TORONTO TRANSIT COMMISSION
REPORT NO.

MEETING DATE: October 23, 2013

SUBJECT: **YORKDALE FATALITY OF SEPTEMBER 14, 2012 - FINAL INVESTIGATION REPORT**

INFORMATION ITEM

RECOMMENDATION

The Board receive this report for information.

FUNDING

There are no budgetary impacts associated with this report.

BACKGROUND

At 4:44 AM on September 14, 2012, southbound work car RT-4 struck a Rail Infrastructure Department Roadmaster and a Track Mechanic, who were on the southbound tracks just south of the bridge crossing Highway 401. The Roadmaster was pronounced dead at the scene, the Track Mechanic suffered serious head lacerations requiring hospitalization along with contusions to his chest and legs. The Operator of RT-4 suffered serious chest pains, was admitted to hospital and later underwent treatment for a heart condition. The fellow crew members, several staff responding to the scene and staff at the Transit Control Centre suffered psychological trauma injuries as well.

The CEO commissioned a full incident investigation to determine the root causes for the fatality and to make recommendations for the prevention of a recurrence. The report of this investigation is attached. Management has responded to the recommendations with a corrective action plan, which is appended as Appendix F to the report.

DISCUSSION

The Ministry of Labour, assisted by Toronto Police Service conducted a full investigation of the incident and did not lay any charges against any individual nor to the Toronto Transit Commission as a corporation pursuant to the Occupational Health and Safety Act.

JUSTIFICATION

Despite the absence of charges, management and, by extension, the Board have a duty of care to

take every precaution reasonable in the circumstances for the protection of a worker. The investigation of the fatality at Yorkdale points to weaknesses in the safety management system that must be addressed in order to ensure the safety of track maintenance work. Management is committed to complete the corrective actions in a timely fashion and to report back to the Board on its progress in June 2014.

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13.3

Attachment Yorkdale Fatality Investigation Report

TORONTO TRANSIT COMMISSION

YORKDALE FATALITY INVESTIGATION REPORT

Yorkdale Fatality Investigation Team

Spadina Line, Southbound Track at
277+54
Toronto Transit Commission

September 14, 2012

Report Date: September 27, 2013

Senior Management Statement

On September 26, 2012, I approved the Terms of Reference for the creation of a level 3 Incident Investigation Team as required by the Corporate Program for Incident Reporting & Investigation. This Team was created to investigate the contact of RT-4 with two workers on September 14, 2012. This contact resulted in fatal injuries to Road Master Peter Pavlovski, serious head injuries to Track Mechanic Celso Machado, a cardiac episode to the train Operator and acute psychological trauma to other crew members and responders. The team's responsibilities have been completed with respect to this investigation. The analysis, identification of direct, contributing and root causes and judgements of need reached during the investigation were performed in accordance with the Terms of Reference. I accept the findings of the Team.

The Executive of the Toronto Transit Commission is committed to addressing the Recommendations of this investigation and has put in place corrective actions to address each of them (see *Appendix F).* The corrective actions will be tracked to closure in my regular monthly Safety Executive Meetings.

Andy Byford
Chief Executive Officer

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1.0 EXECUTIVE SUMMARY

At 4:44 AM on September 14, 2012, southbound work car RT-4 struck a Rail Infrastructure Department Roadmaster and a Track Mechanic, who were on the southbound tracks just south of the bridge crossing Highway 401. The Roadmaster was pronounced dead at the scene, the Track Mechanic suffered serious head lacerations requiring hospitalization along with contusions to his chest and legs. The Operator of RT-4 suffered serious chest pains, was admitted to hospital and later underwent treatment for a heart condition.

The Roadmaster and Track Mechanic were inspecting track defects beyond the bounds of a work zone established in the northbound tracks for RT-81 near the scene of the incident. Neither employee had requested permission from the Transit Control Centre to conduct a walking inspection on the southbound tracks as is required by the Subway Rule Book. Consequently, this did not prompt the Transit Control Centre to make a radio call to alert work car Operators of the workers' presence. Neither person performed the duties of a dedicated watchperson since the Subway Rule Book does not require it. Therefore neither provided hand signals with a flashlight to the Operator of RT-4.

Three causal factors were identified and explored for root causes:

1. The two person track crew did not notify the Transit Control Centre of their intention to enter the southbound track for a walking inspection.

2. Both the Roadmaster and the Track Mechanic were not aware of the approaching work car RT-4 in time to avoid contact.

3. The work car Operator was not aware of the presence of workers at track level in time to avoid contact.

The Incident Investigation Team used four analytic tools to arrive at its Judgements of Need and has made seven recommendations.

