TRANSPORTATION
systems operations

2019
Operations Program Annual Report

Oregon Department of Transportation

introduction

Another year has come to a close which brings me to one of my favorite times of the year – assembling the operations program annual report. I enjoy the process because I get to focus on the great work that has been done across the program and celebrate our accomplishments. With that in mind, here are a few highlights I'd like to mention, many of which are illustrated in this report.

January: At the Transportation Research Board (TRB) annual meeting, ODOT received the National Operations Center of Excellence (NOCoE) Public Communications Award for our use of social media to engage first responders across Oregon to promote traffic incident management best practices.

April: Brought three major events:

- FHWA awarded ODOT a $12M Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD) Program grant. For more information, see page 3.
- We released the Response Plan System (RPS). More information can be found on page 19.
- In partnership with Metro and the local agencies in Portland, we released an update to the TripCheck Local Entry system. More detail can be found on page 7.

July: The majority of our ITS systems connect through a firewall in Salem which was at end of life. The team successfully executed the replacement through careful planning and excellent execution of the plan.

September: Phase 2 of the Oregon Automated Vehicle Task Force wrapped up. The final report included overviews of many important topics for the state to think about in planning for automated vehicles including the potential for impacts to road and infrastructure design.

October: We released a software enhancement to allow maintenance and incident response employees to complete the required major incident report electronically, for details, see page 20.

November: Traffic HQ staff completed the third year of rating traffic signals with the new condition rating methodology.

December: TDD and the Operations Program hosted FHWA Planning for Operations training – one of the action items identified in the Operations Program Plan. This training provided staff with best practices as we look to further mainstream operations concepts and include operations in various planning processes.

These are a few of the significant accomplishments from the year, and the danger in making lists like this is it fails to recognize the many other contributions that Operations Program staff make on a day to day basis. So thank you to everyone that has contributed to the success of the Operations Program this past year, and I look forward to continuing to work together to improve the safety and efficiency of our transportation system.

Galen McGill, Systems Operations & ITS Manager

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its projects

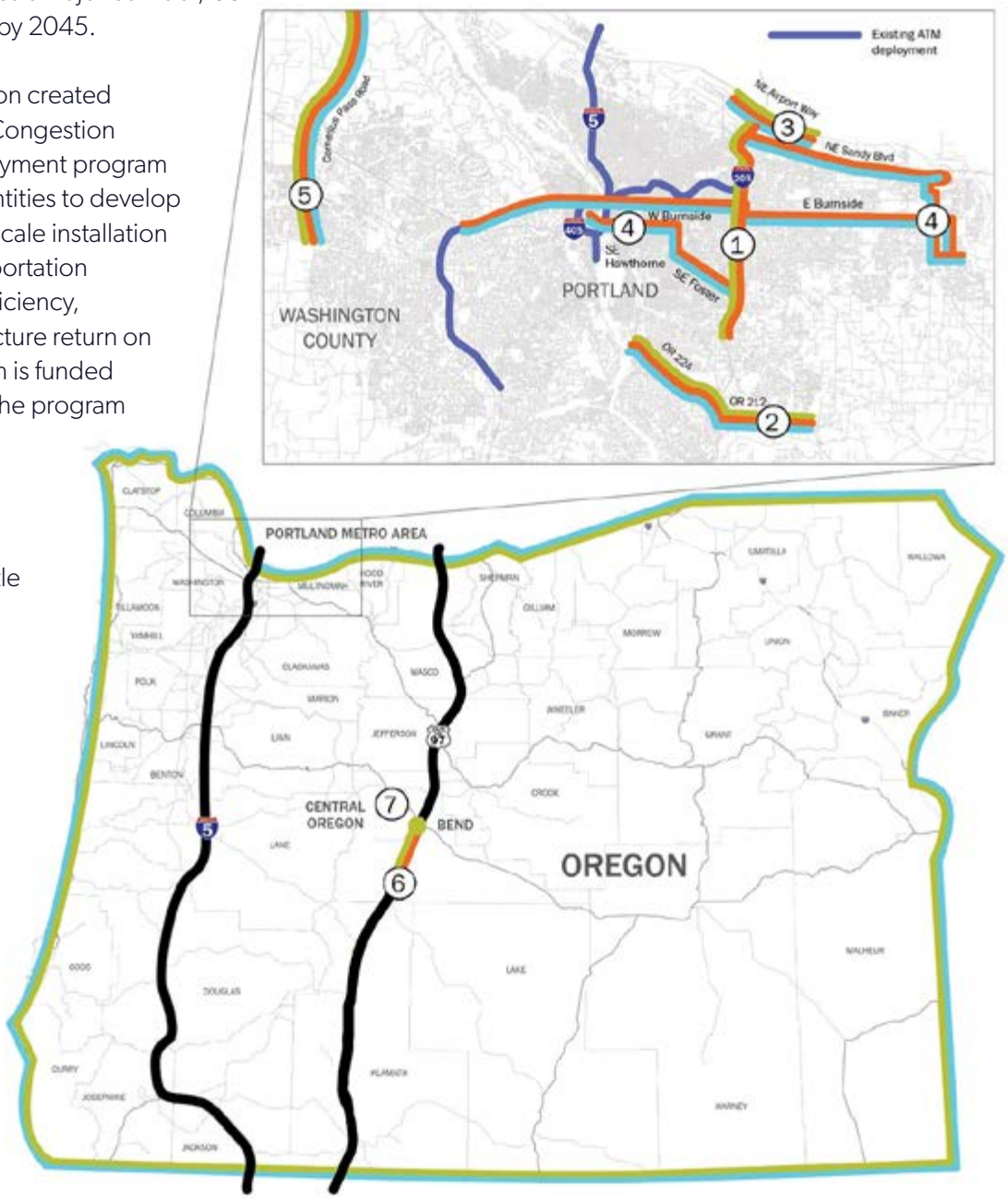
The Intelligent Transportation Systems Engineering team worked on approximately 105 projects in support of ITS and traffic signal operations in 2019. This included projects at the planning, engineering design and construction support stages. Some noteworthy projects include:

ATCMTD GRANT

Oregon is experiencing unprecedented growth. For the past four years, Oregon has been one of the top two US destinations for inbound moves, with 2.2 million more people expected by 2065. Oregon tourism has increased 74% since 2003 and is now an $11.7 billion industry. And since 2015, Port of Portland's marine terminal is no longer served by major global cargo container shippers, meaning that interstate freight mobility will rely heavily on trucks traveling between Portland and Tacoma/Seattle.

All these factors have combined to make Portland area traffic the 12th most congested in the nation, with delays collectively costing $3.9 billion in fuel and lost time. As congestion in the Portland region affects travel time and the distribution of trips, so too does the growing congestion in Central Oregon. Bend, the region's largest city, is the fourth fastest-growing metro area in the country. Freight volumes on the area's major corridor, US 97, are expected to increase 45% by 2045.

The Federal Highway Administration created an Advanced Transportation and Congestion Management Technologies Deployment program that provides funding to eligible entities to develop model deployment sites for large-scale installation and operations of advanced transportation technologies to improve safety, efficiency, system performance, and infrastructure return on investment. The ATCMTD program is funded at $60 million per year. This year, the program funded 10 projects valued at $53 million. ODOT was awarded $12 million for its Smart Mobility Network project. ODOT and its local partners are contributing a little over $19 million as match funds. ODOT's partner agencies for the Oregon Smart Mobility Network program include the Portland Bureau of Transportation (PBOT), TriMet, Metro, Oregon State Police, Portland State University, Washington and Multnomah Counties, and the Cities of Bend and Gresham. Nine projects selected for the program deploy 30 smart technologies to form an integrated and cohesive congestion planning, management, and recovery program serving all modes.



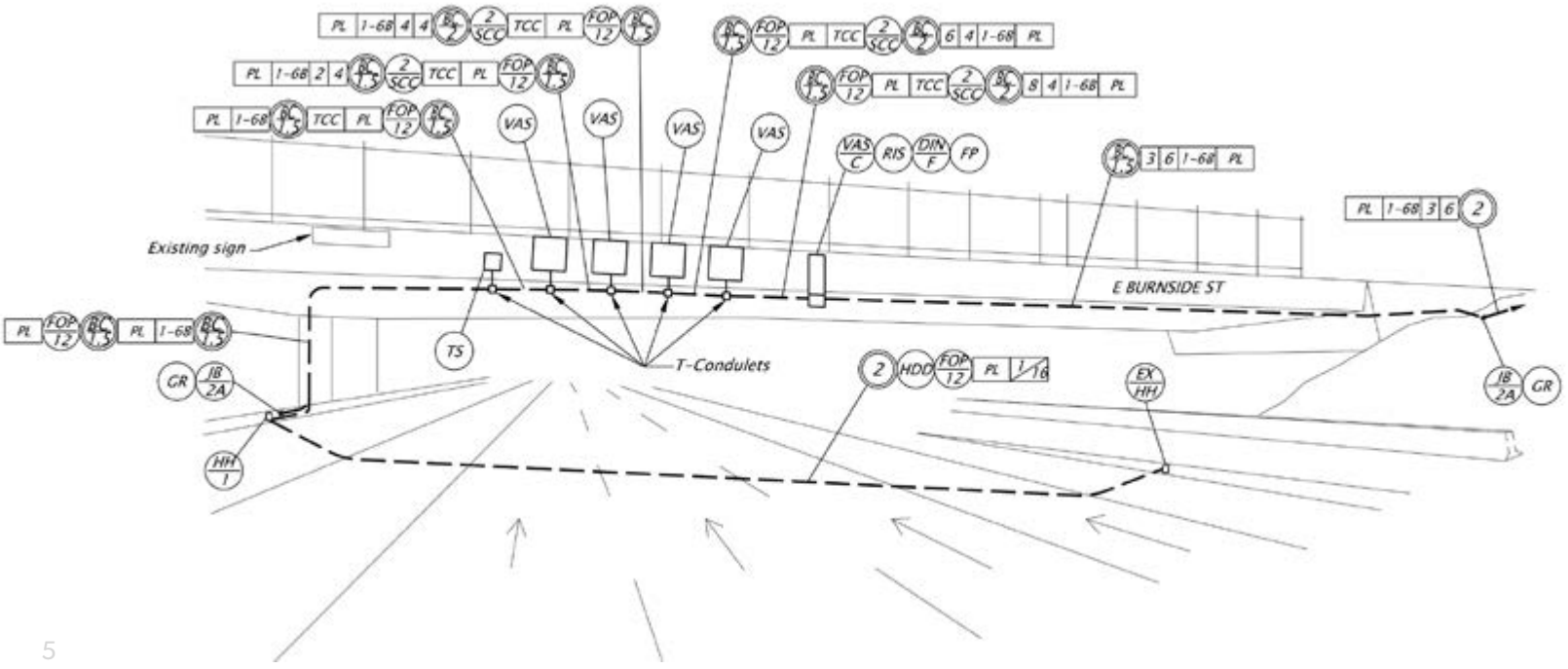
Since the award earlier this year, the Operations team has worked diligently drafting intergovernmental agreements, developing evaluation plans, working on STIP/MTIP amendments, setting up funding accounts, and reporting progress to FHWA with plans to get projects started in 2020.

