Rail Transportation Compliance Audit

Assessment Conducted September, 2016

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Prepared for:

Tri-County Metropolitan Transportation District of Oregon

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EXECUTIVE SUMMARY

The Tri-County Metropolitan Transportation District of Oregon (TriMet) requested an independent third party audit of operational rules compliance on the TriMet rail system (MAX). TriMet has experienced an increase in operational rule violations and requested the assessment to determine the scope of the problem and to identify potential solutions. TriMet asked that the assessment focus on Passing a Stop Signal (PASS), overspeed events and train doors being opened on the wrong side or outside the platform. Each of these incident types by themselves are serious, but there was a concern that the increasing frequency of these incidents could be part of a larger problem adversely affecting the safety of the light rail system. Specific tasks requested as part of this assessment were:

1. Review and analyze rule violation data
2. Conduct an onsite review of signal and overspeed locations in relation to rules violations
3. Review rail operator training related to rules compliance
4. Review rail operator rules compliance program
5. Review current operating rule book and standard operating procedures
6. Interview rail operators, supervisors and managers
7. Provide technical support on signaling and communication systems

The Oregon Department of Transportation (ODOT) is the primary safety regulatory agency governing TriMet's light rail operations. TriMet invited ODOT to participate in this assessment and an ODOT representative was on site and participated during portions of the onsite assessment.

The team found employees at all levels of the organization we encountered during the assessment to be cooperative, knowledgeable and interested in doing a good job.

The assessment team appreciates the assistance and cooperation afforded by all TriMet employees who were contacted throughout the assessment process.

Some of the conclusions reached by the assessment team were:

- Operating rules non-compliance has become accepted as normal
- Follow up with rail operators who have violated operating rules is uneven and often not timely
- Rail managers are overwhelmed by the numbers of operating rule violation incidents and, because of this, not all events are investigated
- There is limited formal supervisory oversight of rail operator rule compliance in the field

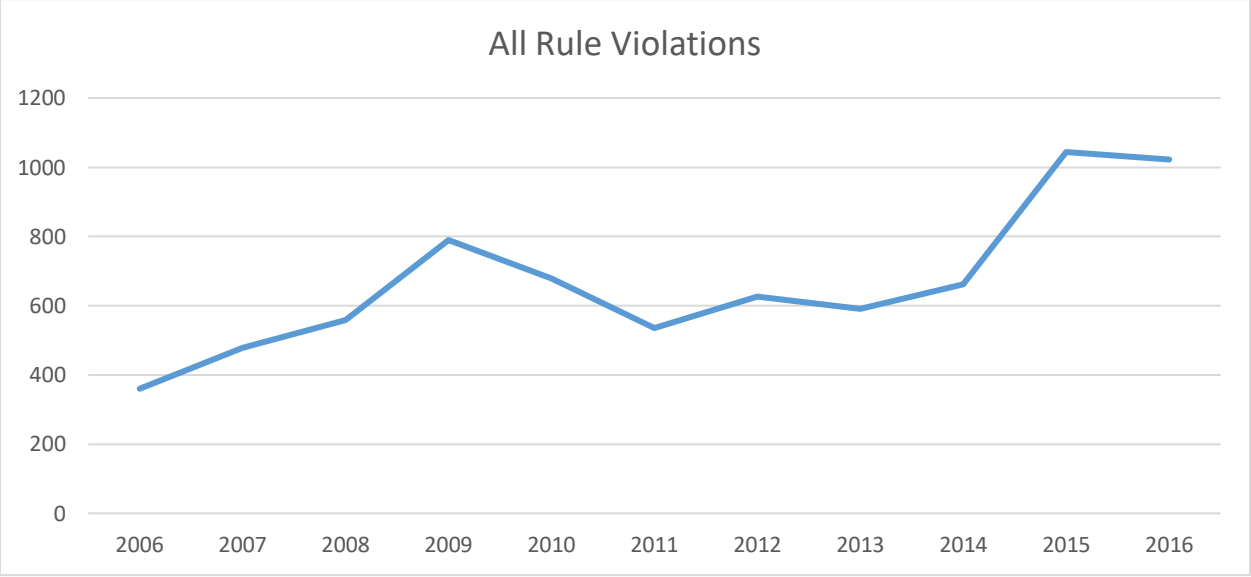
- There is no regular ongoing comprehensive program of tests and inspections on rail operating rule compliance
- There is inadequate information sharing between departments
- While some equipment issues led to operating rules violations that we examined, the great majority were human factors related

The assessment team makes specific recommendations in the following areas:

- Processes to “catch up” on investigations
- Interdepartmental communication and coordination
- Field training exercises involving operational tests, observations & coaching of operators
- Data analysis and distribution
- Operating rules
- Rail operator training
- Staff resources
- Engineering and equipment modifications

INTRODUCTION

TriMet has experienced a substantial increase in operating rules violations. The number of operating rules violations has nearly doubled over the past 4-years and the overall direction over the past 10 years shows an upward trend.



Operating Rule Violation Trends (note: 2016 is a partial year)

Of concern to TriMet management were the increases in passing a stop signal (PASS), speeding and door opening outside platform or wrong side.

We were unable to identify a single cause for the increases. New line openings (in 2009 and 2015) correspond to spikes but an overall upward trend exists over the entire 10-year period.

TriMet managers and represented employees we spoke with had several possible explanations for the increases. These included a less punitive management approach to operating rule violations that has evolved over time, the changing demographics of the rail operator population and the operational challenges of new line openings.

Our analysis, detailed in the sections below, discusses trends, possible causes along with recommended actions that TriMet can take to reduce the number of operating rule violations and improve the safety of the system.

ASSESSMENT METHODOLOGY

The assessment team was provided detailed light rail system rules violation data for the 12-month period from August 2015 through July 2016. These data were provided from the TriMet Accident/Incident Database (ACID) system. The team met with a TriMet data analyst who provided more detailed reports and assisted with further queries and analysis.

As a basis of comparison, data were also provided for the calendar year 2010. There were few new rail operators hired in 2010 and no new line openings. The 2010 data were analyzed for trends and compared to 2015/2016 data as well as with peer system data.

The team was provided access and interviewed a selection of managers, supervisors and line employees to gain perspectives from a variety of viewpoints on the issues related to operating rules violations.

The team was provided with the TriMet operating rule book and various relevant Standard Operating Procedures (SOP). These were compared with applicable regulations, industry standards and best practices. Several peer agencies that operate LRT systems were contacted for data and procedures to provide a basis of comparison.

The team was given access to the MAX system, made several LRV rides with operators and visited several locations were PASS and overspeed events had occurred to better understand general operations, the physical layout and operation of the signal and speed restriction systems.

The team performed the on-site portion of the assessment from September 6-9, 2016. A summary of on-site assessment activities is provided in Appendix A.

MAX SYSTEM DESCRIPTION

Tri-Met's light rail system has been in operation since 1986. Service was begun on a 15-mile line running east from downtown Portland to Gresham with 26 high-floor LRVs. Through a series of expansions, the system has grown to five lines, 60 route miles and 145 LRVs. Weekly ridership stands at approximately 800,000.

Rolling stock consists of 26 high-floor (Type 1) cars, and 119 low floor cars of four generations: 52 Type 2 (1997), 27 Type 3 (2004), 22 Type 4 (2009) and 18 Type 5 (2015). Cars are single or double articulated, 90 – 95 feet long, and have four two-panel doors on each side. Trains operate mostly as two-car consists. Train length is limited to two cars by the short (200 ft.) city blocks in Portland. Current vehicle mileage is approximately 9.2 million annually.

SIGNAL AND SPEED RESTRICTION SYSTEMS OVERVIEW

As is typical for light rail systems, The MAX system operates in a variety of environments. Line-of sight operation is normally used in segments where operating speed is 35 mph or less. Movements are controlled by traffic signals, with bar signals for the trains.

Where operating speed exceeds 35 mph, an automatic block signal (ABS) system with stop enforcement is employed. The ABS system largely follows AREMA and AAR standards. It enhances safety in the movement of trains and improves the overall efficiency of train operations. Functions include the protection and control of track switches; the protection and control of bi-directional train operation; the protection for following trains operating with the normal current of traffic; and highway grade crossing warning systems. The need for signaling, and the type of signalization provided is based on the specific requirements of each line segment.

