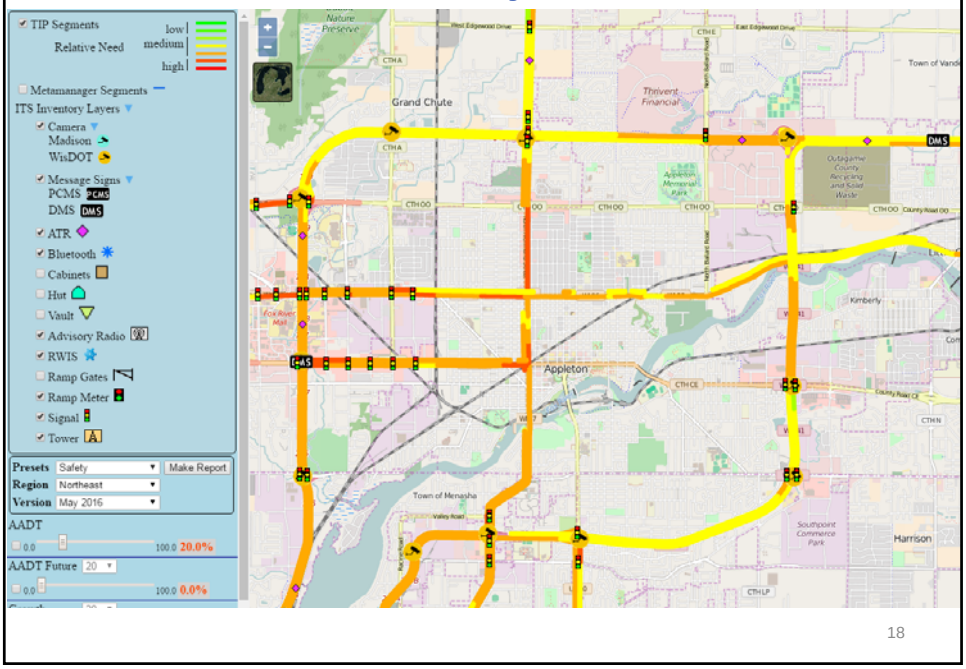
TSMO-TIP Flowchart – Detailed Tasks



Needs Analysis Tool



Needs Analysis Tool



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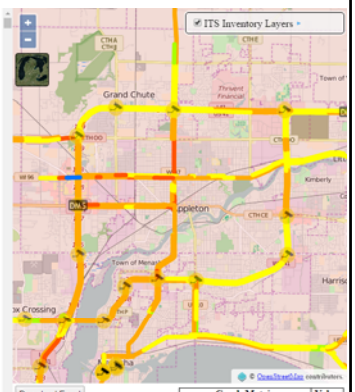
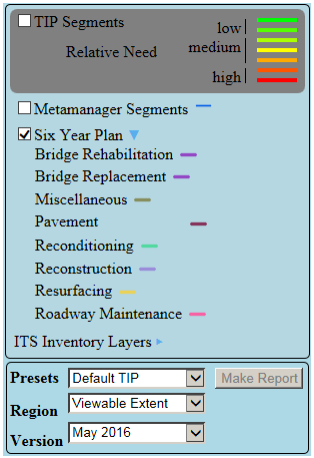
Needs Analysis Tool – Report