	PROJECT
1	**I-205 Johnson Creek-Glen Jackson Bridge (ODOT - R1 Traffic)** Active Traffic Management, RealTime system, auxiliary lanes
2	**OR212/224 Arterial Corridor Management (ODOT - R1 Traffic)** Traffic signal intersection equipment upgrades and signal performance measures for improving operations
3	**NE Airport Way Arterial Corridor Management (PBOT)** Traffic signal intersection equipment upgrades, signal performance measures, variable message signs and cameras
4	**Next-Generation Transit Signal Priority (ODOT/TriMet/PBOT)** Central software based traffic signal pre-emption and priority control system. TriMet's central AVL software will connect to ODOT's and PBOT's central traffic signal software
5	**Cornelius Pass Rd Arterial Corridor (ODOT/Washington Co/Multnomah Co)** Traffic signal intersection equipment upgrades, signal performance measures, variable message sign, curve warning system, road and weather station, and adaptive pedestrian operations
6	**US97 Road Weather Management (ODOT R4 Traffic)** Weather based variable speed limit system along US97 near Bend
7	**City of Bend Colorado/Arizona Couplet ATSMPs (ODOT R4 Traffic/City of Bend)** Traffic signal intersection upgrades, communication improvements, and signal performance measures for improving operations
8	**Unmanned Aircraft System (UAS) Crash Reconstruction (ODOT ITS /OSP)** Using drones for lowering the time it takes to reconstruct an incident scene along freeways, thus reducing congestion
9	**Multimodal Integrated Corridor Management Architecture (ODOT/Metro)** Regional planning activity for operational improvements

I-205 - GLENN JACKSON ATM PROJECT

This project included operational and safety improvement that combined an auxiliary lane, Active Traffic Management (ATM) systems on freeways, and performance monitoring to reduce crashes, improve travel time reliability, safety and operations on I-205 between the Glenn Jackson Bridge and the Johnson Creek Blvd structure. This operational project was identified in HB2017 as needed to be completed by December 1, 2019. Region 1 Project Delivery, working with the ITS engineering and maintenance staff, developed an aggressive schedule to meet HB2017's timeline.

A new bent monotube structure design developed by Traffic HQ was used. The structures and variable message signs were procured early in parallel with the design phase to meet the project schedule. ITS maintenance staff made commissioning of the variety of sensors, variable message signs, and communication equipment a priority in order to meet the aggressive construction schedule. The construction phase of the project was completed in October 2019.

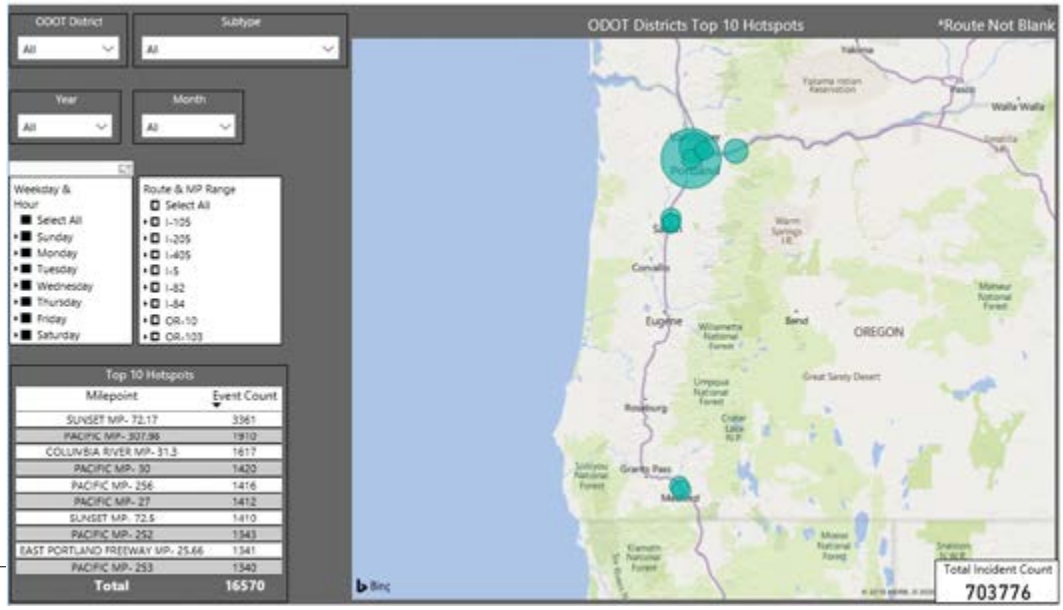


system operations performance measures

The Performance Management Plan is nearly three years old and we are making great strides in providing meaningful measures in many program areas. We have better access to data, are adding new data and are making the reports more accessible to audiences who use the reports.

INVIEW

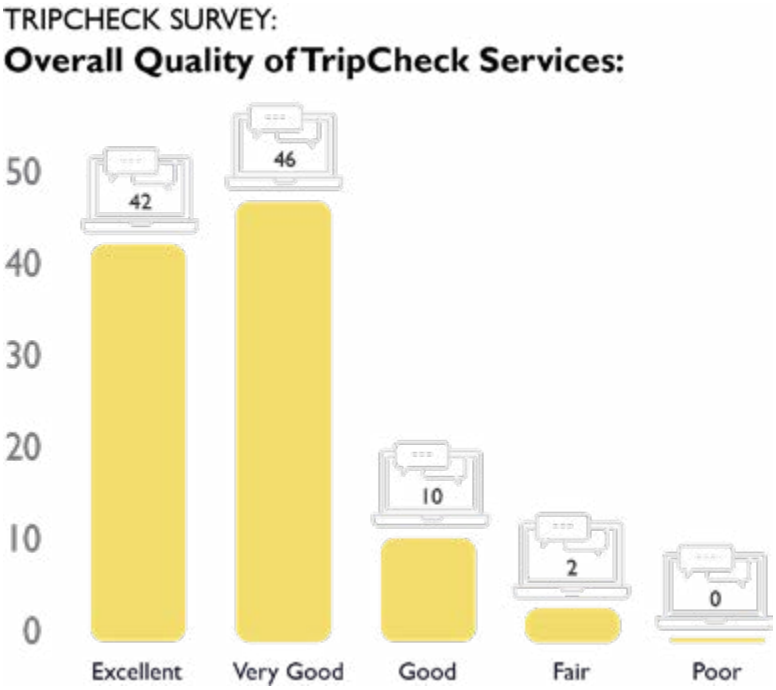
This year we added more reports to the Inview reports page. Through the general reports link on the left, dashboards, incidents, inventories, clearance times and more can be accessed.



TRIPCHECK SURVEY RESULTS

A survey of TripCheck users was completed in early 2019. ITS partnered with Oregon State University's Survey Research Center to design and implement the survey. 5,748 people accepted the invitation to participate in the survey. Some of the survey results were intriguing. For example, 77% of respondents live in areas other than the Portland/Metro compared to 70% during the last survey in 2013. Cameras are still the most popular feature of TripCheck, with mountain pass camera's receiving the most use, as supported by Google Analytics. Yes, that's nearly 169M camera views last year!

Also interesting, according to the survey, nearly 79% of those answering the survey altered their commute based on information provided to them via TripCheck.



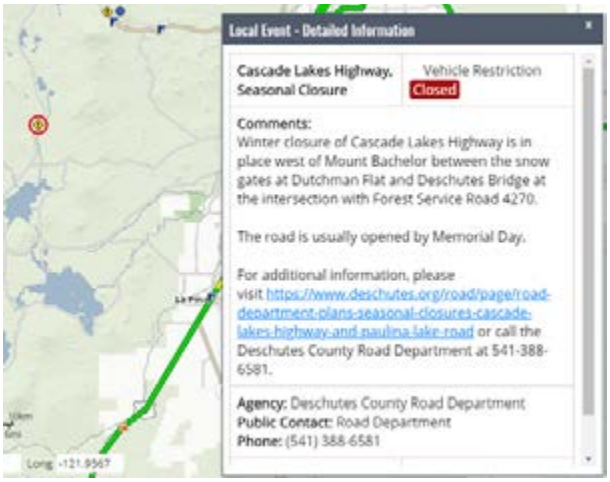
Event Label	Total Events
	168,899,069 % of Total: 71.34% (236,762,015)
1. US20 at Santiam Pass(567)	2,523,770 (1.49%)
2. US20 at Santiam Jct(401)	2,372,591 (1.40%)
3. US20 at Santiam Jct(719)	2,372,549 (1.40%)
4. US20 at Sisters(236)	1,514,568 (0.90%)
5. ORE58 at Willamette Pass(207)	1,445,314 (0.86%)

traveler information

Traveler information is more than TripCheck and 511. Included under the Traveler Information umbrella is TripCheck Local Entry (TLE) and TripCheck API (formerly TTIP). Both of these systems serve to enhance the traveler experience today and into the future.

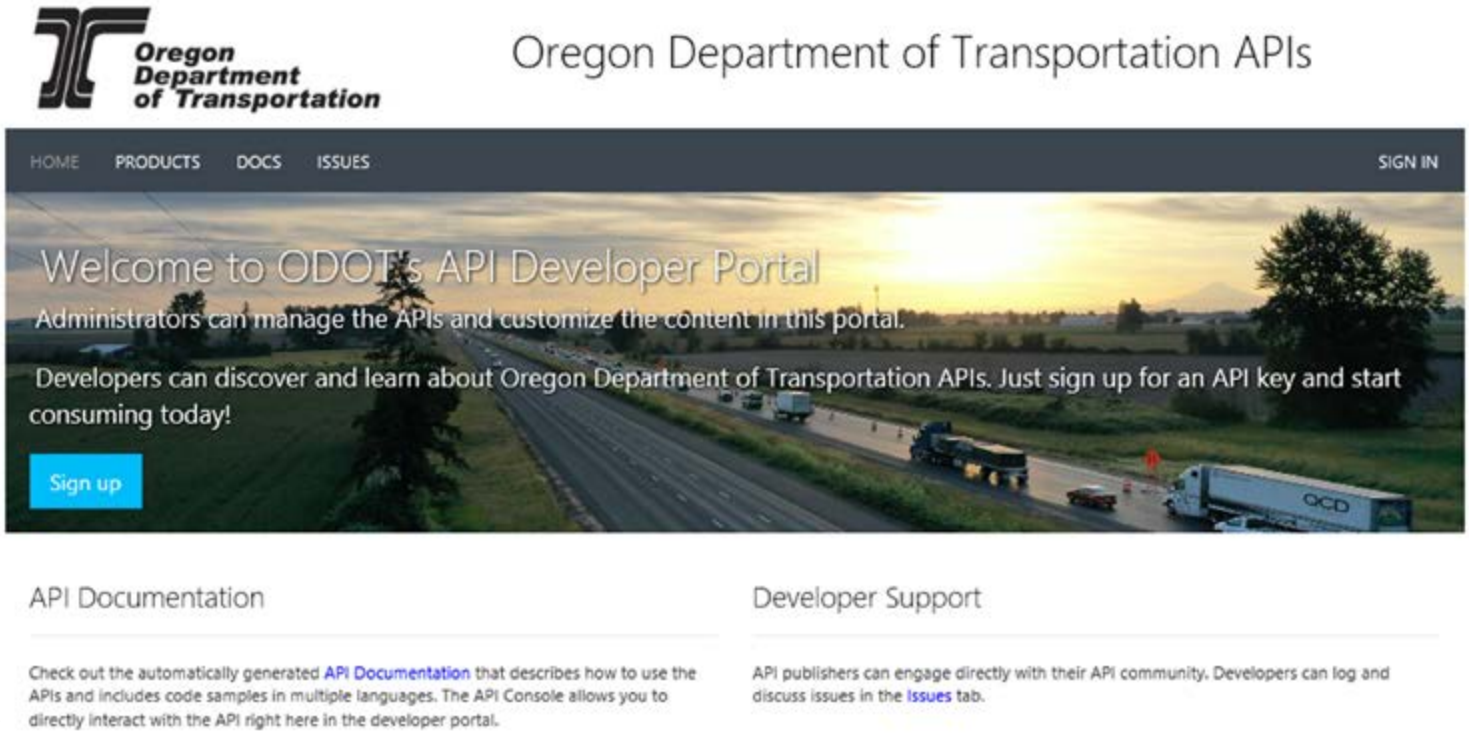
TRIPCHECK LOCAL ENTRY (TLE)

In collaboration with Metro and the TransPort Committee in Portland, the TLE Modernization project was completed in April 2019. It is meant to improve the user experience for local agencies and increase the number of local events on TripCheck. At the end of the year we have 24 organizations with 64 users who created 524 local road events which were all on TripCheck.