This arrangement permits higher operating speeds than would be possible by relying on line-of-sight operation without signals. The ABS system provides information to rail operators concerning the condition and occupancy of the track ahead. Approximately 48 miles is equipped with ABS. In the remaining track way sections, MAX operates in the median or in city streets in a shared use environment.

Train-To-Wayside Communications (TWC) System

TriMet's LRVs are equipped with a Train-to-Wayside Communication (TWC) system based on the Philips Vetag design. When the LRV-mounted TWC transponder is over a wayside loop, it transmits a serial 19-bit message, identifying the LRV's car number, train number, route number (destination), and other information. Thumb-wheel switches and push buttons, in each cab, are provided to rail operators, to enter the route

number and train number of the consist and other requests such as switch call, preempt call, or cancel.

Interlockings

Interlockings are provided for all power switches and movable-point frogs. Routes are established either by the Operations Control Center (OCC) or by TWC requests. Interlocking signals govern train movements into and through interlocking limits.

Highway Grade Crossing Warning System

Warning devices for highway grade crossings are in ABS sections of the Right of Way. These crossings are equipped with gates, flashing lights, and bells. Traffic signals and bar signals are used to control motor vehicle and LRT train movements in the median of city streets where the train is operated through traffic signal controlled intersections.

Automatic Train Stop (ATS)

An inductive automatic train stop system is provided for stop signal enforcement in ABS territory and at most interlockings. Signals are equipped with wayside magnets (Trip Stops). The wayside magnets are always active unless the signal governing movements over the magnet is displaying a permissive aspect. The wayside magnets are deactivated by energizing a quenching coil when the associated signal aspect is permissive. All TriMet's LRVs are equipped with matching antennas that put the train into a penalty brake mode when an active wayside magnet is detected. An ATS magnet is also used to enforce civil speed restrictions and safe braking distance (see below).

Signals and Block Layout

Signals are located at the leaving end of station platforms, in ABS territory. Interlocking Signals are located at a calculated safe braking distance from (in approach to) switch points, and fouling points.

A two-aspect block signal is provided when the next signal ahead is a station-leaving signal. In other cases, a three-aspect signal provides information about the aspect displayed by the next signal ahead to avoid the necessity for always approaching it prepared to stop.

Signal Names, Aspects and Indications

Color Light Signals are provided in ABS territory. (Names, Aspects and Indications are from TriMet Signal Design Criteria and differ slightly from those in the operating rule book)

COLOR LIGHT SIGNALS		
NAME	**ASPECT**	**INDICATION**
Stop	Red	Stop
Restricting	Red over Red over Lunar White	Proceed on tertiary route prepared to stop short of any train or obstruction
Restricting	Red over Lunar White	Proceed on secondary route prepared to stop short of any train or obstruction
Restricting	Lunar White	Proceed on primary route prepared to stop short of any train or obstruction
Approach	Red over Red over Yellow	Proceed on tertiary route prepared to stop at the next signal
Approach	Red over Yellow	Proceed on secondary route prepared to stop at the next signal
Approach	Yellow	Proceed on primary route prepared to stop at the next signal
Proceed	Yellow over Green	Proceed (displayed when next signal displays an approach aspect for movement to the secondary route)
Proceed	Red over Green	Proceed on secondary route (displayed when next signal displaces a clear aspect)
Proceed	Green	Proceed on primary route
Proceed	Green over Green	Proceed (displayed when next two signal display a proceed or approach aspect for movement to the secondary route)
Restricting	“END AUTO BLOCK” Sign	Proceed prepared to stop short of any train or obstruction

Bar Signals are provided for interlocking in paved track or mixed use right of way to avoid confusion for motorists as to which vehicle is controlled by the aspect.

BAR SIGNALS		
NAME	**ASPECT**	**INDICATION**
Stop	Red Light or Red Horizontal Bar	Stop
Stop & Proceed With Caution	Yellow Horizontal Bar	Approach the intersection prepared to stop, primary route is set
Stop & Proceed With Caution	Red over Yellow Horizontal Bar	Approach the intersection prepared to stop, secondary or tertiary route is set
Restricting	Red over White Bar	Proceed, on secondary route through the intersection with caution
Restricting	Red over White Diagonal Bar over White Vertical Bar	Proceed, on tertiary route through the intersection with caution
Restricting	White Vertical Bar	Proceed, on the primary route through the intersection with caution

Train Separation, Safe Braking and Headways

A fundamental design aspect of the system is safe train separation, as illustrated in the figures below.

Figure 1 shows the typical arrangement. There are two red signals behind Train A. Train B is not permitted to enter the block behind Train A, and the block is at least the length of safe braking distance.

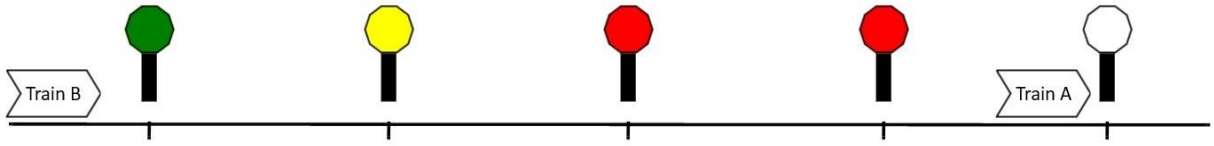


Figure 1

To reduce headways, a block may be divided into two track circuits, see Figure 2. The first track circuit past the signal behind Train A is at least the length of safe braking distance. Train B will be allowed into the block behind Train A, once Train A has vacated this track circuit.

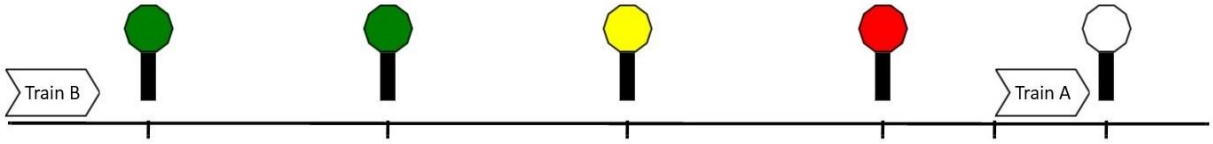


Figure 2

Safe braking is calculated using a two second vehicle reaction time, a derated brake rate of 1.95 MPHPS, and a 35% (distance) safety margin. In addition, all safe braking distance calculations in ABS open-track territory assume a 59 mph LRV entry speed. For example, minimum safe braking distance from 59 mph on level track requires a length of 2,001 ft. Speed control zones are provided where insufficient clear distance past a signal would otherwise compromise safe braking.

Signal system design headways are typically 165 seconds, based on a 20 second station dwell time. On the Blue Line, between Gateway and Lloyd Center, the design headways are 105 seconds.

Train Detection

Train detection in the ABS sections and at interlockings is accomplished via two rail, shunt-type, phase selective 60 and 100 Hz track circuits with impedance bonds and two-element vane relays.

Single Rail shunt-type, phase selective 60 and 100 Hz track circuits are used in yards and in some interlockings in paved track.

Audio frequency, overlay, shunt-type track circuits are used for train detection in the control of highway grade crossing warning equipment. All track circuits indicate occupancy when a shunt with a resistance of 0.2 ohm or less is applied at any point between the two rails of any track circuit.

Train detection at civil speed restrictions enforced by speed trip stops is accomplished by wheel detectors.

Speed Zones

Speed Zones were introduced into the TriMet system with the Westside Project in 1997 for two purposes: 1) To provide derailment protection in the transition from high speed sections to sharp curves and 2) to provide safe braking distance. Later, their use was expanded to provide overrun protection at nearside stations with adjacent gated crossings.

Speed zones are based on a simple time/distance concept: A wheel detector starts a timer when the first axle of an approaching train is detected. An ATS magnet is placed some distance past the wheel detector. When the timer expires, the compensation coil of the ATS magnet is activated, allowing the train to pass. If the train arrives at the ATS magnet too soon, before the timer has expired, the ATS magnet remains active, causing a penalty brake application and stopping the train.

Speed zones are typically set to allow a 2-mph tolerance above the civil speed restriction, i.e. a 25-mph speed zone should permit a train at 27 mph to pass, while a train at 28 mph would be tripped.

The Orange Line project significantly expanded the use of speed zones, adding 20 new zones in seven miles to the previous total of 37 zones.