pdp_id	hwy_dir	weighted score	aadtyr_1	aadtyr_20	crash_rate	crash_severity	event	growth_20	losyr_1	losyr_20	trkdyr_1	weather
17694	114W	2.5146	18210	22180	5265.07	190	6.0	21.8	3.32	3.45	8.8	40.0
4544	023E	2.5052	26490	32270	14405.8	53	7.0	21.82	4.19	6.04	8.8	38.0
4660	023W	2.4013	11990	13870	21504.0	38	7.0	15.68	4.91	5.22	8.8	38.0
17954	125W	2.3739	35790	41650	2228.53	215	6.0	16.37	6.38	6.63	8.8	43.0
17654	114E	2.1809	25520	30190	4308.52	72	6.0	18.3	3.59	4.33	8.8	40.0
17016	096E	2.1233	27030	29050	1424.3	187	6.0	7.47	4.23	4.45	8.8	43.0
9836	045N	2.0619	11890	14480	1555.56	255	8.0	21.78	2.1	2.15	8.8	36.0
10124	045S	2.0115	3770	4060	3791.72	134	7.0	7.69	3.45	3.47	8.8	39.0
10115	045S	1.9701	15110	17430	6079.97	35	8.0	15.35	3.19	3.25	8.8	36.0
6373	032N	1.957	10000	11980	5426.61	47	11.0	19.8	2.96	3.15	8.8	43.0
10114	045S	1.9252	11890	14480	7998.62	26	8.0	21.78	2.1	2.15	8.8	36.0
9668	044N	1.9226	16780	20430	1977.46	93	9.0	21.75	3.3	3.39	8.8	35.0
4547	023E	1.9124	27640	32710	901.97	158	7.0	18.34	4.28	6.1	8.8	38.0
4070	021E	1.8944	12100	14740	3162.74	89	8.0	21.82	3.13	3.2	8.8	36.0
4654	023W	1.8744	29160	34560	948.66	130	7.0	18.52	3.42	5.47	8.8	39.0
18300	141N	1.8721	19310	23610	2009.47	73	12.0	22.27	3.59	3.72	8.8	44.0
17655	114E	1.8443	18210	22180	1861.61	75	6.0	21.8	3.32	3.45	8.8	40.0
4656	023W	1.8424	27640	32710	966.98	119	7.0	18.34	4.28	6.1	8.8	38.0
8955	042N	1.8246	20160	23050	1651.03	76	4.0	14.34	3.89	4.0	8.8	41.0
9803	045N	1.8188	8650	9300	1310.26	103	7.0	7.51	3.57	3.63	8.8	39.0
10233	047N	1.8043	21640	25170	733.9	231	6.0	16.31	3.47	3.64	8.8	43.0
17937	125E	1.7889	35790	41650	972.79	88	6.0	16.37	6.38	6.63	8.8	43.0
10116	045S	1.7819	9580	10300	2739.31	58	9.0	7.52	2.14	2.19	8.8	36.0
9002	042N	1.7817	16620	17860	1311.08	94	4.0	7.46	2.37	2.4	8.8	41.0
17953	125W	1.7804	27200	28040	1021.92	94	6.0	3.09	4.24	4.31	8.8	43.0
9676	044S	1.7794	10980	13370	4005.51	36	9.0	21.77	2.68	2.72	8.8	35.0
17026	096E	1.7652	15630	15880	1012.89	121	6.0	1.6	3.16	3.17	7.2	44.0
10227	047N	1.7602	17980	19590	1452.39	76	6.0	8.95	3.23	3.28	8.8	43.0
17020	096E	1.7563	25520	28140	1464.94	62	6.0	10.27	4.11	4.27	7.2	43.0
12118	054E	1.742	17920	19270	844.9	127	12.0	7.53	3.95	4.01	8.8	44.0
5438	028W	1.7397	17620	21560	1917.42	54	5.0	22.36	2.37	2.45	8.8	41.0
12611	057N	1.737	6670	7180	2537.36	59	4.0	7.65	1.71	1.74	13.7	46.0
2925	015E	1.7273	26150	31840	598.96	143	6.0	21.76	3.83	5.51	8.8	44.0
6537	032S	1.7266	10000	11980	3515.22	37	12.0	19.8	2.96	3.15	8.8	43.0
18810	151N	1.7262	5250	5950	5671.75	45	6.0	13.33	1.0	1.0	7.2	41.0
4554	023E	1.7218	24220	29190	588.92	149	7.0	20.52	6.66	6.78	8.8	39.0

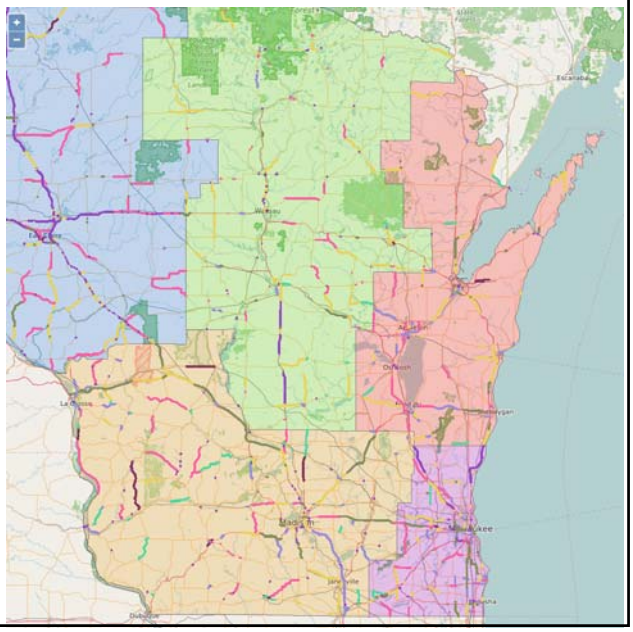


Crash Metric	Value
5 Yr Fatal Crash	0
5 Yr Incapacitating Crash	2
5 Yr Nonincapacitating Crash	3
5 Yr Possible Injury Crash	43
5 Yr Property Damage Crash	73
5 Yr Weather Crash	42
5 Yr Avg	24.2
Intersection Crash %	56.2
5 Yr Avg A Crash	0.4
Run off Crash %	7.44

Needs Analysis Tool – Continuous Improvement
6 Year Construction Plan – Beta Version



Beta Version – Snapshot from July 2016



Benefits Tool

- Calculates estimated benefits ($) for a given project
  - Communication expansion
  - Software
  - ITS device replacement
  - DMS
  - CCTV
- Excel-based tool where user supplies inputs (many via drop-down menus)

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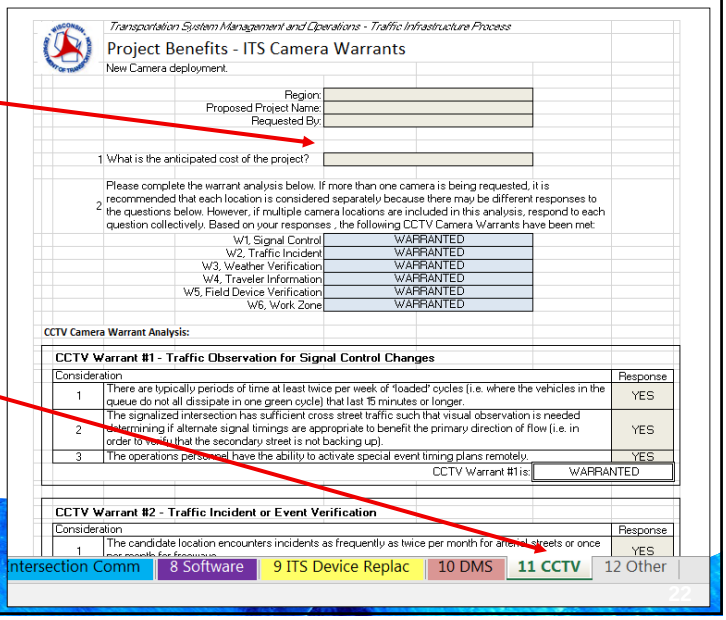
Benefits Tool Overview