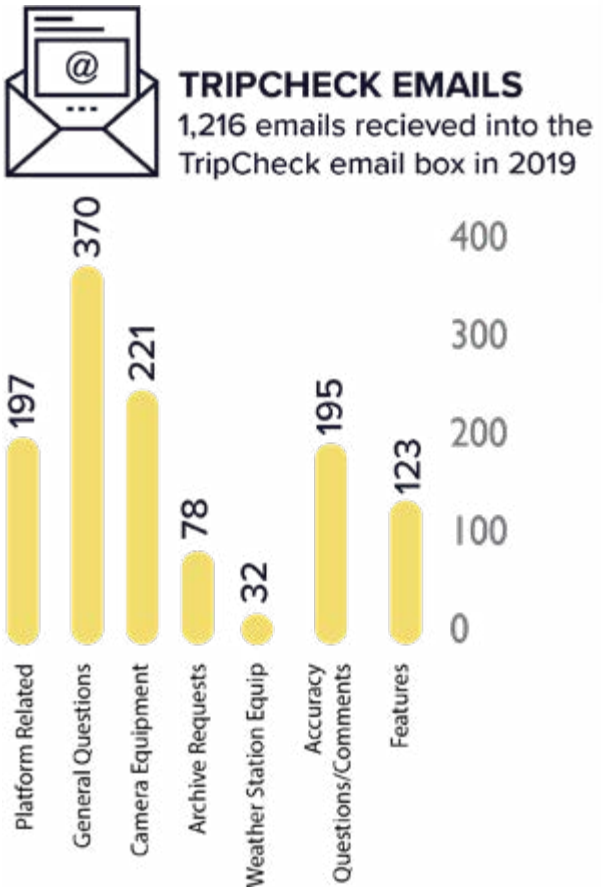
TRIPCHECK API

A project to replace our 12 year old TripCheck Traveler Information Portal (TTIP). It is planned to go live during the first quarter of 2020. The TTIP Modernization project will re-engineer the TTIP system to improve the usability and efficiency of the portal. TTIP and the new API will provide real-time operations data to subscribing organizations, including news organizations and businesses. The type of data provided includes information about crashes, Road construction, Maintenance activities, Travel time, Traffic volume and Camera feeds to name a few. The API will use modern formats and technology, improve refresh rates and standardize data feeds.



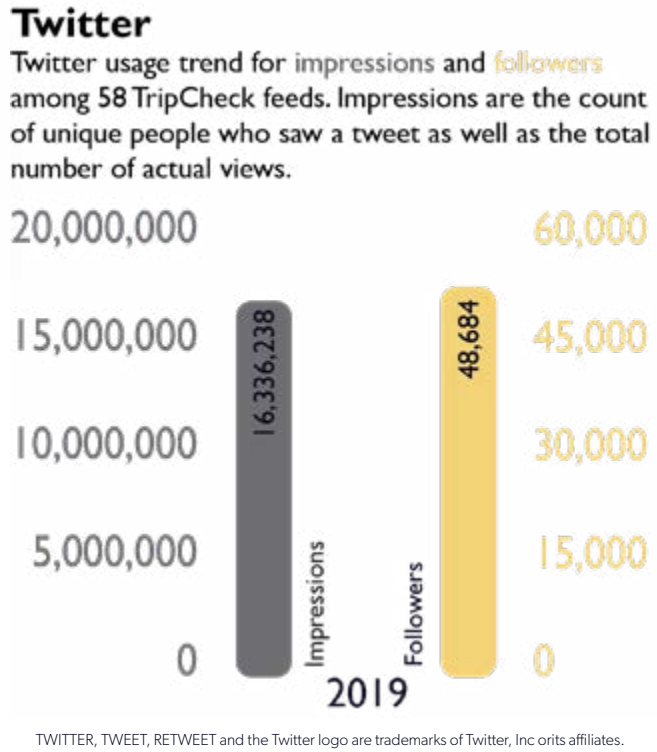
USAGE

We invite the public to email us with TripCheck related comments or concerns.



TWITTER

TripCheck uses Twitter to provide up to the minute information to its followers on specified sections of highway in Oregon.



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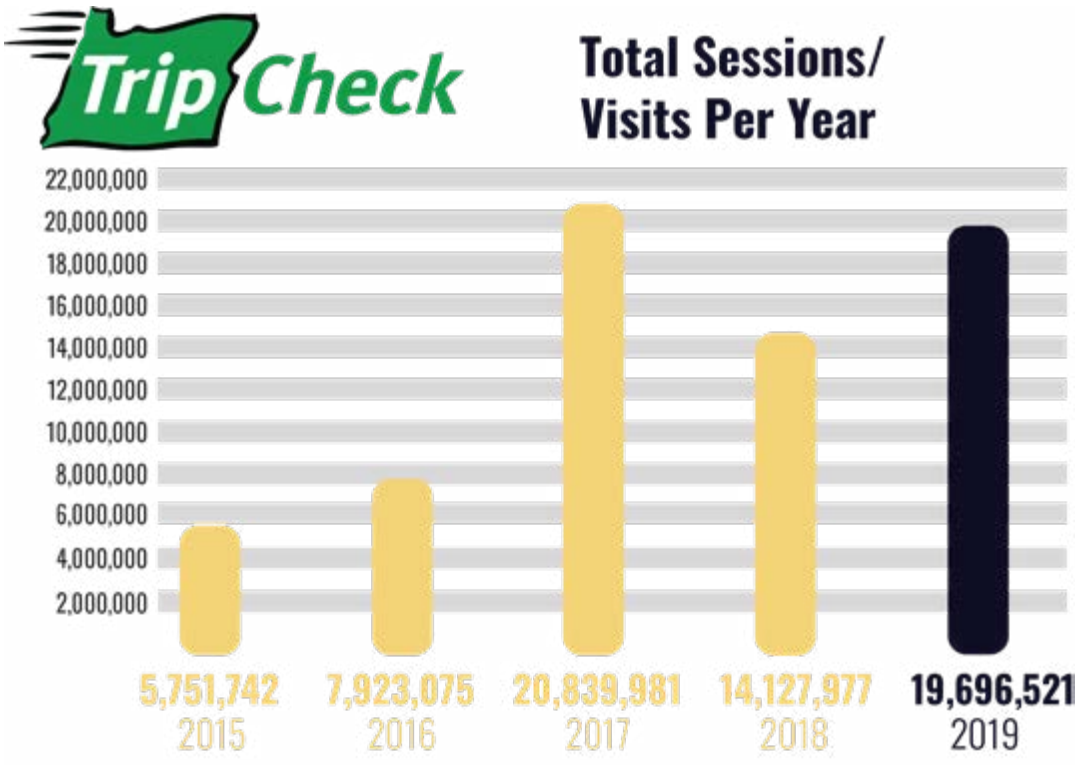


TRIPCHECK

TripCheck continues to be a vital source of information for the traveling public in Oregon. Many use the service to help them decide how to get where they are going safely. As an example, one user told us: **"I use TripCheck on a daily basis. It is wonderful to use and the additional cameras are essential since I drive daily. Thank you so much for all the updates and improvements!"**

traffic incident management

The Traffic Incident Management team's goal is to promote 'Safe, Quick Clearance' through multiple ways including; conducting TIM team meetings, training responders and through social media. Since the implementation of the TIM Strategic Plan, we have trained 6,994 Oregon first responders. By sharing best practices we have reached over 23,000 people on a single post through Facebook in 2019.

OREGON REGIONAL TIM TEAMS

ODOT has been facilitating TIM team meetings for several years across the state and this year we added teams in Astoria, Columbia county, and Roseburg.

TIM Teams are an invaluable resource to ODOT and our partner agencies, allowing all responders to gather, grow relationships, get local updates and learn about other disciplines.

2019 ANNUAL TIM CONFERENCE

This year, responders from across the country gathered on a beautiful September day in Salem with the common goal of responder safety and education. This years conference was big, including 113 responders - the biggest group we've had. It included equipment demos - the tow participants flipped a bus. Additionally, we had attendees from Washington, California and Georgia joining the Oregon responders.

Not only was it big, but it had a different feel to it. There were stations set up that educated our partners on specific topics such as crash evidence, heavy tow operation, work zone set up, and hybrid and electric vehicle safety. In addition to the outdoor activities we addressed a not so pleasant topic, post traumatic stress awareness. ODOT's own Todd Mundinger addressed the uncomfortable topic in a presentation he has delivered many times, but never to such a diverse crowd. The topic was well received and we truly brought these responders together as a family. Thank you to Todd for such an incredible job on this presentation.

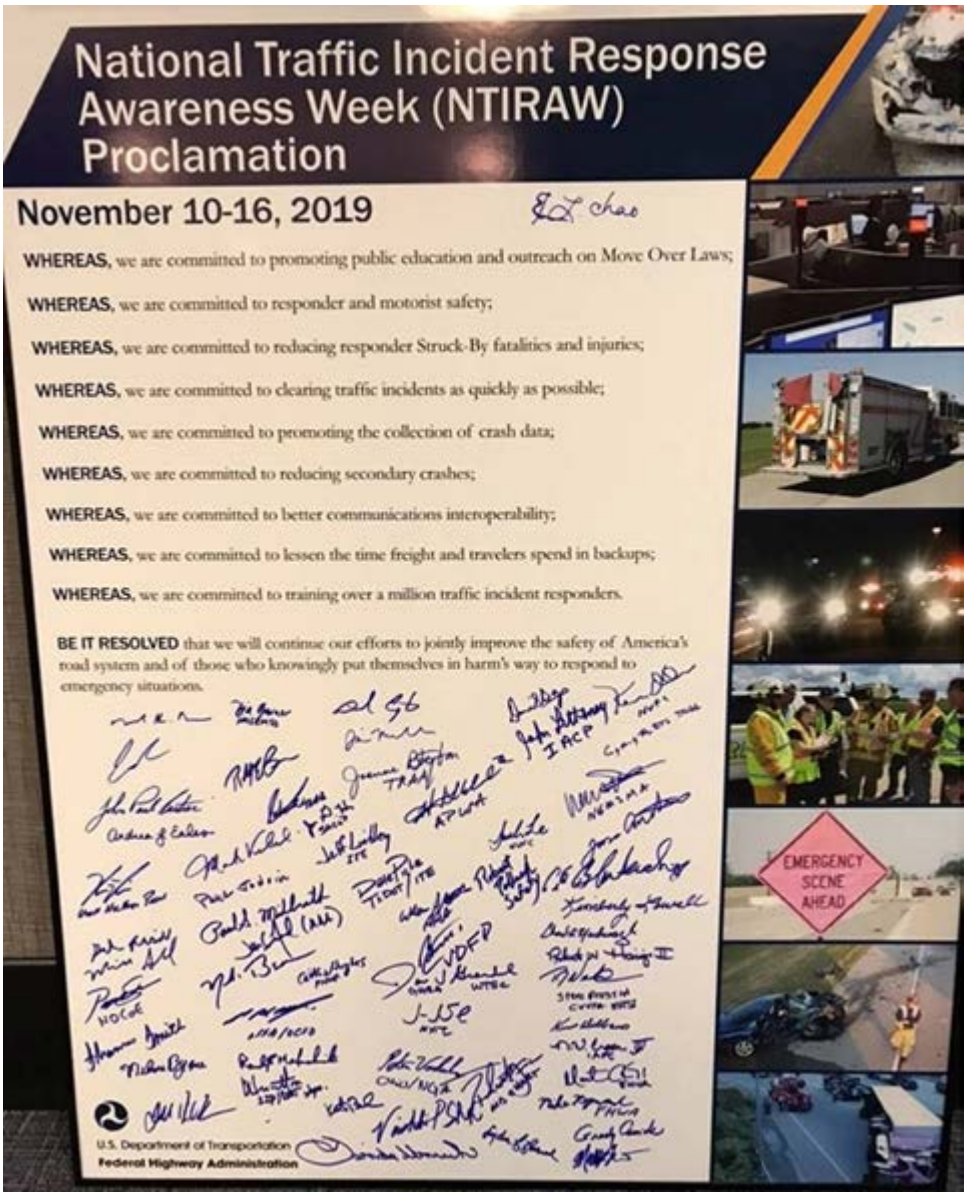
In addition to Todd's presentation, our own Jess McGraw delivered a presentation about the importance of communicating, illustrating the Move It law and other TIM communication campaigns we conducted over the year.

TIM EXECUTIVE SUMMIT IN DC

by Galen McGill

On November 14th and 15th, I had the opportunity to attend the 3rd Senior Executive Transportation & Public Safety Summit in Washington DC. The summit was organized by the US DOT during National Incident Response Awareness Week as a follow up to the previous two summits held in 2012 and 2015 respectively. The event brought together leadership from the national organizations representing all of the first responder disciplines to continue to advance first responder and motorist safety while also mitigating the impacts of traffic incidents on the transportation system.