PASSENGER CAR DOORS

The passenger doors are opened and closed by the operator. Depending on the station, the platform may be on the right or the left. In a few cases, platforms are on both sides. To open the doors, the rail operator depresses a button on the console corresponding with the side of the train where the platform is located. Where doors on both sides are to be opened the rail operator first opens the doors on one side, then on the other.

Door operation is interlocked with propulsion to prevent doors being opened while the vehicle is moving. When the train is stopped, the doors can be opened by the operator.

There are slight differences in the rail operator door control panels on the TriMet LRV types. All types have a left door open control buttons on the left side of the console and right door open control buttons on the right side of the console.

Opening the doors on the correct side and within the platform boundaries is strictly up to the rail operator. There is no wayside system to prevent doors from being opened on the wrong side or outside the platform when the train is stopped.

DATA ANALYSIS

Data on reported operating rules violations is available in the ACID system. The assessment team was provided data on operating rules violations from the ACID system covering the period August 1, 2015 through July 31, 2016. With assistance from TriMet's data analyst, examination of the data yielded trends that help better understand operating rules violations on the system.

The assessment team was asked to focus on 3 areas of operating rules compliance:

1. Passing A Stop Signal (PASS) without authorization
2. Operating above authorized speed
3. Improper door opening (wrong side or outside platform)

Most rule violations, where causal areas have been identified, are human factors related based on descriptive entries in the ACID system.

On average, during the 2015-16 data examination period, each TriMet rail operator had about 6 operating rules violation entries. Rules violations were not distributed evenly across the rail operator population. Rail operators with less than one year of experience averaged about 18 operating rules violation entries.

Some of the entries were later determined to be not the operator's fault due to (1) an event assessed not to be a violation, (2) no data download (vehicle, signal or video recorder) available (3) the investigator giving the operator the benefit of the doubt or (4) disciplinary time limits being exceeded.

There were 1181 rule violations entered in the TriMet ACID system for the 2015-16 data examination period. Of those, 564 (48%) were attributed to the 32 rail operators (17% of the population) with less than 1 year of experience.

Of the operations rule violations examined, between 25 – 40% had not been investigated (indicated by an absence of information in the system). It should be noted that some of these incidents may have been in a pending state and information may be added in the future. The table below provides an overview of incidents in the data we examined.

Attributed Causal Area	ATS App-roach	ATS Dep-arture	ATS Inter-mediate	All ATS Trips	Speed Trip	Doors	Train Order Inst-ruction	Notes
HUMAN FACTORS	21%	25%	45%	30%	18%	59%	58%	Generally attributable to RO or Controller action
SIGNAL SYSTEM	7%	12%	0.0%	8%	12%	0.0%	0.0%	Generally attributable to false trips or inaccurate speed detection
UNDETERMINED	20%	28%	17%	21%	21%	0.0%	3%	No causal area suggested
NO INVESTIGATION RECORD	39%	34%	36%	35%	25%	40%	40%	No record of investigation
TRAINING TESTING	0.0%	0.0%	0.0%	0.0%	22%	0.0%	0.0%	Generally, applies on Orange Line and speed trip related
VEHICLE	0.0%	0.4%	1.7%	1%	3%	2%	0.0%	Generally attributed to slip slide function or speedometer error
TRIP DURING BIRTHING	13%	0.0%	0.0%	2%	0.0%	0.0%	0.0%	Low speed during birthing
Total Events by Type	61	262	121	443	305	65	105	

Summary of selected operating rules violation data and causal area

There are two columns in the ACID data reports that can be more useful if more detailed information were entered during the investigative process; Location and Rule Violation. When a signal or speed trip is involved in a violation, a more detailed description of the location – signal number, milepost or other specific locator--would facilitate trending to see if there might be a wayside problem or if train operations are particularly challenging at that specific location. Information could then be directed to maintenance, engineering or training to address the local issue. Likewise, under the Rule Violation heading, including the specific rule number would provide better detail on where rail operators are having challenges that can be addressed by training and or supervision.

1. **Recommendation: Review guidance and training provided to employees who input information into ACID to assure that specific**

detail needed is understood. Consider using a rule violation template for ACID entries to remind those making entries of the detail needed.

Distribution of data analysis products from the ACID system was found to be limited. TriMet's Data Analyst produced several summary reports that are useful for trending and placed them in a shared file accessible to many managers. However, some managers who could use the information were not aware of its existence. There are several managers and supervisors who could benefit from seeing these data (or summary reports). These include Safety Department, Field Operations and Training personnel. It would also be useful to develop a higher level "dashboard" report on operating rules compliance that can be distributed to senior managers so they can monitor the state of operating rules compliance on the system.

2. **Recommendation: Make summary data reports on rules violations available to the training department and to managers and supervisors who have a role in ensuring rules compliance. Develop a higher-level dashboard for senior managers so they can better monitor rules compliance trends on the system.**

Of the ACID entries on improper door openings, door events at four locations exceed 5% of the total and are listed below.

Location	No. of Events	Percent	Line(s)
Convention Center	4	6%	G. B. R
Expo Center	4	6%	Y
Gateway Transit Center	9	13%	G, B, R
SE Park Ave	4	6%	O

Higher frequency locations for door events

None of the managers we interviewed could recall a passenger injury resulting from doors being opened on the wrong side or outside the platform. TriMet reviewed several year's ACID data and did not find any injuries associated with a wrong side opening.

Of the ACID entries on PASS events, several locations exceeded 5% of the totals and are listed below:

Location	PASS Type	No. of Events	Percent	Line(s)
Elmonica/SW 179	Approach	4	6%	B
Jackson Turnaround	Approach	7	11%	G, O
Glisan[1]	Approach	10	16%	G, O
Glisan	Intermediate	13	11%	G, O
82 Street	Intermediate	12	15%	R, B, G
SW Moody	Departure	28	11%	O
Portland AP	Departure	14	5%	R
Milwaukie/Main	Departure	18	7%	O

Higher frequency locations for PASS events

We sorted signal, speed and door violations by time of day. About 1/3 of events door events occurred during each of the three six-hour time segments 0600-1200, 1200-1800 and 1800-Midnight.

The number of PASS events during the 0600-1200 and 1200-1800 time periods were about even at 35% each. The number of PASS events dropped to about 16% between 1800-Midnight. The remaining PASS events occurred from Midnight to 0600 or the time was unspecified.

About 31% of speed trip events occurred during the 0600-1200 period. That increased to 38% during the1200-1800 period. The evening hours from 1800 to Midnight accounted for 26% and the few remaining speed trip events occurred from Midnight to 0600

Knowing where and when operating rules violations are more likely to occur is useful data for training and supervisory personnel.

3. **Recommendation: Track the frequency of rule violation events by time and location and distribute data on trends to affected departments so that training and supervision can better address higher frequency times and locations.**

[1] Several the entries for Glisan approach appear to be signal M24 which is an intermediate signal.

After completing the on-site evaluation, TriMet asked that we examine ACID data for calendar year 2010. This year was selected because there were few new rail operators hired and there were no new line openings. An examination of this data revealed a lower incidence of violations. A comparison of the number of events is shown in the table below:

Event	CY 2010	Exam Period 2015-16
PASS (all types)	331	443
Speed Trips	113	305
Door Events	41	68

Comparison of event counts for CY 2010 and the 2015-16 Exam Period

While the number of violations in ACID for 2010 is lower than the 2015-16 exam period, they are still high in comparison with peer LRT operations (discussed in another section of this report).

Since the ATS and speed trips annunciate in the control center and are reflected on a counter in the vehicle, the numbers of incidents recorded is considered accurate. Several other safety relevant operating rule violations, none of which are automatically annunciated to the control center, are most likely under reported in the statistics. These may include rules related to door operations, traffic signals, call boards, civil speeds at locations not protected by trips, blue flags and temporary speed restrictions. A program of operations tests and inspections (discussed in another section of this report) will help to fill in these gaps. Another way to improve data on non-monitored events is to encourage more reporting by employees.

Data on these “non-monitored” event types are only captured when rail operators self-report, the event results in an accident, a supervisor or manager happens to observe the event or when reported by the public. Since operating rule violations may subject an employee to discipline, there is a disincentive for rail operators to report these events. Thus, valuable information on problems and trends is lost. TriMet should consider a confidential non-punitive close call and violation reporting system to address this gap.