Tool will compute estimated benefits and a B/C ratio given project cost

Tabs for each type of project (e.g. ITS Device Replacement, CCTV, DMS)



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Benefits Tool Overview

Transportation System Management and Operations - Traffic Infrastructure Process

Project Benefits - ITS Camera Warrants

New Camera deployment.

Region:
Proposed Project Name:
Requested By:

1 What is the anticipated cost of the project?

2 Please complete the warrant analysis below. If more than one camera is being requested, it is recommended that each location is considered separately because there may be different responses to the questions below. However, if multiple camera locations are included in this analysis, respond to each question collectively. Based on your responses , the following CCTV Camera Warrants have been met:

W1, Signal Control	WARRANTED
W2, Traffic Incident	WARRANTED
W3, Weather Verification	WARRANTED
W4, Traveler Information	WARRANTED
W5, Field Device Verification	WARRANTED
W6, Work Zone	WARRANTED

User Response

CCTV Camera Warrant Analysis:

CCTV Warrant #1 - Traffic Observation for Signal Control Changes

	Consideration	Response
1	There are typically periods of time at least twice per week of 'loaded' cycles (i.e. where the vehicles in the queue do not all dissipate in one green cycle) that last 15 minutes or longer.	YES
2	The signalized intersection has sufficient cross street traffic such that visual observation is needed determining if alternate signal timings are appropriate to benefit the primary direction of flow (i.e. in order to verify that the secondary street is not backing up).	YES
3	The operations personnel have the ability to activate special event timing plans remotely.	YES

CCTV Warrant #1 is: WARRANTED

CCTV Warrant #2 - Traffic Incident or Event Verification

	Consideration	Response
1	The candidate location encounters incidents as frequently as twice per month for arterial streets or once per month for freeways.	YES
2	The incidents and events that occur on freeways typically cause delay to travelers of at least 15 minutes while the incident is active and has not been cleared.	YES
3	The incidents and events that occur on arterials typically impact travel such that the signal progression is no longer occurring and vehicles in queues are unable to clear intersections during the cycle's allotted green time.	YES
4	Incident location verification is needed by 911 dispatchers (e.g. large complex interchange where drivers don't know where they are, closely spaced interchanges).	YES
5	The location encounters at least 2 hours per day of peak period travel where traffic flow exceeds 1,100 veh/hr/lane.	YES
6	The location encounters conditions considered Level of Service C.	YES
7	The location encounters average annual daily traffic (AADT) of 16,800 for a 2 lane road; 33,600 for a 4 lane road; 50,400 for a 6 lane road, 67,200 for an 8 lane road.	YES

CCTV Warrant #2 is: WARRANTED

Benefits Tool Overview

Calculates estimated benefits for safety, mobility, productivity, and energy/environment as applicable.

Safety Benefits

S1. How many crashes, by type, occurred in the past year at this intersection or corridor?

- Fatal Crashes
- Incapacitating Injury Crashes
- Non-incapacitating Injury Crashes
- Possible Injury Crashes
- Property Damage Only Crashes

Estimated Safety Benefit:

Mobility Benefits

M1 (W1). What is the estimated AADT for all vehicles entering the intersection? vehicles per day

M2 (W1). What is the average Relative Need at this intersection according to the Needs Analysis Tool - Service preset?

M1 (W2, W3, W4, W6). Estimate the average number of traffic events that occur per year within site distance of the proposed camera(s). events per year

M2 (W2 W3, W4 W6)

M3 (W2 W3, W4 W6)

Productivity Benefits

P1. It is assumed that productivity benefits will be realized through reduced maintenance efforts. Estimate for how long maintenance efforts have been increasing at the proposed device replacement location(s).

P2. How many Cartegraph tickets have been required at this location over the length of time indicated above in P1? (if request is for multiple intersections, include cumulative total here) tickets

P3. What was the total cost of these tickets?

d project?

Energy and Environment Benefits

Estimated Annual Energy and Environment Benefit:

What data does the user need to obtain to calculate benefits?

Transportation System Management and Operations - Traffic Infrastructure Process

Project Benefits - Data Needs

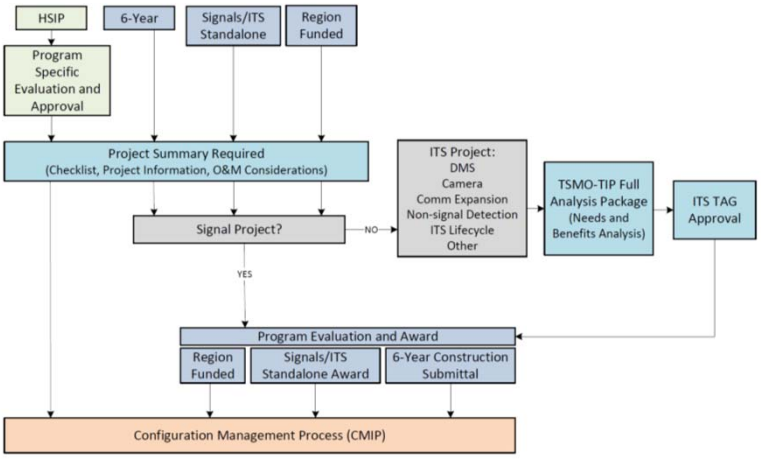
Tabs for each type of project (e.g. CCTV, DMS, ITS Device Replacement)