The focus was first responder safety. In her comments to summit attendees, Elaine Chao, US Secretary of Transportation, reported that 39 first responders had lost their lives along our nation's roadways in 2019. The victims included 15 law enforcement officers, 13 towing professionals, 8 firefighters, and 3 mobile mechanics. In her comments she said, ***" These awful, needless tragedies have got to stop."*** She added that while all 50 states have move over laws, more work is needed to improve driver awareness and compliance with these laws.



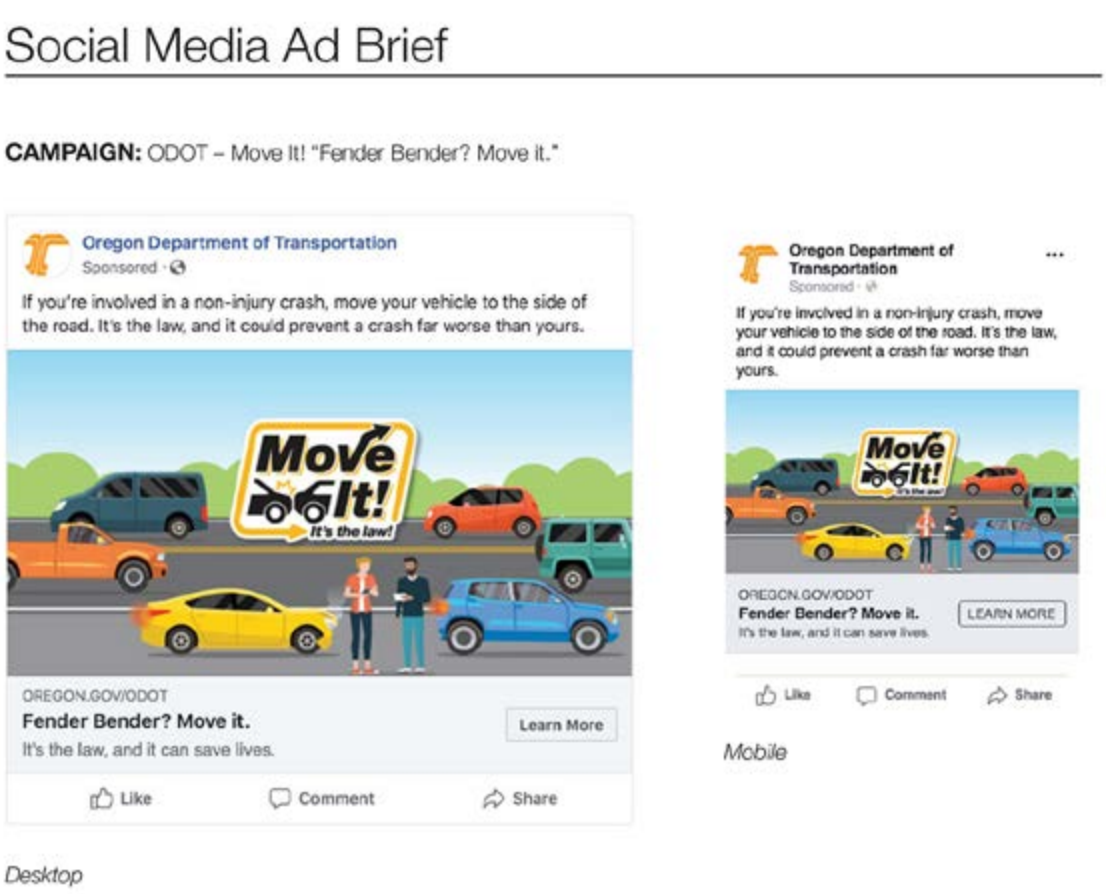
Jane Terry from the National Safety Council reported results from a 2019 survey performed by her organization related to driver behavior around emergency vehicles. An alarming number of drivers **(71 %)** self-report having used their phone to take photos or videos of an incident scene. In addition, **60 %** report posting to social media, and **66%** report sending an email about an incident all while driving a vehicle. It is no wonder that **1 in 10** of survey respondents report having struck or nearly struck a first responder. Also, **24%** of drivers reported being unaware of the existence of move over laws. In spite of this, **62%** of drivers rate themselves above average when driving through emergency scenes. Clearly there is more work to be done to reduce distracted driving and improve awareness of move over laws.

These are just a few highlights from a couple of the 30+ presenters at this event. I was invited by FHWA to present about Oregon's use of data to improve our Traffic Incident Management (TIM) Program. I'm proud that Oregon is recognized as a national leader in this area that we were invited to participate in this event. In the closing ceremony, Martin Knopp, FHWA Associate Administrator for Operations, highlighted the progress made to date as we close in on 500,000 first responders trained in TIM best practices. He also discussed the work left to do. As the event closed, I was glad to add my signature to those of the other summit participants on a proclamation committing to continued efforts to pursue TIM safe, quick clearance goals.

COMMUNICATION

Communication continues to be an important component to the success of the TIM program. This year we focused on reaching the public to promote the Move It law.

The Move It law keeps motorists and responders safe. If you crash your vehicle, you are required to remove your vehicle from the travel lane if you are able to safely do so and no one is seriously injured. The reality is, law enforcement may not be able to get to the incident in a reasonable amount of time. Moving vehicles involved in a fender bender keeps lanes moving and reduces further injuries or secondary crashes.



To improve awareness of the Move It law, we worked with a creative team to build deliverables for Facebook, radio, and movie theaters. The team also generated items like brochures and training videos so we could continue our outreach into the future.

Oregon TIM Responder Training Program

2017	2018		2019
360	679	FIRE/RESCUE	337
514	214	TRANSPORTATION & PW	10
117	160	LAW ENFORCEMENT	185
75	103	TOWING/RECOVERY	71
28	40	OTHER	11
33	4	ONLINE	0
17	3	EMS	2
1,144	1,203	TOTAL TRAINED DURING THE YEAR	616

6,994 Total Trained

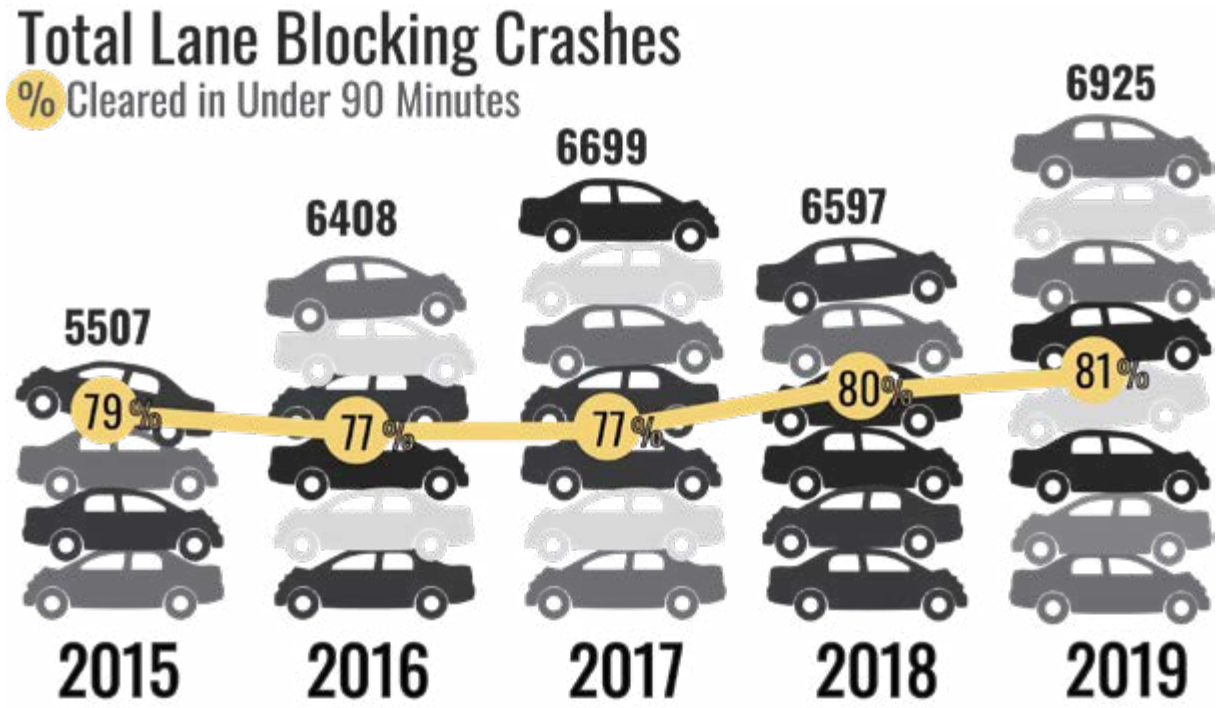
TIM TRAINING

Although we did not have as many sessions or responders trained as in past years, we did conduct larger training sessions. For example, we trained 116 patrol division deputies in 8 sessions, at the Multnomah County Sheriff's office. We will to continue to promote TIM training in 2020.

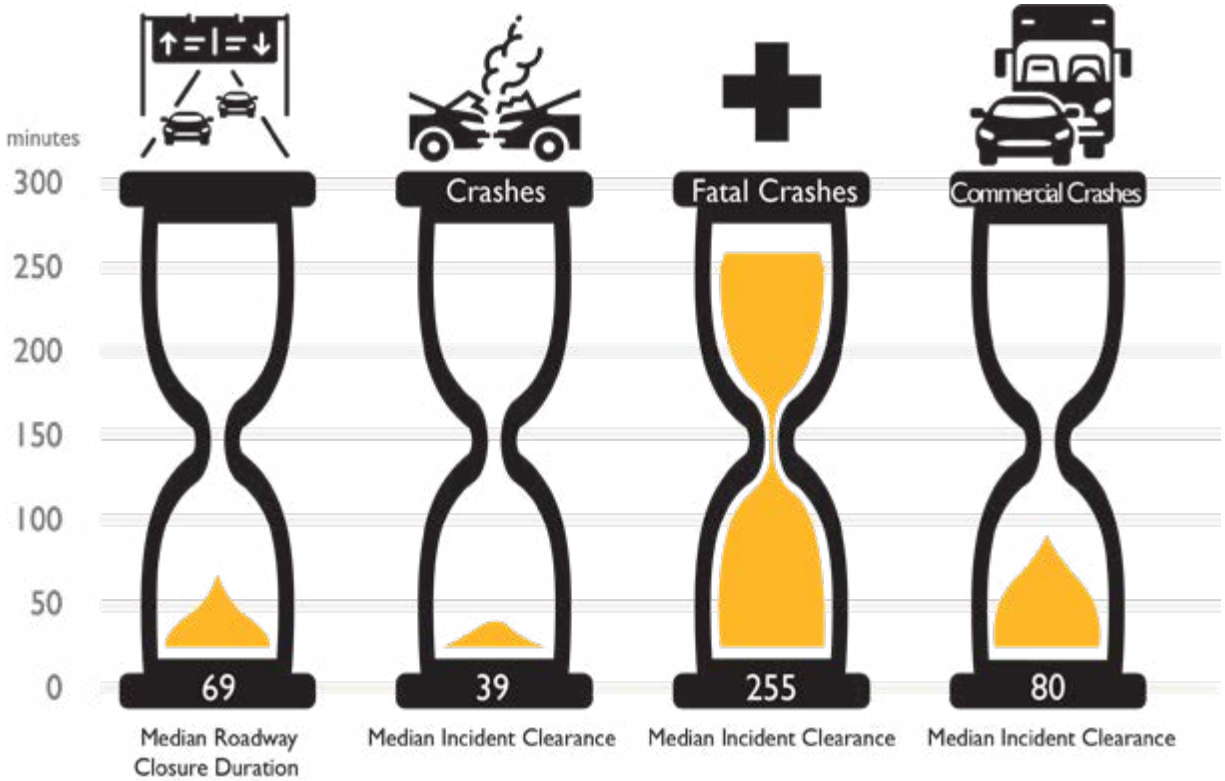
PERFORMANCE MEASURES

TIM performance measures enable us to identify trends, prioritize program activities, track performance and set realistic goals.