4. **Recommendation: Develop a confidential non-punitive reporting system so that employees can report events that might otherwise not be reported because of concern over punishment or peer pressure.**

SIGNAL AND SPEED RESTRICTION SYSTEM ANOMALIES

The assessment team found several signal system anomalies that help to explain some of the ATS trips examined.

Between 20% and 30% of all ATS trips were caused by system issues or are perceived as system issues. Issues include dropped signals, berthing issues and false speed trips.

Dropped Signals: Many ATS trips, and departure trips are caused by dropped signals, i.e. a clear signal changes to red just as the train is about to pass, not giving the operator sufficient time to react and stop. The main reasons for dropped signals are false cancel, conflicting move, and signal time out.

False Cancel from TWC: The TWC loop just in advance of a signal may receive a false "Cancel" message as the train passes over the loop, turning the signal red. This is typically caused by excessive electrical noise emitted by the train. Type 2/3 LRVs have a known issue with traction motor cable shielding, often causing this problem. The traction motor cable problem has been an ongoing issue for many years, and a permanent fix seems unlikely at this point. An easier solution to this problem may be increasing the noise immunity of the TWC system. A simple method would be to accept a message as valid only if it is received twice, or perhaps even three times in a row. Reportedly, the number of repetitions before a message is accepted is adjustable in at least some, if not all generations of TWC interrogators.

5. **Recommendation: Evaluate methods to increase the noise immunity of TWC Interrogator. For example: increase the number of repeats for a valid message.**

False Cancel by another train: At some locations in the system, a second train can cancel a signal for its leader. For example: A train proceeding at signal M36 (5th and Irving) may have its route canceled by a follower sitting at 6th & Hoyt.

Conflicting Move: At a few locations, a clear signal may suddenly drop due to a conflicting move by another train. For example, this may occur on a westbound move at Signal W1056 (170th Ave). When a second train makes a reverse move from the 185th platform through the crossover just east of the platform, Signal W1056 will unexpectedly drop to red.

6. **Recommendation: Prepare a full list of locations where a legal move by a second train may drop a cleared signal. Make infrastructure changes to eliminate this issue where practical and**

provide information and operating procedures to controllers and operators allowing them to avoid a dropped signal from second train.

Signal Time Out: Once a route is requested, the route will time out and cancel after a set period if no movement into the route is detected. Typically, timeouts are set to 90 seconds, but at a few locations, they are shorter to improve the efficiency of the system. Milwaukie Ave NB is a notable example, where the timeout is presently set to only 45 seconds, to reduce the already lengthy delays experienced by motorists. A planned system modification at this location will reduce warning times, and, as a side benefit, increase the timeout duration to 90 seconds. Timeouts are an important feature to maintain an efficient system. Timeout duration should be standardized as much as possible, but occasional exceptions from the standard may be necessary.

7. **Recommendation: Standardize time-out durations as much as possible.**

8. **Recommendation: Review training material covering signal route time-out functions during operator training. Consider wayside signs showing non-standard signal route time out lengths.**

Berthing Issues: At some locations, the berthing window is extremely short, particularly for Type 4 and Type 5 consists, leading to ATS trips on approach to a stop. Rose Quarter and Jackson turnaround are the primary problem locations.

Until a recent infrastructure change was implemented, a Type 5 train at Rose Quarter had to stop within one foot of the ATS magnet so the rear axle would clear the track circuit behind. The spotting window at Rose Quarter has now been improved, but infrastructure changes at Jackson turnaround are likely not possible.

9. **Recommendation: Evaluate berthing markers at problem locations, make improvements as required and emphasize these locations in operator training.**

Speed Trips: The number of speed trips has tripled since opening of the Orange Line. Where the previous two years showed an average of about 100 speed trips per year, that number has now climbed to 300. Only half of those are successfully investigated, mostly due to the unavailability of data from the train event recorder.

A detailed analysis of a two months' period (June/July 2016) showed a total number of 38 speed trips. Of those, 28 (74%) were on the Orange Line and only ten were on the remainder of the system. About half, 17 of the 38 (45%), were successfully investigated. Of those 17, 11 (65%) were found to be false trips, i.e. data from the train event recorder showed that the train was going below trip speed. All but one of these 11 false trips were on the Orange Line. In the six remaining cases, the train was exceeding authorized speed.

Some percentage of the false trips are likely caused by faulty wheel detectors delivered for the new Orange Line. The manufacturer has confirmed a systematic failure, where about ten percent of detectors from this batch become unreliable in hot temperatures. Additionally, there are reportedly issues with proper adjustment of the detectors.

We suspect however that the bulk of false trips are caused by a design issue: The distance between the wheel detector and ATS magnet on the Orange Line is significantly shorter than it is on older speed zones in the TriMet system. That requires a highly accurate time response of the system. As an example, the time difference from detection to arrival at the magnet between a 47-mph train (should pass) and a 48-mph train (should trip) is only 0.06 seconds. Tolerances in the system response time, particularly magnetic field build-up, are likely of the same order of magnitude.

10. **Recommendation: Improve the process to follow up on false trips. Any time a train event recorder shows a trip below the design trip speed, Engineering/MOW should be informed and provided with the data so the incident can be investigated and corrective action can be taken.**

11. **Recommendation: Improve the accuracy of Orange Line speed zones, continue the replacement of potentially faulty wheel detectors, assure all wheel detectors are properly adjusted, investigate moving wheel detectors further away from ATS magnet and as a potential alternative, investigate wheel detectors with built-in speed detection**

12. **Recommendation: As a temporary measure, consider increasing the allowable speed tolerance before a trip from the currently 2 mph above the speed limit to 4 or 5 mph above the speed limit for at least some, if not all Orange Line speed zones. Before increasing the tolerance, perform a risk analysis to assure that the reduced safety margin is acceptable to TriMet.**

13. **Recommendation: Review and revise the standards for the use of speed control zones and establish clear criteria for speed zones including:**
    - **When use of speed zones is appropriate**
    - **Safety margins for each purpose**
    - **Number of zones required**
    - **Target speed for derailment protection**

RAIL OPERATOR TRAINING

TriMet uses rail training supervisors as instructors and line instructors as on-the-job trainers. The quality of rail operator training is highly dependent on the capabilities and professionalism of these trainers. Often, these individuals are chosen because of their strong technical ability as rail operators. Being a proficient rail operator does not automatically make an individual a proficient trainer. Currently, there is limited formal training for these instructors.

14. **Recommendation: Develop a formal training and certification program for training supervisors and line instructors with periodic professional development refreshers to keep training skills sharp.**

Rail operators begin their rail career after having first served as TriMet bus operators. During the 9-week rail training period, they are held to a strict standard of rules compliance. Any absence is considered a “no go” event and the individual is sent back to their former job as a bus operator. Weeks 1 to 5 are a combination of classroom and field operations. During the 6th week of training, operator trainees must successfully take a train from one yard to another on the main track. Any safety infraction or operating rule violation is considered a fail the operator trainee washes out.

A training manager suggested that the optimum instructor-student ratio was no more than 3 students to one instructor during field training. Some classes exceed this ratio.

Statistics were not available on the average number of wash outs during training, however the manager estimated that it ran about 30%. This would be a good statistic to keep track of along with average class scores and the number of violations experienced during post training solo operations. Any changes made to the training program (instructor student ratios, instructor training, addition of a simulator, etc.) can be measured against prior performance measures to assess effectiveness.

15. **Recommendation: Develop statistical performance measures on rail operator training to assess and monitor the effectiveness of the training program.**

Potential operators are issued daily checklists to check off the subject matter covered. There are frequent quizzes, homework and exercises to reinforce training material.

The requirements of rail operator training, certification and re-certification are outlined in TriMet SOP-495. The SOP requires new rail operators to pass all tests at 85% and at 80% during recertification. Some agencies and railroads require a 100% score on written tests related to the most operational critical rules, such as signal rules.

16. **Recommendation: Based on the high number of TriMet incidents involving ATS trips and door operations, we recommend placing a greater emphasis on these areas during training by developing a signal/speed/door operations written rules exam and requiring a 100% passing score.**

Prospective rail operators spend the next week working on trouble shooting problems on trains before spending a week working on revenue trains with training supervisor instructors. The 9th week is spent with line instructors (rail operators who have been selected to provide on-the-job training).