Anticipated Data Source	Data Request	Project Type					
		7 Communication Expansion	8 Software	9 ITS Device Replacement	10 DMS	11 Camera	12 Other
User Response	Project Specific Description	X	X	X	X	X	X
	ITS Warrant Information				X	X	
	Signal Warrant Information						
	Urban/Rural						
Estimated	Events per Year				X	X	
	Average Event Duration				X	X	
	Average Travel Time Savings				X	X	
	Peak Period Travel Time Reduction						
Asset Management / Maintenance Reports	Maintenance Tickets and Cost	X		X			
Needs Analysis Tool	Crash Data by Type	X			X	X	
	Average Vehicles Entering Intersection	X					
	Average Daily Traffic Volumes Per Area				X	X	
	Relative Need - Level of Service Preset						

Where will the user be pulling data from?

Required Documentation

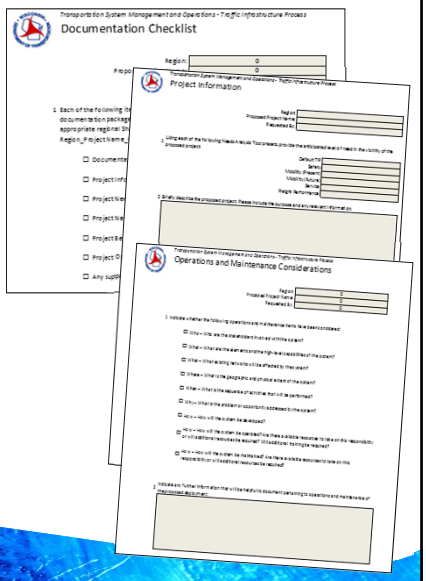
First, consider the potential anticipated funding source:



Note: If the project does not follow typical funding sources, contact State ITS Engineer for project documentation requirements.

Required Documentation

- Project Summary Package:
  - Documentation Checklist
  - Project Information Sheet
  - Project Operations and Maintenance Considerations
- Full Analysis Package:
  - Project Summary Package
  - Needs Maps
  - Benefits Analysis



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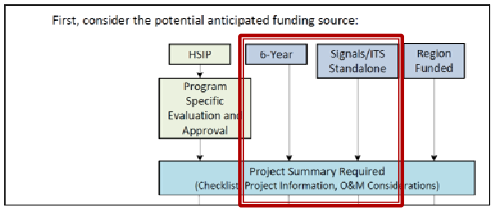
Example Project Package:
DMS on I43 south of Exit 78 (not a real project)

- Potentially funded through 6-Year Construction or Signals and ITS Standalone Program



  - Project Summary Required

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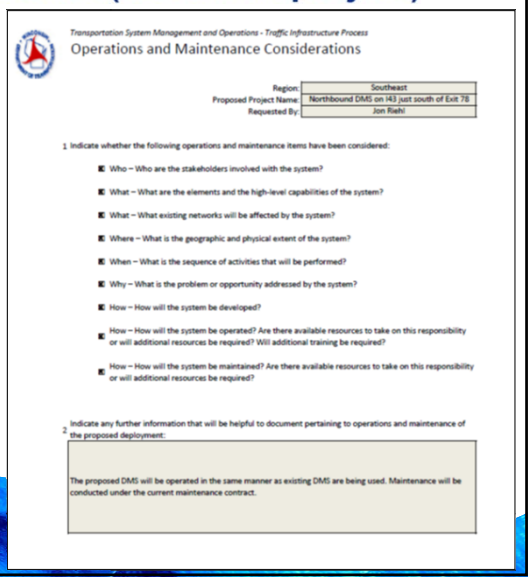
Example Project Package:
DMS on I43 south of Exit 78 (not a real project)

- Project Summary:
  - Checklist
  - Project Information
  - O&M Considerations



Transportation System Management and Operations - Traffic Infrastructure Process

Operations and Maintenance Considerations

Region:	Southeast
Proposed Project Name:	Northbound DMS on I43 just south of Exit 78
Requested By:	Jon Riehl

1 Indicate whether the following operations and maintenance items have been considered:

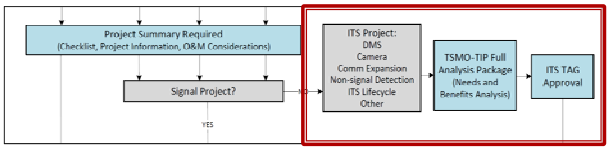
- Who – Who are the stakeholders involved with the system?
- What – What are the elements and the high-level capabilities of the system?
- What – What existing networks will be affected by the system?
- Where – What is the geographic and physical extent of the system?
- When – What is the sequence of activities that will be performed?
- Why – What is the problem or opportunity addressed by the system?
- How – How will the system be developed?
- How – How will the system be operated? Are there available resources to take on this responsibility or will additional resources be required? Will additional training be required?
- How – How will the system be maintained? Are there available resources to take on this responsibility or will additional resources be required?