One of ODOT's key performance measures is the percentage of lane blocking crashes that are cleared in 90 minutes or less. The goal is 85% and as you can see from the graphic, we made a slight improvement, clearing 81% of crashes within the 90 minute goal while dealing with an increase in number of incidents. A snapshot of 2019 Oregon State Highway incidents performance measures is shown here.



2019 STATE HIGHWAY TIM KEY PERFORMANCE MEASURES



traffic systems services unit

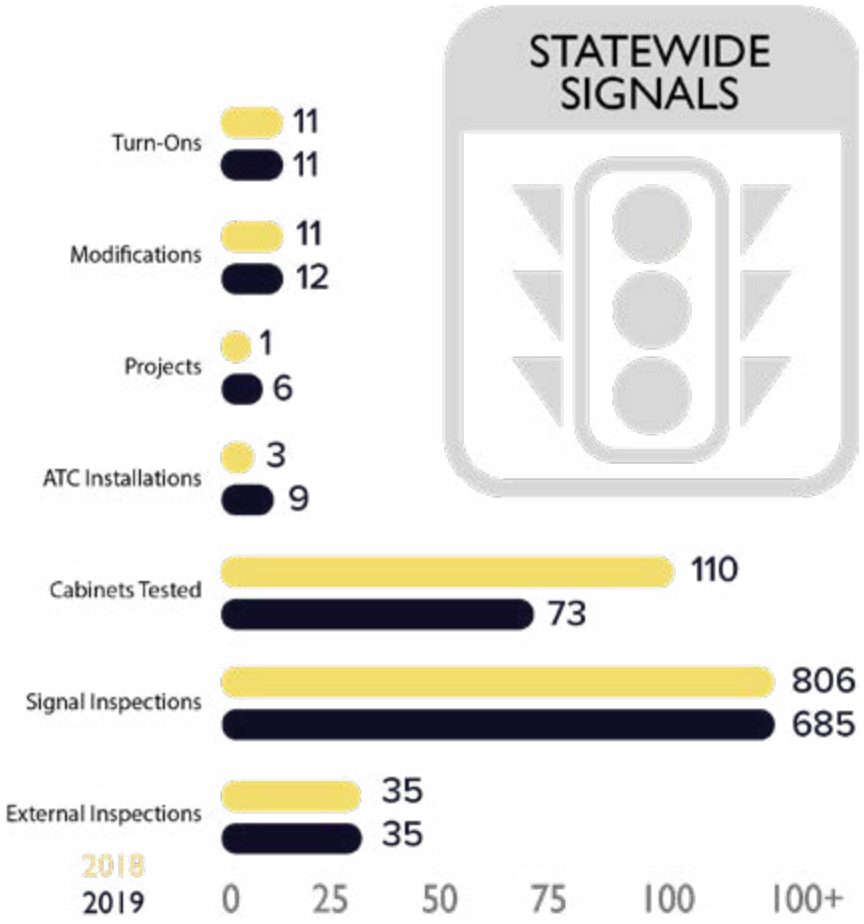
The Traffic Systems Services Unit works with the electrical, traffic and signal timing staff to ensure new signals and cabinets are tested properly, installed to code and existing systems are inspected annually. In every corner of the state, they have completed a significant amount of work in 2019.

CHANGES

2019 was the year of change for TSSU. One of the largest changes being in staffing. With several retirements, hires and coverages being adjusted, they were still able to maintain over half of their annual signal inspections, conduct both level 1 and level 2 signal classes and assist with 26 bridge cathodic protection inspections and maintenance. Since both of the chamber technicians retired, there was significant effort in documenting chamber processes, making improvements and cross training.

Another notable change, was to the TSSU building itself. Because of its age, asbestos was a real concern and abatement was conducted, and allowed for updated flooring to be installed. New storm drains to prevent further room damage were also installed and the roof damage was also repaired.

The conversion of the file area to a conference room now gives staff a dedicated place to meet as opposed to someones desk or break room table.

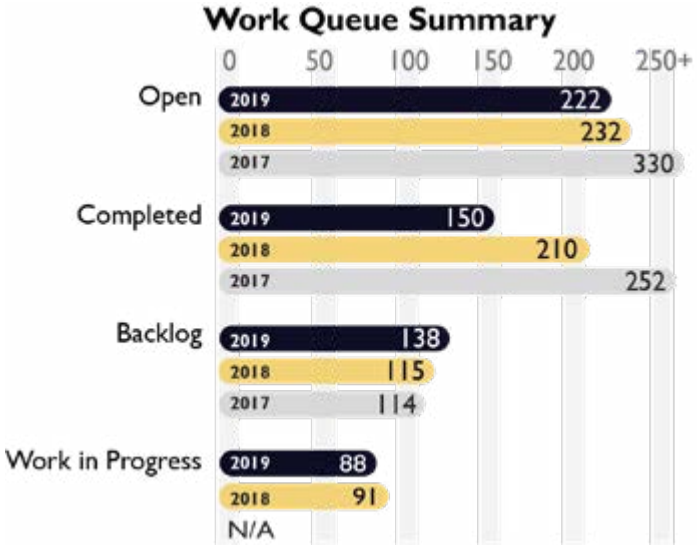


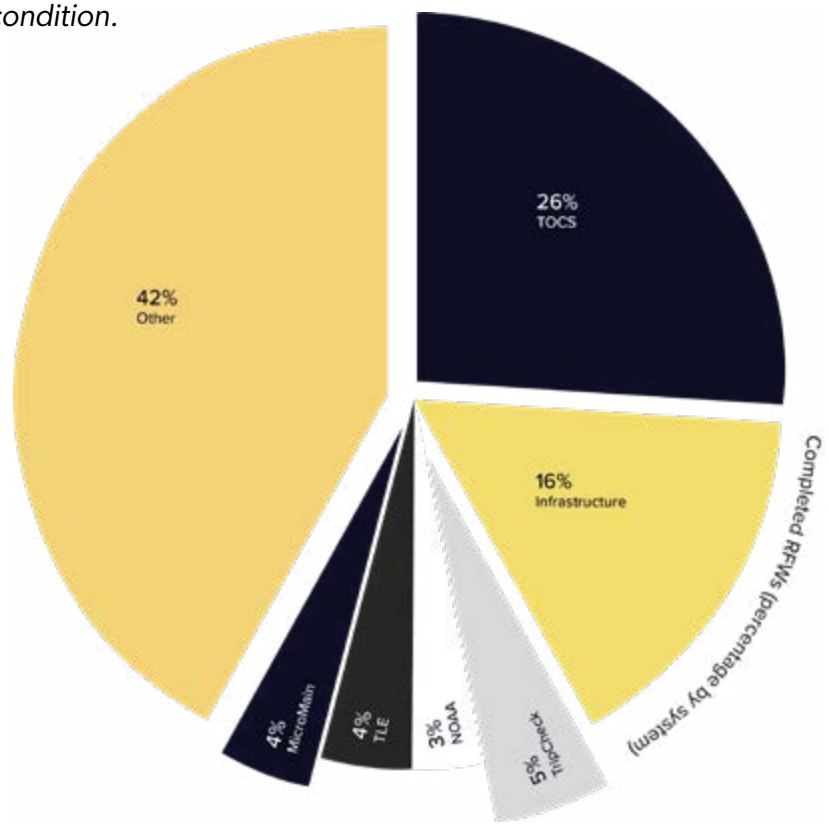
A large, grass lot has always been a part of the property and was unused until 2019. The lot was fenced and graveled to accommodate the storage of ITS equipment that was waiting to be installed. Additionally, it allowed for room for large trucks to enter and exit the property in a safe manner.

its central systems

Behind all of our roadside equipment are approximately 44 software systems that monitor road conditions, process data and take action 24/7, 365 days per year. The Central Systems Team monitors and maintains these systems and associated hardware to keep them in peak operating condition.

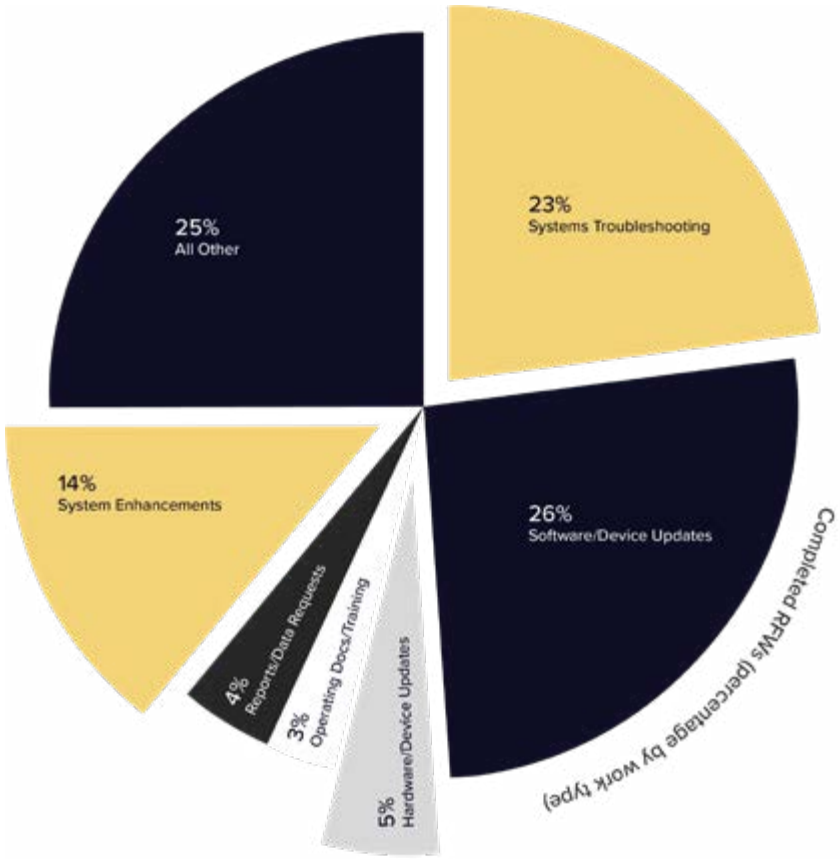
This year, the Central Services team completed 68 software deployments, navigated through 13 SWAT (critical, all hands on deck) situations and 124 emergency tickets .





Notable 2019 ITS Maintenance Accomplishments

- Launched the Response Plan System statewide and decommissioned ATMS
- Released a completely new TripCheck Local Entry application
- Two MicoMain maintenance releases deployed and interface to Kronos implemented
- Released the ITS Device Console application
- Implemented video sharing across regions and with Oregon State Police
- Releases two upgraded versions of the Central Ramp Metering System
- Deployed new improved version of the Overlength Detection System
- MaxView Connected Vehicle pilot implemented
- Major Incident Report solution released to production
- 21 pieces of IT equipment upgraded or decommissioned
- 11 software upgrades/maintenance releases
- 3 new software systems deployed



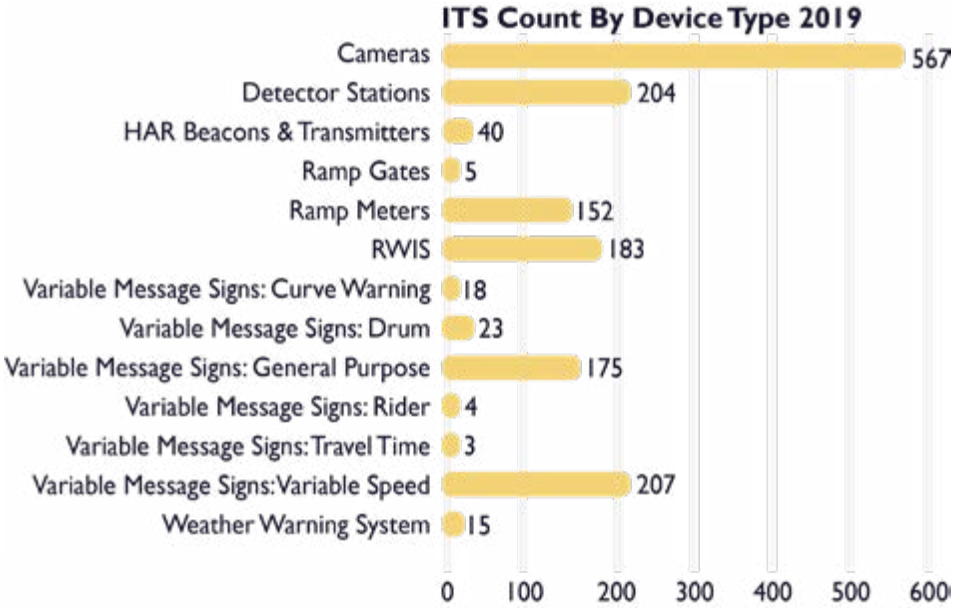
its field maintenance

2019 was another busy year for the ITS Field Maintenance team. From installing new equipment to repairing and maintaining the existing equipment, this team is always on the move across our great state.