After a week of operating under the instruction of line instructors, the prospective rail operators now “solo” by operating revenue trains. After completing training, rail operators receive an additional 3 check rides during their first 90-days. If an operator has 4 rules violations, a “safety intervention” may be scheduled where the operator receives additional class room training focused on their rules violation events. Any subsequent operating rules violations fall under the progressive discipline program. Additional training or coaching is not provided unless a manager or controller sees a specific need.

The rail operator probationary period is 90 days from the completion of training. In some cases, there are not sufficient openings for new operators and they return to bus operations until call up. If 30 days has elapsed since the completion of training, they are required to go through additional training before operating revenue trains.

Based on the ACID statistics, rail operators are most in need of focused training, supervision and coaching during their first year as operators. Given the challenges facing new operators and the statistics on rules violations, a 90-day probation period leaves little time for TriMet to adequately assess new rail operator performance.

17. **Recommendation: Consider extending the current probationary period for new rail operators from 90 days to 6-months.**

18. **Recommendation: Evaluate the use of rail vehicle simulator technology to support training and particularly follow up training for operators who are having problems during their first year.**

19. **Recommendation: Examine the training program hands-on elements and increase the amount of hands-on operation (actual or simulator based) under instruction. Focus that additional time on some of the specific locations and conditions that appear to be drivers of the increased operating rules violations (speed trips, intermediate signals, berthing, departure signals).**

20. **Recommendation: Any rules violation during the probationary period should automatically trigger a check ride (or simulator session) that focuses on the circumstances of that event.**

21. **Recommendation: Establish performance criteria for the probation period (performance on check rides, maximum allowable number/types of rules violations, customer service expectations, etc.) to govern under what circumstances a rail operator should be disqualified. Formalize a certification process allowing both transportation and training departments to sign off (certify) that a new operator is ready to move from the probationary period into permanent status.**

TriMet has a recertification requirement covering an operator who is absent for more than 30-days. There is no procedure governing an operator who has not worked a line or territory for a prolonged period. Some railroads provide a “pilot” (a second qualified engineer on that territory) for the first trip over the territory if the engineer has not operated over that territory in 6-12 months.

22. **Recommendation: Consider a policy to address the situation where an operator has not worked over a line or territory for a prolonged period.**

PROGRAM OF OPERATIONAL TESTS AND INSPECTIONS

The purpose of an operating rules test and inspection program is to:

1. Assess workforce practices, competency and capability to perform duties in line with procedures
2. Identify employees who need coaching, additional training and/or additional management intervention
3. Recognize and encourage competency and compliance
4. Generate data that feeds into training, supervision, hazard analysis and planning for future tests and observations

TriMet does not have a formal program of operations tests and inspections to verify rules compliance. TriMet does have some elements of such a program.

Rail supervisors are TriMet's eyes and ears in the field. Should they observe operating rules violations they are required to determine fitness for duty, coach and report (via ACID). We found ACID entries generated by rail supervisors, however, there is no formal program of operations tests and inspections to help document how effective supervision is in meeting these responsibilities.

TriMet Field Operations has access to radar/lidar speed measuring devices and occasionally rail supervisors perform speed checks on trains. When an overspeed event occurs, the rail supervisor may enter it into the ACID system. Other data from the checks are not maintained. There is no SOP or program document providing guidance on performing speed checks.

TriMet also requires rail supervisors to perform ride checks where they ride with operators over portions of the systems and complete a check list. TriMet SOP 577 describes this process. There are two types of check rides; Service Quality Rides (SQRs) and Observation Rides (OBRs). Rail supervisors perform SQRs and training instructors perform OBRs. The SOP requires that at least one SQR or OBR be performed on each rail operator per calendar year.

ACID data for the calendar year 2015 show a total of 177 SQR and 132 OBS ride checks were performed. Check ride by type and number per employee are shown in the table below.

	No Rides	SQR	OBS
RO with zero rides	42		
RO with 1 ride		126	36
RO with 2 rides		24	46
RO with 3+ rides		1	4

Check Rides in CY 2015

All rail operators with zero rides listed in the ACID system either started work or ended work as rail operators during the 2015 calendar year.

SOP 577 requires the supervisor to inform the operator that they are having an SQR or OBR, advise OCC and obtain an ACID number. Supervisors are in uniform when they perform check rides. Some rail supervisors stated that they make part of a check ride incognito by boarding a trailing car so they can observe operator train handling, door operations and other operational events. It is unknown how wide spread this practice is and it is not required by the SOP instructions.

Observations by observers who are not detected by those observed are more likely to provide an accurate picture of the state of operating rule compliance on the system. Such observations play an important role as one element in a program of operational tests and inspections.

"You can see a lot by observing" said Yogi Berra

23. **Recommendation: Address incognito ride checks and other observations as part of the program of operational tests and inspections.**

TriMet rail operators cannot be observed from inside the train because the windows separating the operator's compartment from the passenger area are blacked out. We were told this was done to eliminate glare and/or for unspecified security concerns. We suggest that TriMet revisit this decision based on the need for improved supervision and monitoring of the safety of rail operations. Additionally, having the operator visible to passengers would provide confidence that an alert and observant employee was at the controls and able to observe and summon assistance to any events of concern in the passenger area of that car. Criminal activity is discouraged by the visible presence of an operator with access to communications.

24. **Recommendation: Reevaluate the policy of blacking out the rail operator compartment from view and consider alternative methods to reduce glare if needed.**

During a check ride, a check list is completed by the supervisor and several parameters are marked off as (1) exceeds requirements, (2) meets requirements or (3) needs work. Although not specifically mentioned in the SOP, presumably the supervisor would create a separate ACID file should an operating rules violation be observed.

Based on interviews, our understanding is that the results of check rides rarely identify operating rule violations and generally result in a "meets requirements" report. Additionally, we were told that rail supervisors performing SQRs were not allowed to perform a ride over the entire line as they needed to remain in their assigned territory.

Check rides are a valuable tool, however the assessment team found that rail supervisors are not being used to their full potential in reducing operating rule violations.

Under 49 CFR Part 217.9, the Federal Railroad Administration (FRA) requires railroads to develop and implement programs of operational tests and inspections to assess compliance and understanding of operating rules. TriMet LRT operations do not fall under FRA regulatory jurisdiction, but plans that meet Federal requirements can provide a template that is useful for developing a TriMet program.

In a 2002 Special Investigation Report on two CTA rear-end collision, the NTSB identified the absence of any rules compliance testing as a factor in the causes of these accidents and a significant gap in the rail transit industry. The NTSB recommended that such compliance testing be required in the rail transit industry. Thus, the Federal Transit Administration (FTA) revised the State Safety Oversight regulation at 49 CFR Part 659 to include a requirement that agencies include a description of their rules compliance programs in the System Safety Program Plan.

> 49 CFR 659.19 (m) A description of the process used by the rail transit agency to develop, maintain, and ensure compliance with rules and procedures having a safety impact, including:
>
> (1) Identification of operating and maintenance rules and procedures subject to review;
>
> (2) Techniques used to assess the implementation of operating and maintenance rules and procedures by employees, such as performance testing;
>
> (3) Techniques used to assess the effectiveness of supervision relating to the implementation of operating and maintenance rules; and
>
> (4) Process for documenting results and incorporating them into the hazard management program.

TriMet addresses this requirement with a Rail Operational Safety Checks Program as outlined in the System Safety Program Plan (SSPP) item J-3.

The TriMet experience clearly shows that simply having operating rule requirements in place is not sufficient to ensure that they are followed. Railroads and many transit systems have developed formal operating rules test and inspection programs to (1) provide assurance that there is a high level of compliance, (2) monitor employee understanding and competence in complying with operating rules and (3) coach and counsel those employees who may be having difficulties.

25. Recommendation: Expand the Rail Operational Safety Checks Program referenced in TriMet's SSPP by developing and

implementing a formal program of operating rules tests and inspections that includes field observations and scenario tests of rail operating employees. The program should list specific tests or observations that supervisors should perform, numbers of tests/observations expected of them and include directions on how to safely perform the observations and tests.

Union Pacific titles their FRA compliant program Field Training Exercises (FTX). The UP FTX Manual contains some 30+ individual tests with detailed instructions for managers in carrying out the tests. We suggest that TriMet examine the UP's program document as a resource but not copy it since it is copyrighted.