2 Indicate any further information that will be helpful to document pertaining to operations and maintenance of the proposed deployment:

The proposed DMS will be operated in the same manner as existing DMS are being used. Maintenance will be conducted under the current maintenance contract.

Example Project Package:
DMS on I43 south of Exit 78 (not a real project)

- Not a signal project
- ITS project



  - TSMO-TIP Full Analysis Package Required
  - ITS TAG Support

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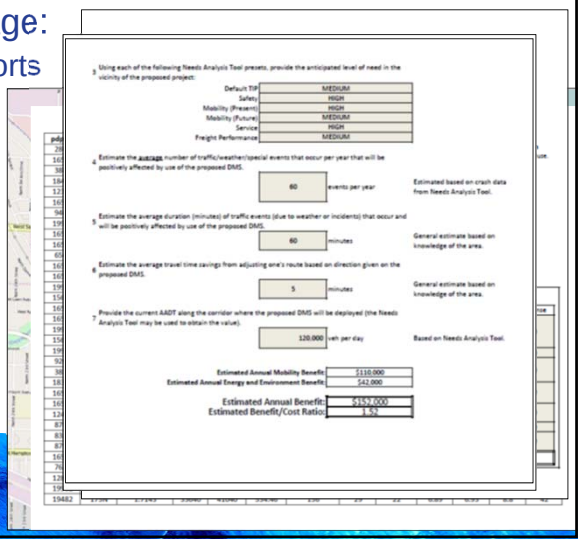
Example Project Package:
DMS on I43 south of Exit 78 (not a real project)

- Full Analysis Package:
  - Needs Analysis Reports
  - Benefits Analysis



FY17 Standalone Approved Projects
ITS Projects needing
TSMO-TIP Documentation

- Bureau of Traffic Operations
  - BTO: I43 - Locust DMS Replacement
- Northeast Region
  - NE002: Leo Frigo Bridge Security
  - NE003: Northeast Region CCTV's
- Northwest Region
  - NW002(FY16): USH 53 Eau Claire Freeway TOIP Implementation South
  - NW005: City of Eau Claire, USH 12, ITS Install
  - NW007: Portable Camera Trailer

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FY17 Standalone Approved Projects ITS Projects needing TSMO-TIP Documentation

- North Central Region
  - N/A
- Southwest Region
  - SW002: IH 90/94 Tomah to Wis. Dells, ITS Enhancement
  - SW007: USH 151, American Parkway Interchange, Madison, ITS Enhancement
  - SW008: USH 12, Middleton, ITS Enhancement
- Southeast Region
  - SE002: Communication Construction 164 & 190
  - SE008: Communication Design of STH 20 & STH 31

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FY18 Deployment Review Process

- All ITS deployments must go through TSMO-TIP
- TSMO-TIP packages due in late January
- Packages finalized for March ITS TAG meeting
- BTO supporting regional efforts and documentation questions
- Working to streamline process with signals and ITS standalone application

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3. TSMO-TIP Technology Annual Review

TSM&O Technology Annual Review

- Cannot keep adding lanes to solve our problems
- Emphasis on problems you have and how you can solve them
  - ITS is an option
  - Other TSM&O options available
  - Who is going to solve these problems – public, private, PPP?
  - What is WisDOT's role?
  - Solving a problem may have unintended consequences…

Unintended Consequences – Distraction

- Increased information
  - Theoretically useful information
  - But, information overload
- Geocaching apps

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TSM&O Technology Annual Review

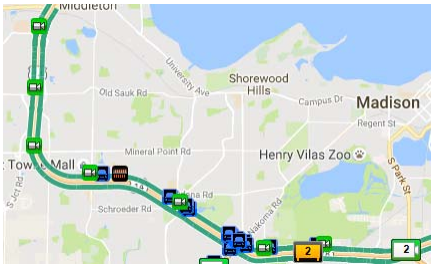
- For each technology
  - Technology Overview
  - National Trends
  - Local Example Projects
- Questions / Discussion encouraged throughout

Emerging Technologies

- Traveler Information / RTSMIP
- Communications Systems / Connectivity
- Adaptive Signal Control
- Active Traffic Management
- Detection Systems
- Probe Data
- Big Data
- Connected Vehicles
- Automation
- Other high-tech TSM&O
- Emerging low-tech TSM&O

Traveler Information – Overview

- Information to provide
  - Traffic speeds / travel times
  - Road work / closures
  - Traffic incidents
  - Weather / road conditions
  - Alternate routes
  - Truck parking
  - Red light / speed cameras, police activity
- Where to provide info?
  - Dynamic message signs
  - Online
  - Smart phones
  - In-vehicle navigation



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Traveler Information – Trends

- Real-Time System Mgmt Information Program (RTSMIP)
- State 511 Systems
- Advanced Traveler Information Systems
- Adaptive routing systems – Waze
- Integrated Transportation Systems
  - Regional Integrated Transportation Information System (RITIS)
- Multimodal traveler information systems
  - Path2Go in San Francisco
- Public-private data sharing

- Local Example
  - WisDOT RTSMIP status – Liz Schneider

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Communications Systems / Connectivity – Overview

- Wired Infrastructure
- Advanced Cellular Infrastructure
  - 4G/5G

- Why Fiber?
  - Network backbone
  - Reliability
  - Redundancy
  - Preparation for CV data/applications

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Communications Systems / Connectivity – Trends