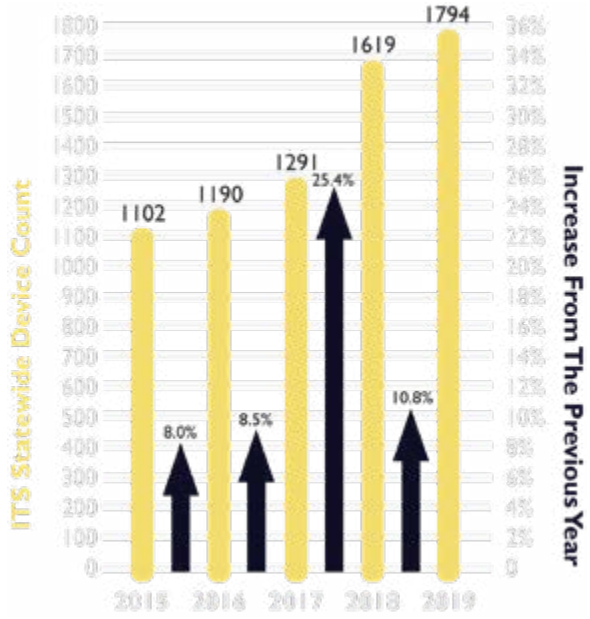
ITS DEVICES

The ITS device growth trend continued in 2019. ITS devices are the backbone of many System Operations strategies such as TripCheck, Traffic Incident Management and Active Traffic Management.

While much of our ITS inventory is fairly new, some of the early ITS equipment is reaching the end of it's design life. The Asset Beyond Design Life Percentage graph shows what would happen to the percentage of equipment beyond design life if no investment is made to replace.



**Classes listed here are permanent, non-signal devices*

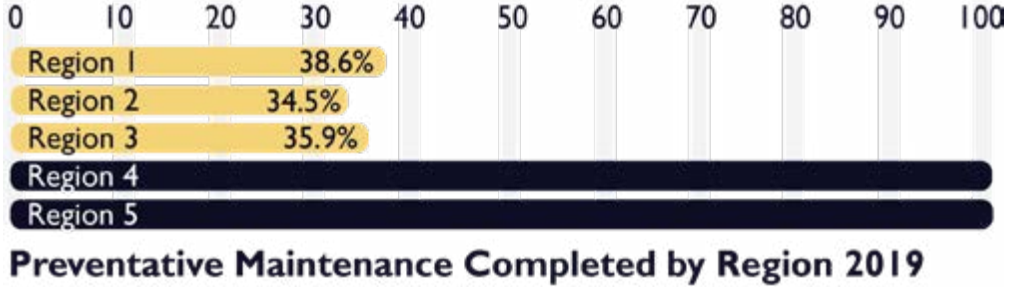


Asset Beyond Design Life Percentage

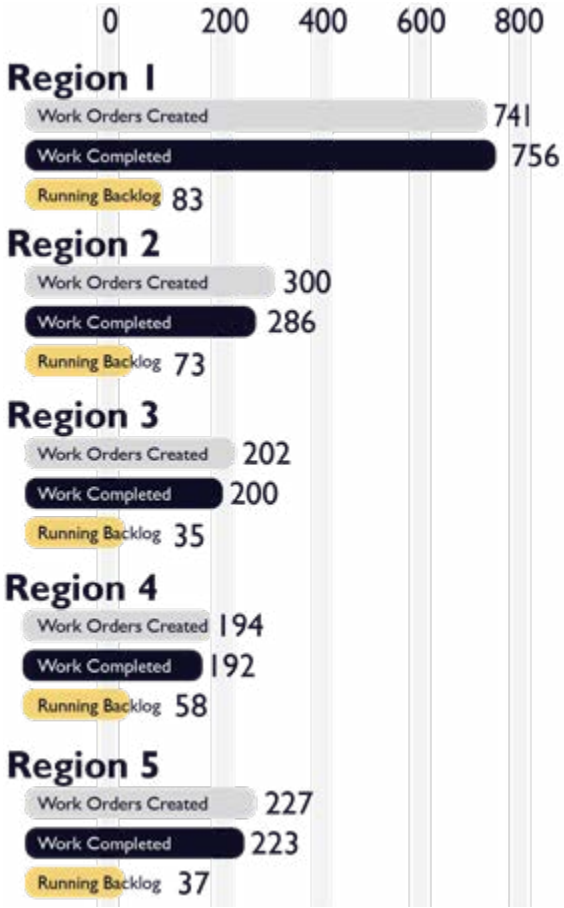
	2017	2018	2019	2020	2021	2022	2023	2024
Cameras: Fixed	0%	0%	0%	0%	0%	0%	0%	0%
Cameras: PTZ	28%	28%	28%	31%	32%	41%	44%	53%
HAR Transmitters	0%	14%	14%	14%	77%	95%	100%	100%
RWIS	0%	0%	3%	11%	14%	15%	15%	18%
VMS: Curve Warning	0%	0%	0%	0%	0%	0%	0%	11%
VMS: Drum	0%	0%	0%	35%	35%	35%	35%	39%
VMS: General Purpose	4%	5%	4%	6%	6%	7%	11%	14%
VMS: Rider	0%	0%	0%	0%	0%	0%	0%	0%
VMS: Travel Time	0%	0%	0%	0%	0%	0%	0%	0%
VMS: Variable Speed	0%	0%	0%	0%	0%	0%	0%	0%

WORK ORDERS AND PREVENTATIVE MAINTENANCE

Separated by Region, each section shows work orders created and completed along with the running back log for 2019.



Preventative Maintenance Completed by Region 2019

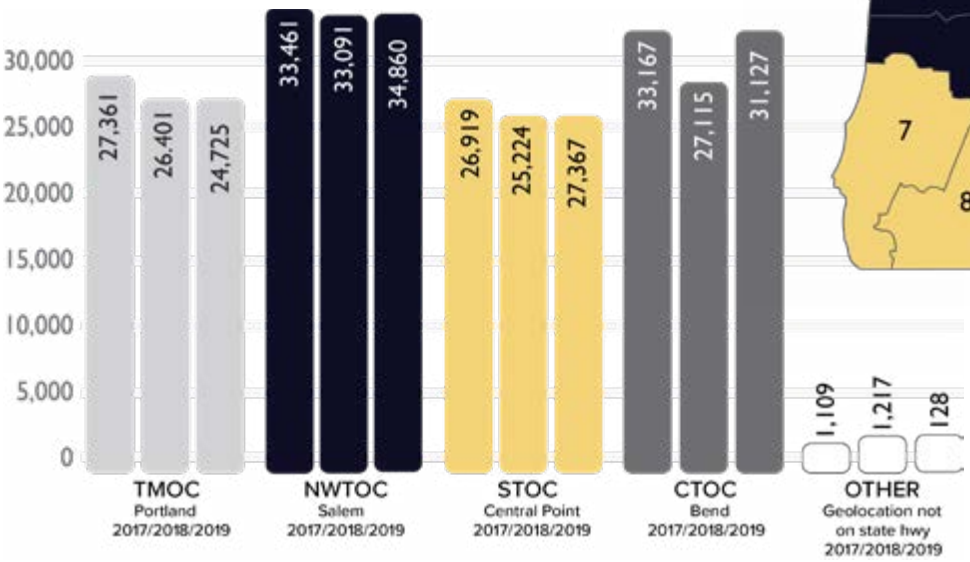


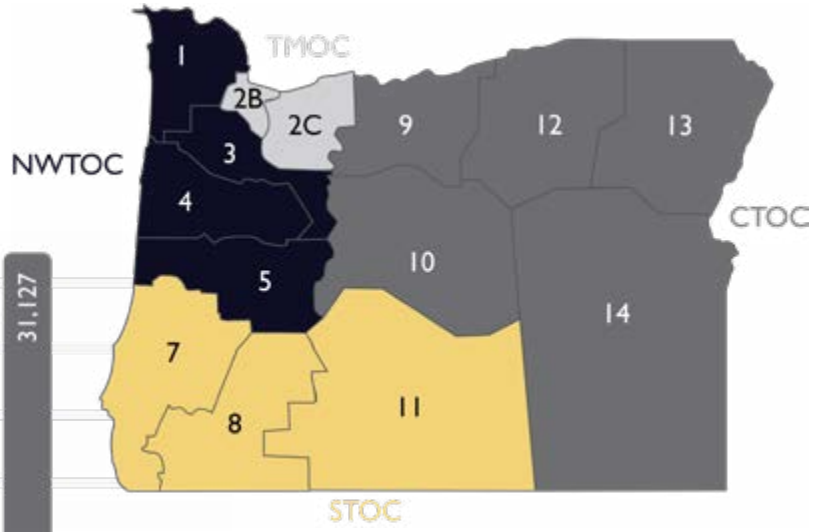
toc operations

ODOT's four Transportation Operations Centers play a vital role in keeping both ODOT staff and travelers safe. The TOCs help our responders be more effective and safe in the field, and each center offers communication and resources that play a major role in keeping roadways safe and clear and informing Oregonians about incidents and road conditions.

EVENT COUNT BY TOC

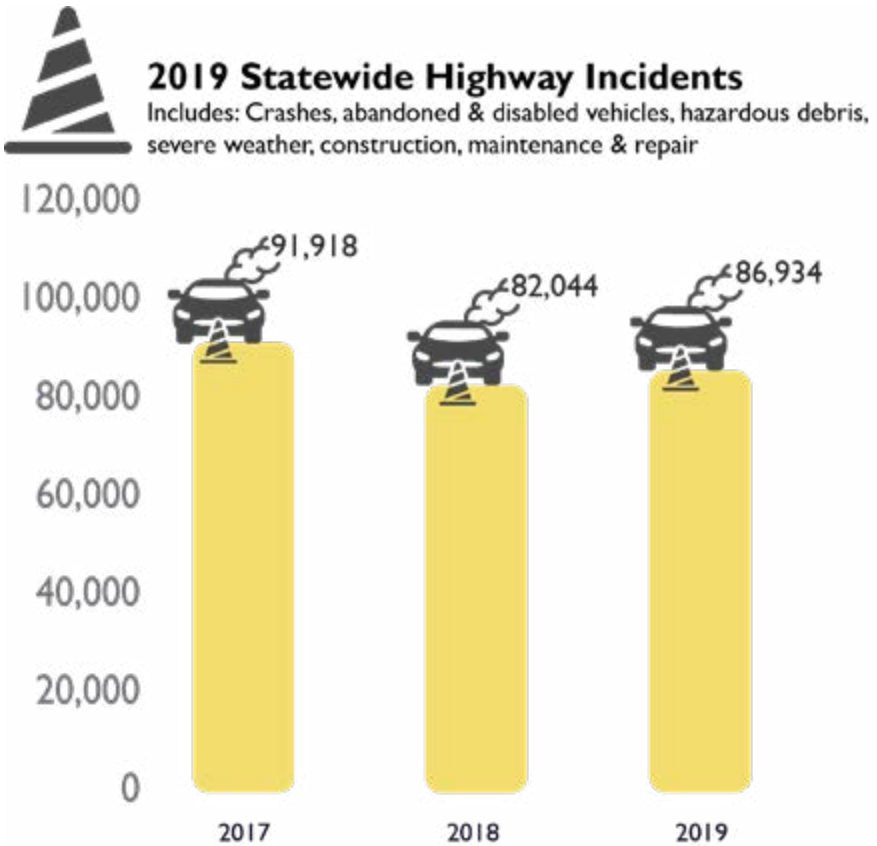
Total event count by each TOC totaled 118,207 in 2019.