We like the UP's use of the terminology "FTX" as it emphasizes the training aspects of a compliance program. One of the optics issues TriMet will need to overcome is the misperception that managers are somehow out to get employees and catch them doing something wrong rather than improve employee competency and the safety of operations.

A TriMet FTX program will require a broad agency policy, a field manual, a training program for those performing the tests and a record keeping system on goal attainment, passes, exceptions and other outcomes. Maintaining accurate data will be critical to making the program a useful tool for improving system safety.

26. **Recommendation: Designate a specific manager to develop and oversee a Field Training Exercise (FTX) program tailored to TriMet MAX. Require that anyone performing tests and observations be qualified on performing tests and observations as well as qualified on TriMet operating rules on RWP on-track safety procedures.**

We suggest that TriMet start with a limited number of key observation/tests based on operating rules of concern (stop signals, speeds and doors) and a few others that may have significant potential consequences such as Blue Flags, Train Order directives, Call Boards and RWP rules.

The American Public Transportation Association (APTA) published a standard on Rule Compliance (APTA-RT-OP-S-011-10) that provides some general guidance on such programs.

We also obtained copies of several LRT operations testing program documents as resources for TriMet to use in developing such a program. Copies of programs from LACMTA and Minneapolis Metro are included on a resource thumb drive accompanying this report. A list of the resource documents on the thumb drive are included in Appendix B.

TriMet has reasonably accurate information on the number of rules violations involving ATS signal and speed trips since they annunciate in OCC. There are many other relevant operating rules where violations are only identified through supervisor/manager observation, self-reporting or accident. The actual number of violations of these types of rules is likely higher than reflected in ACID statistics. A formal FTX program will help to identify potential problem areas and help to reduce the risk posed by operating rule related errors and violations.

OPERATING RULE BOOK AND SOPS

TriMet's operating rules are contained in the Tri-County Metropolitan Transportation District of Oregon Rail Operation Rule Book Revised August 2015. Additional requirements are contained in Standard Operating Procedures (SOP), Special Instructions and Train Orders.

TriMet's operating rule book contains requirements addressing stop signal, speeding and door related operating rules as well as the other operating conditions that are encountered on the system.

Stop signal compliance is covered in rule E.3.2 and augmented by SOP-401. The requirements appear to be generally clear. However, the signal aspects and indications listed in the rule book (p 148-151) do not exactly match the aspects and indications in SOP-401 (Table 1 and 2).

27. **Recommendation: Evaluate and compare the lists in the rule book and SOP-401 for accuracy. Consider only publishing the list in one location.**

Speed requirements are covered in rule D.2.27 and augmented by SOP-410. The requirements appear to be generally clear. However, the speed tables in the rule book (p 167-171) do not exactly match tables 1-5 in SOP-410. Rule B.1.6 states that the rule book supersedes SOPs.

28. **Recommendation: Examine the speed tables in the rule book and SOP-410 to ensure the correct information is available to rail operators. Consider not including the tables in the SOP as trying to maintain duplicate tables can be prone to errors. If a change in permanent speeds is required, use Train Orders or Special Instructions to convey it to rail operators since those documents are superior to the operating rules in the rule B.1.6 hierarchy.**

Several operating rules contain the admonition to operate "with caution". With caution is not defined in the TriMet operating rules. From how it is used, it appears to have several

meanings -- be prepared to stop at the next signal, observe that switches are properly aligned for the move, be alert to movements of other vehicles, expect the next ABS signal to be yellow, expect the next ABS signal to be red, be alert to persons on the track, be alert to malfunctions at grade crossings.

In some cases, the with caution admonition should probably be restricted speed – for example moving through an interlocking and observing that switches are properly aligned. With so many possible meanings, with caution has probably lost any specific meaning for rail operators. By TriMet rules, trains must be operated with caution almost all the time.

In the past many railroads had a "with caution" rule. It was generally almost the same as the restricted speed rule, but without a maximum speed specified. One example follows:

> Proceed at reduced speed, according to conditions, prepared to stop short of a train, engine, car, stop signal, derail or switch not properly lined, or other obstruction. (1980's Southern Pacific Rule Book)

We have word searched recent editions of the General Code of Operating Rules and the Northeastern Operating Rules Advisory Committee rule books (these 2 books cover most US railroads) and do not find the term "with caution" in use.

29. **Recommendation: Evaluate the use of the term "with caution" in the TriMet Rule Book. Examine certain instructions that may be better suited to restricted speed as opposed to with caution. If "with caution" will continue to be used, develop a definition for specific actions required by the rail operator when "with caution" is used in the rules.**

Door operation is covered in rule D.1.2 and specifies, among other requirements, that doors be opened only on the platform side. We did not find a specific requirement that doors not be opened on the platform side outside the platform nor any procedures to handle this possibility. However, this may be technically covered by the requirement that customers must be boarded/de-boarded only at platforms and that a platform overshoot must be report to OCC.

During rail operator's training, a best practice taught is to first observe in mirrors which side the platform is on and then to point to it using the hand on the platform side. At least one other transit system (NYCMTA) requires the person opening the doors to first point to the platform and then open them. NYCTA managers make periodic observations to verify that the -- point, then open -- procedure is followed. Incorporating a pointing requirement provides a reminder to rail operators, counteracts the "muscle memory" response when most platforms are on one side and allows for supervisory/manager field checks of an observable behavior.

30. **Recommendation: Evaluate the rules to ensure that they include a prohibition on opening doors off the platform and an SOP to govern what rail operator actions (for example, locking out a door) are required should a partial overshoot occur.**

31. **Recommendation: Incorporate the training best practice of pointing to the correct side of the train with the hand on the platform side into the rule requirements.**

TriMet identifies some operating rules violations (such as exceeding authorized speed) as “major safety violations”. SOP-584 (Fitness for Duty) references “safety critical” rules. We did not find a list in the rule book or elsewhere explaining what a major safety violation or safety critical rule was or which rules were included.

Some transit systems and railroads establish “cardinal rules” related to the risks involved with violations of those rules. Cardinal rules are those, that when violated, can result in a serious accident or injury. These cardinal rules will often include rules on speeds, signal compliance, blue flags, work zones and on-track safety among others.

The FRA has designated certain rules as critical and mandates that railroads decertify engineers who violate them. The FRA decertification list includes stop signal or mandatory directive violations (much like some of TriMet’s Train Order Restrictions), speeding and tampering with a safety device.

The TriMet System Safety Program Plan identifies rules violations in several areas that are reported to ODOT as hazardous conditions. These can form the basis of TriMet’s key, or cardinal, rules.

32. **Recommendation: Develop a list of key—or cardinal-- rules and publicize it to focus operators’, supervisors’ and managers’ attention on those key rules. This list can help set priorities for an initial formalized FTX program to improve compliance.**

INVESTIGATIONS OF OPERATING RULE VIOLATIONS

Rules violation investigations are largely driven by the ACID system. Most of the initiating entries are made in the control center by controllers. However, supervisors or managers can also initiate entries. When a rule violation, such a PASS event, is identified in the control center, a rail supervisor is dispatched to meet the train and perform a fitness for duty examination of the operator. TriMet SOP-407 states that besides the fitness of duty examination, the rail supervisor is required to provide immediate reinstruction and perform a vehicle event recorder download. It appears neither of these last two requirements are always performed.

Based on interviews with several rail supervisors and transportation mangers, there is generally a very limited field investigation of the circumstances of the operating rule violation. Some rail supervisors said that they ask the circumstances of the rule violation and try some coaching – but there is little formal investigation at the rail supervisor level. We were told that in at least some cases, the operator may not be contacted for a fitness evaluation on the day of the event if they are near the end of their shift. Several interviewees told us that the practice of rail supervisors downloading vehicle event recorders in the field has been discontinued.

Rail supervisors we spoke with reported that removing an operator from service following a fitness for duty exam was extremely rare.

The next level investigation is performed by one of the two Assistant Managers of Rail Operations and is primarily an office document review. The operator or responding rail supervisor may not be interviewed or contacted.

Two of the peer agencies contacted report that they immediately pull a rail operator from service following a red signal violation.

A case study based on ACID entries helps illustrate the challenges of investigating and dealing with operating rules violations.