- States preparing networks for CV
- Adding redundant/dedicated lines
- What to do in rural areas?
  - Fiber, Wireless, Leased (cellular)?
- Local Example
  - WisDOT fiber update – Don Schell

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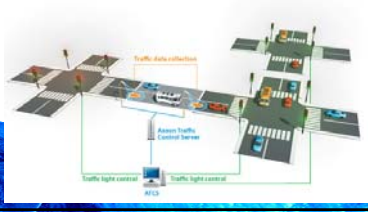
Adaptive Signal Control – Overview

- Benefits
  - Continuously distribute green light time equitably
  - Improve travel time reliability by progressively moving vehicles through green lights
  - Reduce congestion by creating smoother flow
  - Prolong the effectiveness of traffic signal timing
  - Faster response to traffic conditions
  - Reduce user cost and emissions



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Adaptive Signal Control – Many Different Systems

- SCOOT (Split Cycle Offset Optimization Technique)
- SCATS (Sydney Coordinated Adaptive Traffic System)
- LA ATCS (LA DOT Adaptive Traffic Control System)
- RHODES (Real Time Hierarchical Optimized Distributed Effective System)
- ACS-Lite (Econolite Centracs is advanced version)
- OPAC (Optimization Policies for Adaptive Control)
- InSync (Rhythm Engineering)
- ATMS.now (formerly Streetwise, by Naztec)
- RTACL (Real Time Adaptive Control Logic)
- QuicTrac Adaptive (by McCain)
- SPOT (Omaha, Nebraska)

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Adaptive Signal Control – Trends

- Current deployed in less than 1% of signals nationally
- Advanced adaptive systems based on V2I
- Integration with traveler information systems
- Regardless of system used, benefits are apparent

- Local Example
  - Signal Technology in Wisconsin – Joanna Bush

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Active Traffic Management – Overview

- Variable Speed Limits / queue protection
- Ramp metering
- Managed lanes
  - Hard shoulder running / junction control
  - Lane-specific signaling
  - HOV/HOT lanes

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Active Traffic Management – Trends

- Adaptive ramp metering
- Dynamic lane reversal
- Zipper lanes
- Weather responsive speed limits
- Dynamic merge control / zipper merge
- Active demand management
  - Dynamic pricing
  - Dynamic ridesharing
  - Dynamic routing
- Local Example
  - Southeast Freeways / 894 Project – Chris Hager

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Detection Systems – Overview

- Real-time monitoring
- Intersection actuation
- Traffic data collection
- Automated incident detection
- Thermal detection
- Origin/Destination detection
- Intersection performance management

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Detection Systems – Trends

- Performing multiple tasks with one device
  - Can cameras with computer vision software replace other detection systems?
- Automated systems
  - Automated queue warning detection systems
  - Integration with traffic signal control
  - Automated traffic counts
- Local Example
  - Gridsmart cameras in La Crosse – Andy Winga

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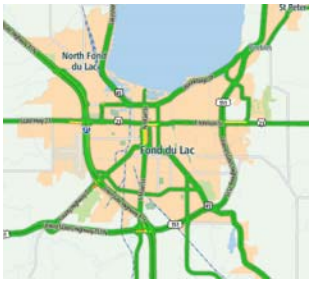
Probe Data – Overview

- Probes by
  - Roadside detection (Bluetooth/toll tags)
  - Automatic vehicle location (AVL)
  - GPS enabled mobile apps
- Aggregated and provided (sold) by third parties
  - TomTom, Inrix, Nokia (Navteq, Here), TrafficCast (Dynaflow), Google, Airsage, etc.



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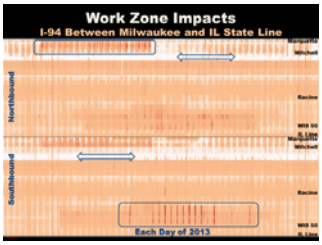
Probe Data – Trends

- Free NPMRDS data
- How good is the data?
  - Data quality comparison projects
  - Truck vs. car percentages
  - Missing observations/outliers
- Mobility Performance Measures
  - Vehicle Delay and User Cost
  - Travel Time Reliability
- Historic vs. Real-time data
- Local Example
  - Wisconsin Probe Data Projects – Peter Rafferty



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Big Data – Overview

- Every day, 2.5 exabytes (10^{18}) of data is generated
- More about the analytics of the data
  - Analyzing the data for meaningful applications
  - Real-time and archived data analytics
- Be careful
  - Data overload/organization
  - Correlation does not equal cause and effect
- Types of transportation data
  - Traveler GPS / probe data
  - Camera and traffic sensor data
  - Connected vehicle data
  - Public transit data

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Big Data – Trends

- Information sharing – across departments and systems
- Predicting traffic jams up to an hour in advance
- Optimize freight movements and routing
- Real-time traffic monitoring and control

- Local Example – Peter Rafferty
  - Planning for ATMS/CV data
  - WisTransPortal and TSM&O DSS
  - Driving simulator data

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Connected Vehicles – Overview

- Vehicle-to-Vehicle (V2V)
- Vehicle-to-Infrastructure (V2I)
- Vehicle-to-Anything (V2X)
  - Pedestrians
  - Bicycles / mopeds
- Connected everything – Internet of Things
- Communications standards
  - Dedicated short-range communications (DSRC) radios
  - Wireless/cellular technologies including 5G

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Connected Vehicle Applications