EVENTS

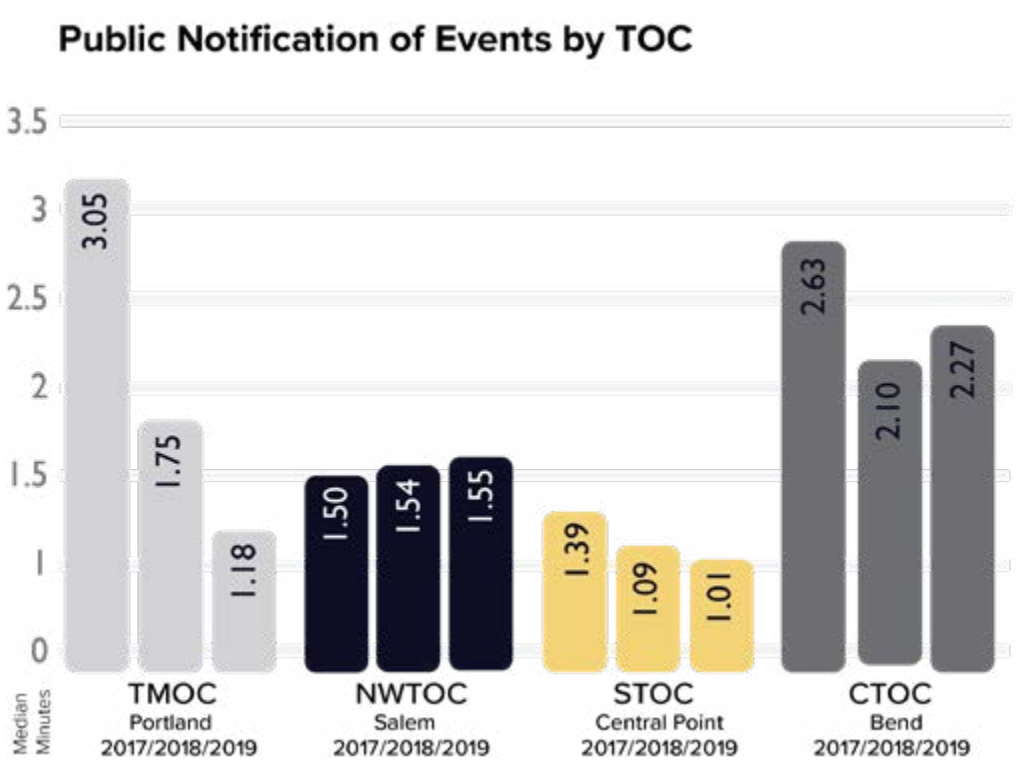
ODOT responded to a total of 86,934 events in 2019. Events consist of crashes, disabled vehicles, equipment repair, fatal crashes, fire, hazardous debris, landslides and rockfalls, road construction, road maintenance and operations, severe weather and abandoned vehicles. These are all subsets of the total TOC event count listed above.



PUBLIC NOTIFICATION OF EVENTS

A key function of the TOC is to ensure that the traveling public is notified of events and hazardous weather to avoid travel delays and dangerous conditions. Federal regulations in 23 CFR 511 require states to make information about lane blocking crashes available within 20 minutes in rural areas and within 10 minutes in metropolitan areas. ODOT and OSP have a joint policy statement in the ODOT - OSP Mutual Assistance Agreement that states:

It is the policy of ODOT and OSP to provide information using Variable Message Signs, the internet, 511, the media and HAR where applicable. The target is to update information within 10 minutes of a condition change.



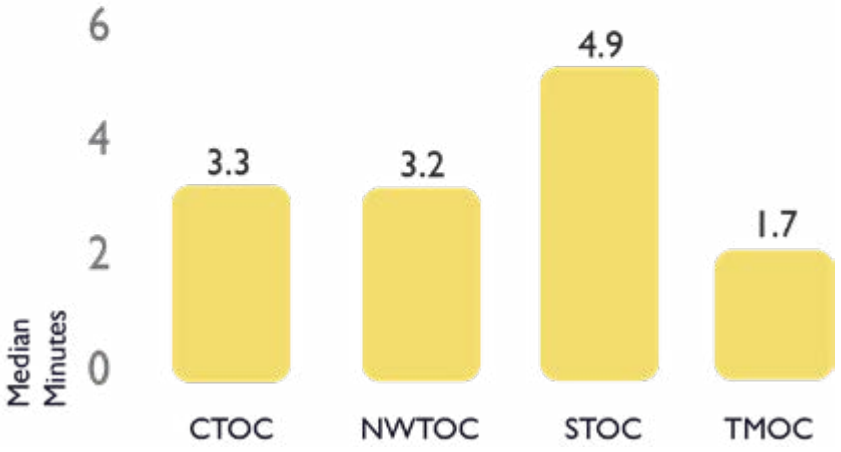
RESPONSE PLAN SYSTEM (RPS)

In April 2019, ODOT launched a Response Plan System (RPS) which interfaces with the Transportation Operation Center Software (TOCS). Based on incident parameters, RPS generates sign plans which contain the appropriate signs and message. Once a plan is reviewed and activated, RPS uses a message queue manager (MQM) to post messages based on message priority. Projects in 2020 will add enhancements to RPS that will increase usability and productivity.

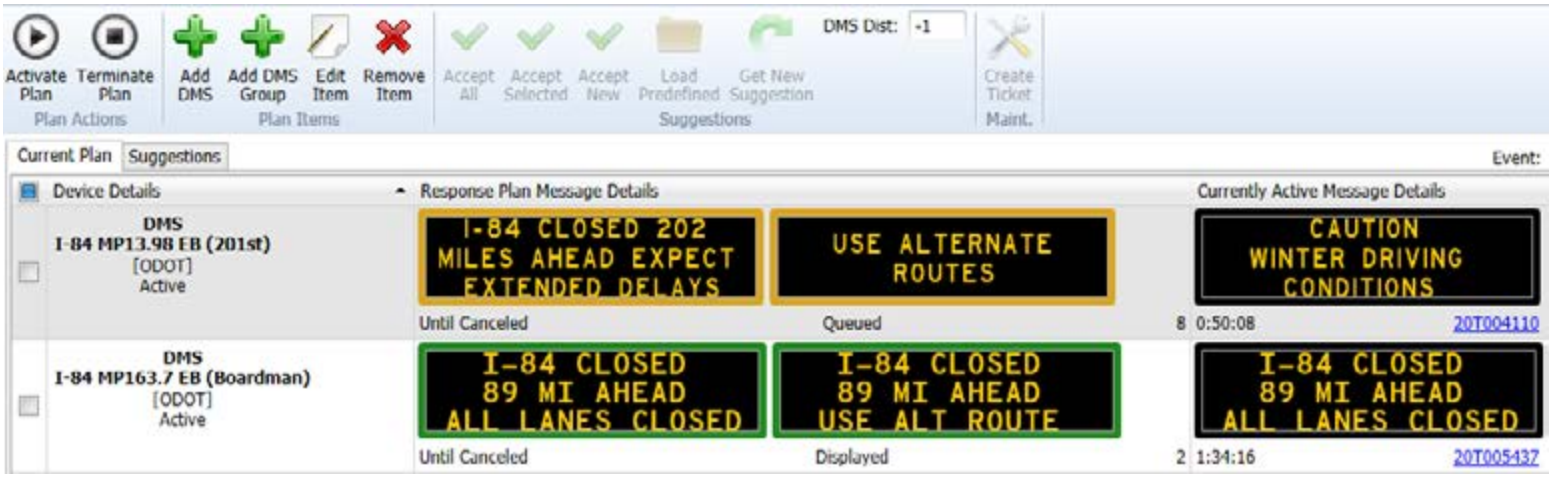
During the late fall of 2019, RPS was successfully posting over 1800 messages per month.

The program goals for RPS are:

- Reduce the time required to post messages and updates to signs
- Improve operator efficiency with managing sign messages
- Increased sign usage allows greater access to the traveling public
- Provide statewide message consistency



RPS SOFTWARE



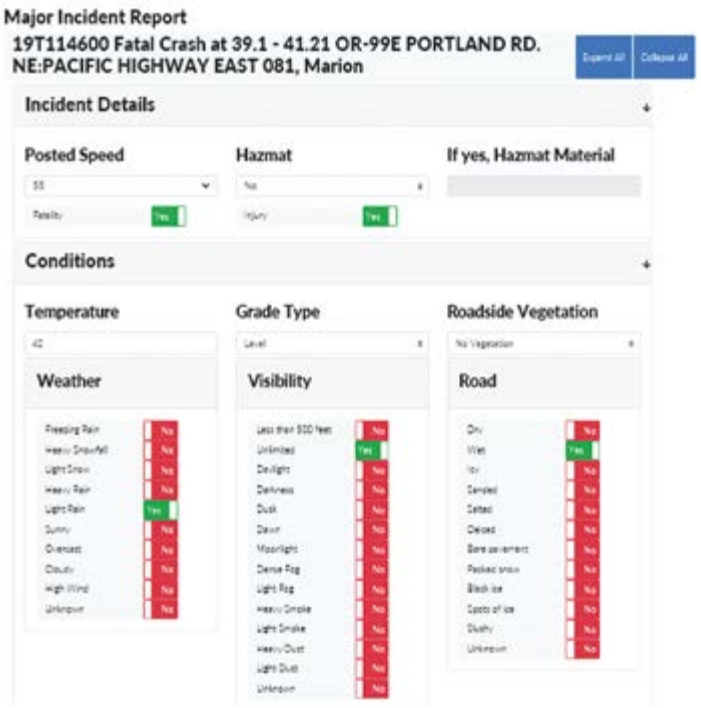
RPS AS DISPLAYED IN THE INVIEW MAP

MAJOR INCIDENT REPORT (MIR)

The Major Incident Report was developed to replace the paper form(s) by leveraging the Inview system. This allows:

- Auto population of information from Dispatchers' event data
- Save time entering information
- The ability to attach photos and other documents
- Central storage; no more file cabinets
- Ability to search for reports
- Ability to track report completion

The MIR was released on October 29th along with 2 online training sessions and a quick reference guide. For additional MIR support, contact Brent Atkinson @ 503 986-3977.



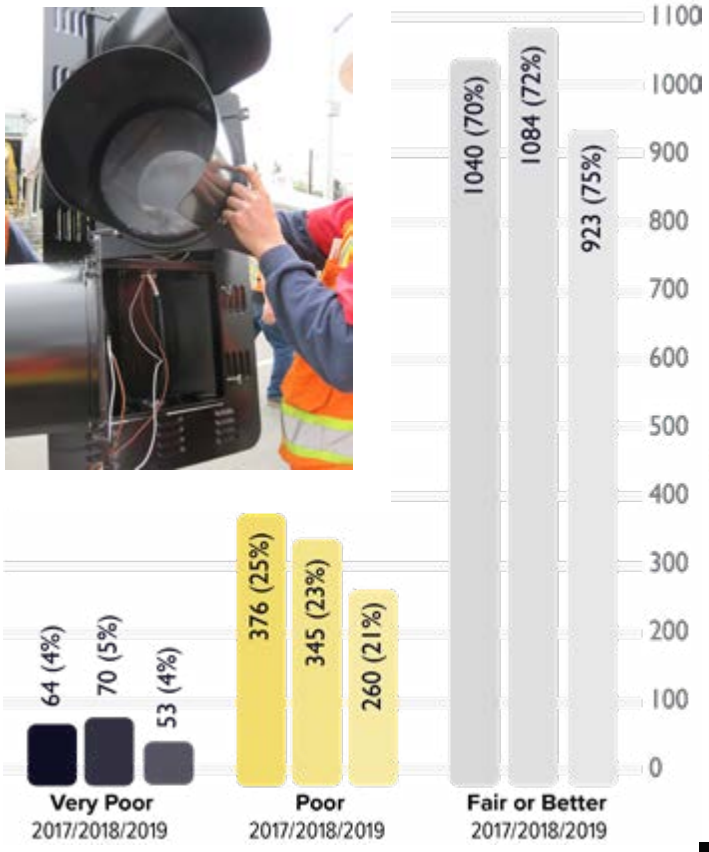
traffic signals and signs

Modernized and well-managed traffic signals are essential to a high-functioning transportation system. The outdated technologies currently in place are costly to maintain and contribute to poor signal timing, accounting for a significant amount of delay and user frustration. ODOT has made a commitment to the Every Day Counts 4 initiative (EDC4) and with that, has begun to implement a modern traffic signal controller technology (advanced traffic controller - ATC), transitioning us toward performance-based traffic signal management. Proactive traffic signal management is one of the most cost-effective strategies to improve operational efficiency, increase safety, and reduce costs.