Based on the ACID data we examined, many rail operators have had multiple ACID rules violations entries. We identified seventy-seven rail operators that each had between six and twenty-two entries. Looking in detail at the operator with the highest entry count (22) the outcomes include eight events that resulted in re-instruction letters, two in warning letters, one in a counseling session, and one in a suspension. Two entries have no investigative information and 6 events were listed as “not at fault” (3 without explanation and 3 due to lack of a download). One entry is listed as pending.

Often, the assistant manager’s determination is based on video, event recorder or signal recorder data. If data is not available, an “operator not at fault” determination often results.

Information from onboard and signal system recorders is perishable because data is eventually overwritten. Generally, data begins to be overwritten after 1-8 days depending on the type and capacity of recorders.

- Vehicle video recorder data capacity varies from 48 to 250 hours.
- Vehicle event recorder data capacity varies from approximately 1 to 8 days. There are reports that the recording time on older car types (1, 2 and 3) may be insufficient to last through a full day of operation.
- Signal system recorder data capacity varies between 4-8 days.

There is often several days' lag between the request for a signal recorder download and the actual download. Some newer signal system recorders can be downloaded remotely greatly facilitating downloads.

33. **Recommendation: Make information available to those managers involved in investigations on the recorder data limitations of various types of equipment and set time limits for requesting and delivering downloads.**

34. **Recommendation: Increase the recording time on older cars to at least one full day of operation or set up processes to assure data is downloaded before it is overwritten.**

Depending on the equipment, downloading and analyzing data from recorders can be time consuming. MOW mangers estimate a minimum of 2 to 4-hours labor is required for signal recorder download and analysis when a field download is necessary. MOW managers estimated that there are about 50 signal download requests per month. Given the labor involved, transportation managers say that they try find other data (vehicle event recorder and video) to meet their needs and prioritize what signal data they request.

35. **Recommendation: Evaluate the use engineering staff to perform and analyze signal downloads. This will accomplish several objectives:**
    - **Free up MOW staff to focus on maintenance**
    - **Allow timely engineering analysis of system anomalies**
    - **Allow engineering improvements to be developed more quickly when anomalies are discovered**

Remote downloading of data would be helpful to managers and save considerable labor. Many railroads remotely download vehicle event recorder data. In some cases, an event can trigger a remoted download. For example, when an Amtrak train goes into emergency braking, a short data burst is sent to the National Operations Center containing about one minute of event recorder and forward facing video data.

36. **Recommendation: Investigate the potential for equipping all vehicle and wayside recorders with remote automated data download capability.**

Several railroads use computer algorithms to scan event recorder data for heavy braking, emergency braking and overspeed among other parameters. Alerts are automatically generated for manager follow up. This type of technology could be useful for transit operations.

37. **Recommendation: Investigate the potential of using automated technology to scan downloaded data for events that merit follow-up.**

In some cases, the investigating Assistant Manager of Rail Operations concludes that the signal system or the vehicle performance was a causal factor in the violation. We were told that conclusions on vehicle or signal system causation of events are usually made without input or concurrence from those departments. This leads to a couple of potential issues: (1) the other department may have additional information that should be considered and (2) without knowledge of equipment related events, the other departments may lack data to identify trends and resolve equipment issues. This gap can be addressed by an interdepartmental approach to investigations discussed later in this report.

Following the completion of the investigation, the rail operator will receive a letter in the mail outlining the determination. If discipline is assessed, it will be described in the letter. To be effective discipline should be timely. Simply getting a letter in the mail weeks after an event with no personal contact is not optimal.

38. **Recommendation: Develop procedures so that any operating rule violation results in timely face to face contact with the rail operator and a discussion about the event, whether discipline is involved or not.**

After four operating rules violations in a 12-month period, a safety intervention usually results. A safety intervention involves sending the rail operator to a training session at the training center and a review of the circumstances of the violations and coaching on rules and operating practices to avoid future violations.

Further operating rules violations after a safety intervention are handled under the TriMet discipline system.

The assistant managers reported that they have a difficult time keeping up with investigations due to the high number of operating rules violations. MOW and Vehicle Maintenance mangers also have a hard time keeping up with the requests for data downloads due to the high numbers.

In evaluating the 2010 ACID data, it appears that TriMet staff were having difficulty in keeping up with investigations in 2010 as well as the more recent data we examined. Approximately 5% of the 2010 entries had no investigative information and 28% were closed out “employee not at fault” due to age (expired time limits).

Some ACID incidents are not investigated because the period for assessing discipline has lapsed. We suggest that the goal of investigations should not be limited to supporting the assessment of discipline. A thorough investigation of incidents is needed to develop information on problem areas, trends, equipment issues and gaps in training and supervision.

39. **Recommendation: Form a temporary multidisciplinary incident investigation task force to work on making sure each incident is fully investigated, any trends (operators, signal locations, speed trip locations, repeat vehicles) are identified and handled by appropriate department. Set up a process to allow affected departments to concur on causal findings. Include a data analyst to assist the task force in developing performance measures and reports to track trends. Include MOW, signal engineering and vehicle maintenance to assure downloads and repeater trouble spots/vehicles are identified and addressed. Include safety for assistance in risk analysis and hazard management.**

Once the backlog of ACID events and the rate of new events is reduced, more permanent policies and procedures can be established.

SOP-407 covers Automatic Train Stop (ATS) trips. When a trip is reported, the controller obtains train location, trip location, LRV number, and new counter number from the rail operator. An ATS trip counter on each LRV displays a number. When there is a trip, the number increases by one. A log is maintained in OCC where each trip event is entered. There is also a log in each LRV. The OCC log also contains information on discrepancies between the counter and in-cab log that are reported when rail operators take over a train. Should the in-cab log not reflect the number on the counter, the rail operator reports that information to OCC. In discussions with OCC staff, it was noted that there was often no investigation or resolution when the counter and in-cab log conflicted. This left open the (albeit slim) chance that an ATS trip could go undetected and unreported.

40. **Recommendation: Examine the trip counter logging process and close any gaps that could allow trip events to go undetected/unreported.**

PEER LRT SYSTEM DATA

As part of this assessment, the team was asked to reach out to several peer LRT systems for comparative information. The systems that were contacted were Dallas Area Rapid Transit (DART), Denver Rapid Transit District (RTD), Metropolitan Transit District of Harris County (Houston), Los Angeles County Metropolitan Transit Authority (LACMTA),

Minneapolis Metro Transit (Minn.) and Utah Transit Authority (UTA). The assessment team thanks these organizations for their cooperation and assistance.

Both the rate and numbers of TriMet operating rules violations are higher than the peer systems examined.

Peer System Information	MAX	DART	RTD	Houston	LACMTA	Minn.	UTA
Directional Route Miles	120	182.4	94.2	22	135.3	44.3	93.9
Annual Train Miles (millions)	4.5	5.6	NA	3.5	8.5	NA	2.9
Number of Rail Operators	182	202	190	142	293	119	120
Number of 1st Line Supervisors	34	30	17	22	65	27	45
Number of Next Level Supervisors	4	0	3	2	0	8	0
Number of Mgrs/Asst Mgrs	3	4	1	4	5	3	4
Cab Signals Used	N	Y	N	N	Y	N	N
ATS Used	Y	Y	Y	Y	Y	N	N
Speed Trips Used	Y	N	N	N	Y	N	N
Number of Ops Rules Violations	1181	NA	NA	NA	NA	NA	NA
Number of PASS Events	443	39	NA	23	26	25	17
Number of Overspeeding Events	305	NA	NA	2 or 3	13	0	NA
Number of Door Events	68	NA	NA	0	0	31	1
Formal Ops Testing Program	N	Y	N	Y	Y	Y	Y

Summary operating information (NA=Not Available)

Rate of Ops Rules Violations PMTM	MAX (current)	MAX 2010	DART	Houston	LACMTA	UTA
All Ops Rules Violations PMTM	262.4	161.7	NA	NA	NA	NA
PASS Events PMTM	98.4	78.8	7.3	6.6	3.1	5.9
Overspeeding Events PMTM	67.8	26.9	0.0	1.1	1.5	NA
Door Events PMTM	15.1	9.8	0.0	NA	0.0	0.3

Summary rule violation rates Per Million Train Miles (PMTM)

The FRA published a study on commuter rail PASS events. That study found that the rate of PASS events over a 20-year period varied between 2 and 10 events PMTM on 6 large U.S. commuter rail systems.