V2I Safety
- Red Light Violation Warning
- Curve Speed Warning
- Stop Sign Gap Assist
- Spot Weather Impact Warning
- Reduced Speed/Work Zone Warning
- Pedestrian in Signalized Crosswalk Warning (Transit)

V2V Safety
- Emergency Electronic Brake Lights (EEBL)
- Forward Collision Warning (FCW)
- Intersection Movement Assist (IMA)
- Left Turn Assist (LTA)
- Blind Spot/Lane Change Warning (BSW/LCW)
- Do Not Pass Warning (DNPW)
- Vehicle Turning Right in Front of Bus Warning (Transit)

Road Weather
- Motorist Advisories and Warnings (MAW)
- Enhanced MDSS
- Vehicle Data Translator (VDT)
- Weather Response Traffic Information (WxTINFO)

Environment
- Eco-Approach and Departure at Signalized Intersections
- Eco-Traffic Signal Timing
- Eco-Traffic Signal Priority
- Connected Eco-Driving
- Wireless Inductive/Resonance Charging
- Eco-Lanes Management
- Eco-Speed Harmonization
- Eco-Cooperative Adaptive Cruise Control
- Eco-Traveler Information
- Eco-Ramp Metering
- Low Emissions Zone Management
- AFV Charging / Fueling Information
- Eco-Smart Parking
- Dynamic Eco-Routing (light vehicle, transit, freight)
- Eco-ICM Decision Support System

Agency Data
- Probe-based Pavement Maintenance
- Probe-enabled Traffic Monitoring
- Vehicle Classification-based Traffic Studies
- CV-enabled Turning Movement & Intersection Analysis
- CV-enabled Origin-Destination Studies

Mobility
- Advanced Traveler Information System
- Intelligent Traffic Signal System (I-SIG)
- Signal Priority (transit, freight)
- Mobile Accessible Pedestrian Signal System (PED-SIG)
- Emergency Vehicle Preemption (PREEMPT)
- Dynamic Speed Harmonization (SPD-HARM)
- Queue Warning (Q-WARN)
- Cooperative Adaptive Cruise Control (CACC)
- Incident Scene Pre-Arrival Staging Guidance for Emergency Responders (RESP-STG)
- Incident Scene Work Zone Alerts for Drivers and Workers (INC-ZONE)
- Emergency Communications and Evacuation (EVAC)
- Connection Protection (T-CONNECT)
- Dynamic Transit Operations (T-DISP)
- Dynamic Ridesharing (D-RIDE)
- Freight-Specific Dynamic Travel Planning and Performance
- Drayage Optimization

Smart Roadside
- Wireless Inspection
- Smart Truck Parking

Source: US DOT ITS JPO

U.S. Department of Transpor n 7

Connected Vehicles – Preparation

- Communications networking enhancements
- Next generation controllers
- DSRC radios at roadside and in fleet vehicles
- Connected vehicle pilots, including private and public sector partnerships

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Connected Vehicles – Trends

- V2I Deployment Coalition
  - Initiatives, Research, Partnerships, Guidance, Standards
  - SPaT Challenge
- CV Pilots – Tampa, New York, Wyoming
- State Pilot Tests
  - Michigan – MCity, Southeast Testbed
  - Arizona, California, Pennsylvania, Utah
- Standards – CV Reference Implementation Architecture (CVRIA)
- Applications – Open Source Application Development Portal (OSADP)
- Data Sharing – Research Data Exchange (RDE)

- Local Example
  - City of Madison CV Initiatives – Yang Tao

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Automation – Overview

- Autonomous vs. Automated
- Autonomed Vehicles on the road now
  - Google in Bay Area, Austin, Seattle, Phoenix
  - Uber/Volvo in Pittsburgh
  - Tesla's Autopilot
  - Ford
    - Testing in Michigan
    - Production by 2021
- Autonomous Microtransit

SAE level	Name	Narrative Definition	Execution of Steering and Acceleration/ Deceleration	*Monitoring* of Driving Environment	Fallback Performance of *Dynamic Driving Task*	System Capability *(Driving Modes)*
***Human driver* monitors the driving environment**						
0	No Automation	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	Driver Assistance	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes
2	Partial Automation	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/ deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	**System**	Human driver	Human driver	Some driving modes
***Automated driving system* ("system") monitors the driving environment**						
3	Conditional Automation	the *driving mode*-specific performance by an *automated driving system* of all aspects of the dynamic driving task with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	**System**	Human driver	Some driving modes
4	High Automation	the *driving mode*-specific performance by an automated driving system of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	**System**	Some driving modes
5	Full Automation	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	**All driving modes**

Source: SAE International / J3016

Federal Automated Vehicle Policy

- Released in the last two weeks
- Guidelines, not regulations
- Public comment period ~60 days
- NHTSA requires safety assessment letter from manufacturers – 15 areas
- NHTSA tasks states with developing state policies based on their Model State Policy

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Safety Assessment Letter Contents

- Data Recording and Storage
- Privacy
- System Safety
- Vehicle Cybersecurity
- Human Machine Interface
- Crashworthiness
- Consumer Education and Training
- Registration / Certification
- Post-Crash System Behavior
- Federal, State, and Local Laws
- Ethical Considerations
- Operational Design Domain
- Object and Event Detection and Response
- Fall Back
- Validation Methods