In 2019, the signal team has put substantial effort into planning out the next decade. They began the process of developing a Traffic Signal Management Plan (TSMP) that will be completed in 2020. The TSMP will lay out priories moving forward. They have also started the process of identifying and evaluating various advanced traffic signal performance measures (ATSPMs). Data is an effective way to keep track of assets as well as their condition. In 2020, the team will identify which measures ODOT will track and report.

CURRENT ODOT SIGNAL RATING

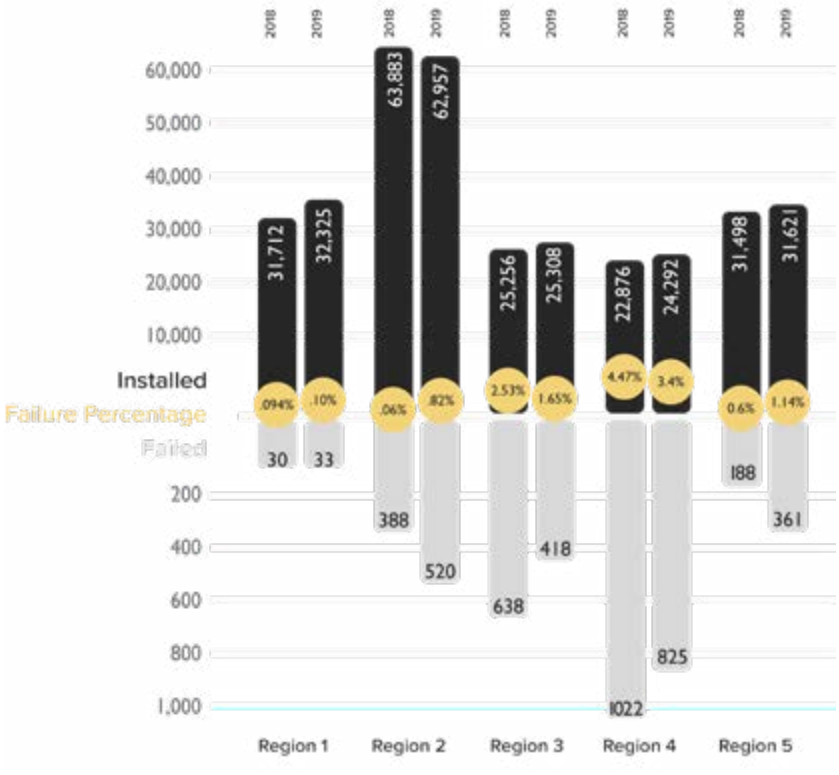
2019 marks the third year of tracking condition rating methods for traffic signals. This chart shows the current status of our traffic signal inventory.



**Beginning in 2019, condition rating for assets maintained by ODOT but owned by cities or counties are no longer tracked.*

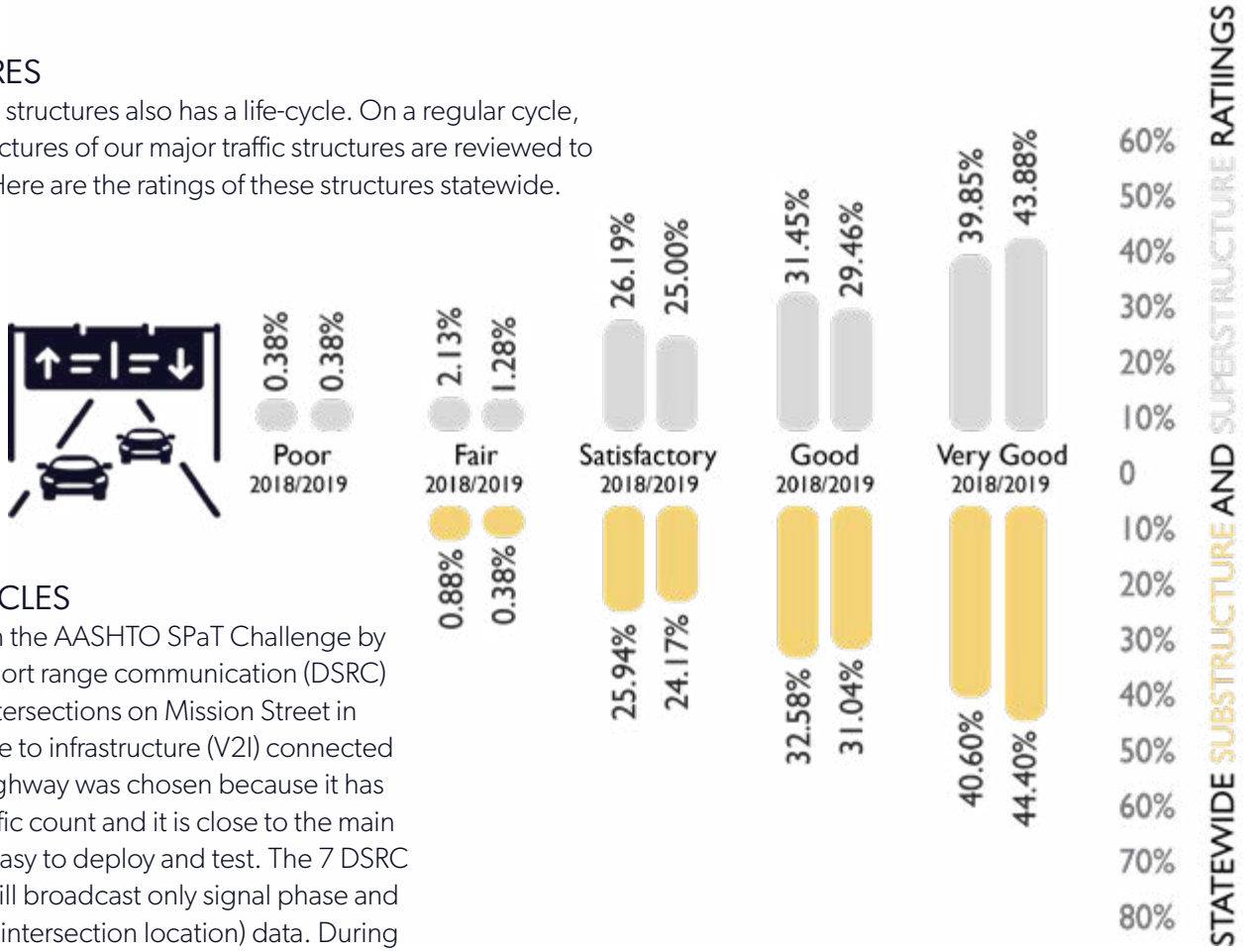
SIGN RETROREFLECTIVITY

ODOT's inventory of signs, like any asset, has a life-cycle. As signs are the largest communication device to the traveling public, keeping them in tip-top shape is vital. Below are the installed signs as well as the percentage failed for each Region.



TRAFFIC STRUCTURES

ODOT's inventory traffic structures also has a life-cycle. On a regular cycle, both sub and super structures of our major traffic structures are reviewed to assess their condition. Here are the ratings of these structures statewide.

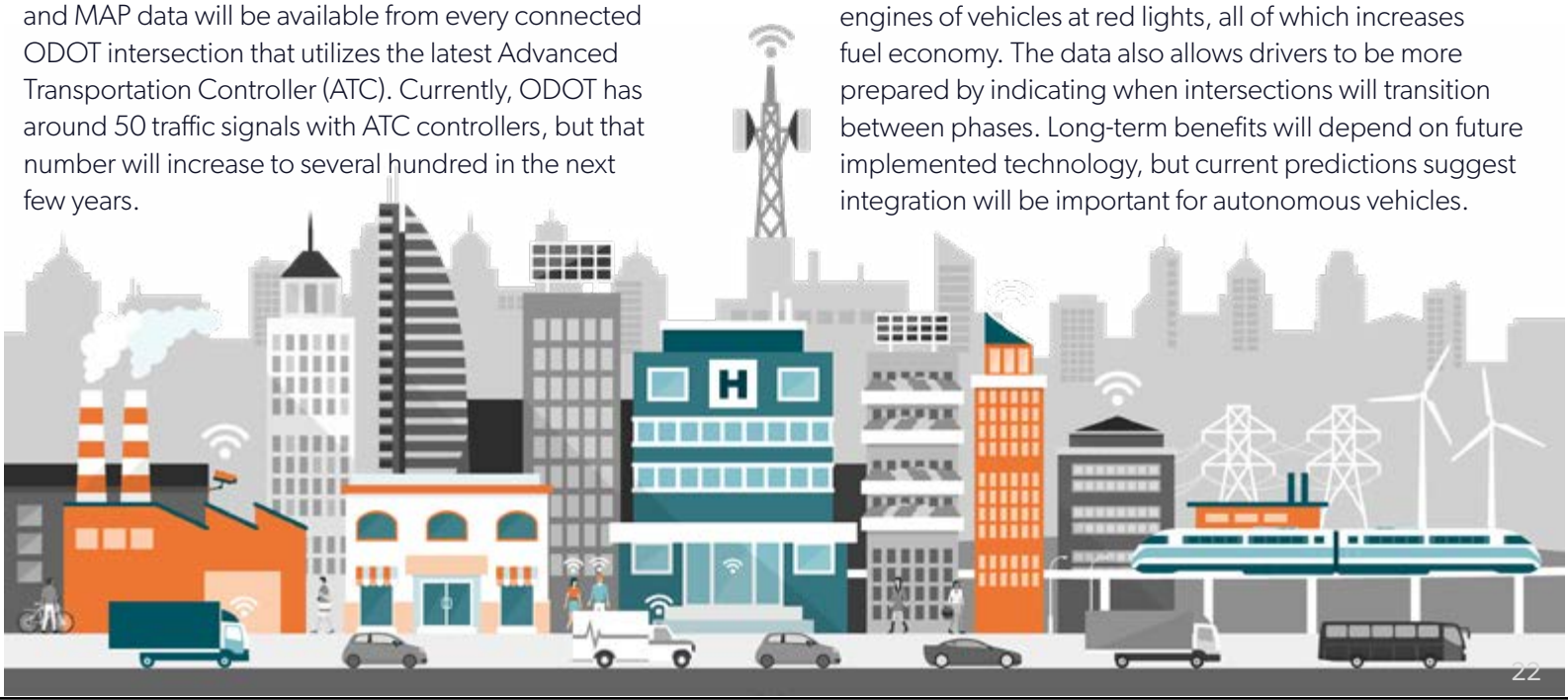


CONNECTED VEHICLES

ODOT is participating in the AASHTO SPaT Challenge by deploying dedicated short range communication (DSRC) radios at 7 signalized intersections on Mission Street in Salem to create a vehicle to infrastructure (V2I) connected vehicle corridor. This highway was chosen because it has a high average daily traffic count and it is close to the main support staff making it easy to deploy and test. The 7 DSRC radios being installed will broadcast only signal phase and timing (SPaT) and MAP (intersection location) data. During the first phase of this installation, data will not be received from any vehicles.

In addition to the roadside DSRC effort, ODOT is also implementing a central portal application called MaxView CV that can broadcast SPaT and MAP data in SAE J2735 format to automotive industry information providers. SPaT and MAP data will be available from every connected ODOT intersection that utilizes the latest Advanced Transportation Controller (ATC). Currently, ODOT has around 50 traffic signals with ATC controllers, but that number will increase to several hundred in the next few years.

What is so great about SPaT and MAP data? In the short-term, this signal data allows vehicles to operate more efficiently between intersections. Applications in vehicles can recommend ideal traveling speeds for vehicles to drive so that they do not have to slow down and speed up at each intersection and can automatically stop the engines of vehicles at red lights, all of which increases fuel economy. The data also allows drivers to be more prepared by indicating when intersections will transition between phases. Long-term benefits will depend on future implemented technology, but current predictions suggest integration will be important for autonomous vehicles.



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