TriMet MAX operated 4.5 MTM during the 2015/16 period for which we evaluated data and 4.2 MTM in calendar year 2010. The PMTM rate of MAX violations was lower during calendar year 2010 but still notably higher than peer agencies and the commuter rail operators referenced in the FRA study.

SELECTION, PROBATION AND DISCIPLINE

Following the on-site assessment, the team was asked to look at TriMet's rail operator selection, probation and discipline policies in comparison to peer agencies. The following agencies provided the information below.

Selection criteria for bus operators entering rail operator training

- DART – Transferees from "Big Bus" (30 & 40 ft. buses) are not subject to review against established criteria. Transfers from DART's "Smart" Bus operations (17 ft. buses) must interview and have no written warnings on their record.
- Houston – Attendance is reviewed but there is no formal set of criteria in use
- LACMTA – detailed selection criteria covering previous 36 months (can be extended) that includes absences, miss-outs, accidents, hearings, suspensions, rule violations and customer complaints. Selection process also involves a physical agility test and an Ishihara Color Vision Test. (copy of criteria provided on memory stick accompanying this report).
- MAX – a scoring system is used to evaluate and weight several factors including preventable accidents, attendance, rules violations, customer complaints and discipline covering a 2-year period before the start of a rail operator training class.

New rail operator probation

- DART – 6-months for new employees, no probation for transfers from bus
- Houston – 90 days (both for internal and external candidates). Probationary operators are terminated if they pass a stop signal.
- LACMTA – 90-days for bus operators following completion of rail training. If a prospective rail operator is disqualified during the 90-day probation, they may not be considered for rail operator for 2-years.
- MAX – 90-days

Typical disciplinary structure in response to operating rules violations

- DART – A 30-month review period is used.
    - 1 violation = written warning
    - 2 = final warning
    - 3 = 2-day suspension
    - 4 = discharge
- Houston – 4 disciplinary schedules that involve a 12-month review period (18-months for Interlocking PASS events). The most serious rules violations (Levels 1 and 2) include stop signal violations and speeding. The 4 levels with discipline schedule are shown below.

Level 1 Safety Violations	Level 2 Safety Related and ADA	Level 3 Service Quality and General Operating	Level 4 Admin
Written Warning	Written Warning	Counseling	Counseling
Final Written Warning	Final Written Warning	Written Warning	Counseling
2-day Suspension	2-day Suspension	Final Written Warning	Written Warning
Discharge	Discharge	2-day Suspension	Final Written Warning
		Discharge	2-day Suspension
			Discharge

Houston Metro Discipline Schedule

- LACMTA – The collective bargaining agreement distinguishes between major and minor rule violations. Major rule violations include PASS events, speeding and doors opened on wrong side or outside platform.
    - Major rule violation schedule during a floating 6-month period:
        - 1 violation = counseling or training
        - 2 = counseling and written warning
        - 3 = 2-day suspension
        - 4 = formal hearing (that can lead to discharge or disqualification)
    - Minor rule violation schedule during a floating 6-month period:
        - 1 violation = verbal counsel
        - 2 = verbal counsel and caution placed in file
        - 3 = interview and possible counsel or written warning
        - 4 = 1-day suspension
        - 5 = 5-day suspension
        - 6 = 10-day suspension
        - 7 = formal hearing (that can lead to discharge or disqualification)

LACMTA transportation managers have some latitude to accelerate the schedule to a formal hearing in egregious circumstances or to lessen discipline in other cases.

- MAX –
    - 1-3 violations = Re-instruction
    - 3 violations = Safety Intervention
    - 4 violations = Warning letter
    - 5 violations = Letter of Reprimand
    - 6 violations = Return to Bus Division, suspension or termination

Key rules that trigger more serious discipline

- DART – Specific rules are not identified. Option for more serious discipline is available if a rule violation can have catastrophic results.
- Houston – Rules matching the 4 levels of severity are spelled out in detail. Stop signal violations and speeding fall under Level 1 (the most serious).
- LACMTA – see notes above on major and minor violations.
- MAX - Specific rules are not identified. The option for more serious discipline is available. Operating a "train out of control" (undefined) is listed as leading to suspension without pay. Immediate termination is possible for behaviors including drug/alcohol use, mishandling cash, destroying/removing property, gross insubordination and actions "posing an immediate or potential danger to public safety."

The APTA Standard on Rules Compliance provides the following general guidance on discipline: "Corrective actions should be administered in a timely manner, commensurate with the severity of the noncompliance." In practice, TriMet's disciplinary schedule appears more lenient than that the of peer systems we contacted. A Transit Cooperative Research Program (TCRP) Report on improving safety-related rules compliance suggests that discipline (punishment) should be prompt and consistent. TriMet's current practice appears to be neither.[2]

41. Recommendation: TriMet should examine industry practices and align its disciplinary corrective actions with industry best practices.

RESOURCES

TriMet will need to find a way to either devote additional resources or reorganize current manager/supervisor work efforts to address the issues identified in this report.

The process of investigating operating rules violations has bogged down due to the large number of events. Investigating managers simply aren't keeping up with the numbers of incidents requiring investigations. Downloads are not always performed because of the

[2] TCRP Report 149, Improving Safety-Related Rules Compliance in the Public Transportation Industry.

volume of requests. Thus, many ACID entries are not investigated, probable operating rules violations are not identified and addressed and rail operators who are having difficulties are not being identified and helped.

Rail operators in their first year are responsible for the most operating rules violations and the current program of three check rides in 90 days has not adequately addressed this problem.

As noted earlier, it is likely that the operating rules violation rate is much higher for those operating rules that do not annunciate themselves in OCC.

Addressing these challengers will require additional (and/or redirected) resources over both the short term and the long term.

TriMet needs three key initiatives to turn the rules compliance trends around. These are:

- An improved incident investigation program
- A formal program of operating test and inspections
- An increased emphasis on training and supervision of new operators following graduation and during initial solo operations

Addressing the investigation backlog: We suggest a temporary multidisciplinary incident investigation task force to work on making sure each incident is fully investigated, any trends (operators, signal locations, speed trip locations, repeat vehicles) are identified and handled by appropriate department. The task force effort needs to:

- Set up process to allow affected departments to concur on causal findings.
- Include a data analyst to assist the task force in developing performance measures and reports to track trends.
- Include MOW, signal engineering and vehicle maintenance to assure necessary downloads are performed and that repeater trouble spots/vehicles are identified and addressed.
- Include safety for assistance in risk analysis and hazard management.

Once the back log has been addressed and the number of events is reduced to a more manageable number, a permanent organizational approach can be put in place.

Addressing the need for an operations test and inspection program: Appoint a rules compliance and investigations manager to help drive down the back log and develop proactive FTX program to reduce rates of noncompliance. The rules compliance and investigations manager can also provide training for managers/supervisors to implement the FTX program. There may be additional effort required from the training group as well.

Addressing the rail operator early career compliance problem: Extend the 90-day probationary period to six months of solo train operations and direct additional effort at identifying the problems operators are encountering. Develop criteria for successfully passing out of the probation period and develop a joint review process with training and transportation concurrence before probation ends. Direct current (and possibly additional) training resources to better support new operators during this period with additional training, post incident focused training and additional field supervision. Consider use of LRT simulator technology to augment field training.

CONCLUSION

Based on our interactions with TriMet staff, employees at all levels want to improve operating rule compliance. Leadership and support from the executive team will be critical as well as careful development and implementation of initiatives aimed at operating rules compliance and safety.

Priority must be given to catching up and getting ahead of the numbers of operating rules violation incident investigations. This will require strong interdepartmental cooperation, coordination and communication.

A Field Training Exercise program on operating rules will be critical to lowering violations in the future. The program needs to include adequate data collection and analysis to understand the problems and monitor implementation of the FTX and other management initiatives. This will allow managers to manage well as well as support new FTA regulatory requirements for Safety Management Systems.

Lastly, the rail operator training program needs to be modified to address the performance issues manifesting themselves during the early months of rail operator solo operations.

The assessment team thanks TriMet leadership for the opportunity to examine these issues and hopes we have provided useful suggestions to improve TriMet operations.

End of Report