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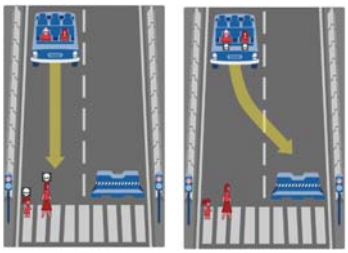
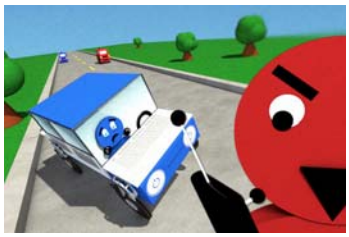
Automation – Concerns

- Winter/adverse weather
- Construction zones
- No-win situations
- Cybersecurity
- Privacy
- Temporary Law Violation



moralmachine.mit.edu



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Automation – Preparation

- What can we do to prepare?
  - Current AVs being developed with existing infrastructure in mind, but future collaboration will improve benefits
  - Stay current with technology and
  - Offer a friendly environment for testing
  - Consider AVs for public transit, state vehicles
- Local Example
  - City of Madison AV Initiatives – Yang Tao

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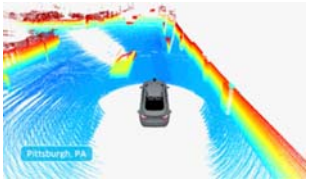
Other Emerging TSM&O Tech

- Variable speed limits
- Curve speed warnings
- Smart parking
- Solar roadways
- Smart pavement
- Truck platooning
- Truck parking
- Flashing yellow arrow
- Advanced mapping w/ LIDAR



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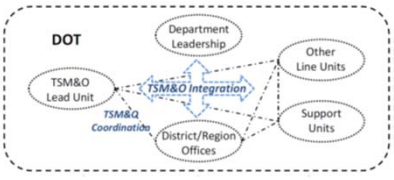
Emerging "Low-Tech" TSM&O

- Remember: Emphasis on problems and how to solve them
- ITS one facet of TSM&O, but there are less technologically advanced solutions
- Examples
  - Congestion pricing
  - VMT tax
  - Crash investigation sites (CIS)
  - Service patrols
  - Work zone management
  - Special event management
  - Transit management
  - Managerial optimization
  - Business process
  - Organizational / culture optimization/collaboration



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Nationwide Trends

- TSM&O pilot programs
  - M-City and other testbeds
  - CV pilots
  - SPaT challenge
- Smart Cities initiatives
  - Columbus update
  - What about the 77 other cities?
- Regional data aggregation/coordination
  - CATT Lab, GLRTOC, etc.
- DOT ITS Commitments
  - Statewide ITS Manager – Michigan
- Federal support and guidance

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New TSM&O Applications in Wisconsin

- ATMS/ATIS – Craig Schanning
- Asset Management – Don Schell
- Work Zone Management – Erin Schoon / Brian Sippel
- Madison Initiatives – Yang Tao / Philip Gritzmacher

- Others?

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Work Zone Queue Warning Systems (QWS)

- WisDOT has been looking for ways to decrease end-of-queue crashes in work zones as well as provide more real-time traveler information to drivers in work zones
- Other states saw a safety benefit and reduced crashes with the QWS
- Wisconsin implemented a QWS in the Milwaukee and Madison area several years ago; however results were not well documented, and technology is getting cheaper and better

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Federal Accelerated Innovation Deployment (AID) Grant

- WisDOT applied for a grant in December 2015 to fund two pilot QWS in the following locations:
  - I-39 near Stevens Point
  - I-39 Rock River Bridge near Edgerton (mega project)
- Grant was approved in May 2016
- As part of the grant, WisDOT will be submitting a detailed analysis and report to FHWA
- Currently developing QWS Decision Support Tool with UW TOPS Lab using data from automated TMP system
  - System will be used to help identify future projects to deploy QWS

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Questions on QWS?

- Contact Information
  - Erin Schoon – BTO Work Zone Operations Engineer
    Erin.schoon@dot.wi.gov
    414-220-6803
  - Brian Sippel – BTO Smart Work Zone Engineer
    Brian.sippel@dot.wi.gov
    414-531-9279

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Retiring Old Technologies

- Highway Advisory Radio (HAR)
  - Support through attrition
  - Focus on rural areas - as rural devices fail, relocate urban systems
- On the chopping block?
  - Inductive loops?
  - DMS?
- What does it mean to “retire” a system
  - No new deployments
  - Support existing units until failure
  - Retire does not equal eliminate
- Evolution of system – another use (of equipment or technology)
  - DMS – transition from traveler info to something else (additional information)
- TSMO-TIP can be used to help make these decisions
  - During needs analysis, benefits analysis, ITS TAG oversight

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5. Next Steps

Next Steps

- Meeting Synopsis – Available next week
- Meeting Survey – Emailed next week
- Technology Report – Available in late October
- ITS TAG Meeting / Technology Discussion – 1:30p-3:00p
  - EH 2227 (building across Randall Avenue)
- 2016 ITS Wisconsin Forum
  - Tomorrow, here at Union South, Varsity Hall

- Questions?
- Thank you

Additional Resources

- TSMO-TIP Official Webpage
  - http://wisconsindot.gov/Pages/about-wisdot/who-we-are/dtsd/bto/stoc/tsmo-tip.aspx
  - Documentation
  - Needs Analysis Tool
  - Benefits Tool
  - Instructional Support
  - Regional Workshop Materials
  - Summit Materials

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