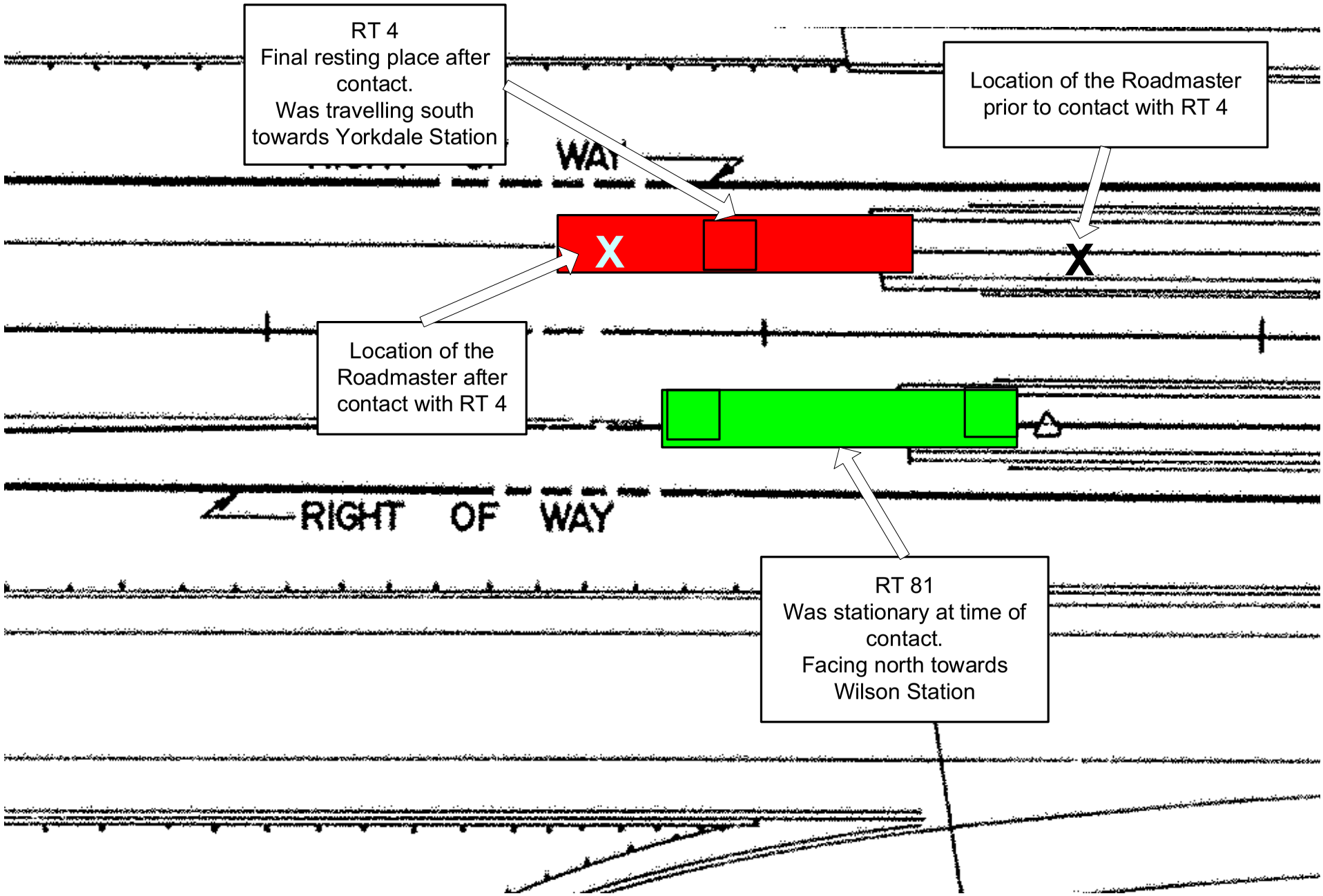
Through the course of the investigation, the Team has identified opportunities for improvement to the work management process beyond the specific facts of this incident. These are presented in section 5.4 with two further recommendations.

2.0 FIGURES

1. Photo of work car RT-4
2. Plan view of incident scene
3. Worker visibility distances
4. Workers' Perspective of RT-4 at maximum line of sight – original headlights
5. Workers' Perspective of RT-4 at maximum line of sight- LED headlights
6. Operator's Perspective from RT-4 at last chance to stop safely - original headlights
7. Operator's Perspective from RT-4 at maximum line of sight- original headlights
8. Operator's Perspective from RT-4 at maximum line of sight – LED headlights
9. Barrier Analysis of *"No Walking Inspection"*
10. Barrier Analysis of *"Crew Not Aware"*
11. Barrier Analysis of *"Operator Not Aware"*

Figure 1

RT-4 Work Car

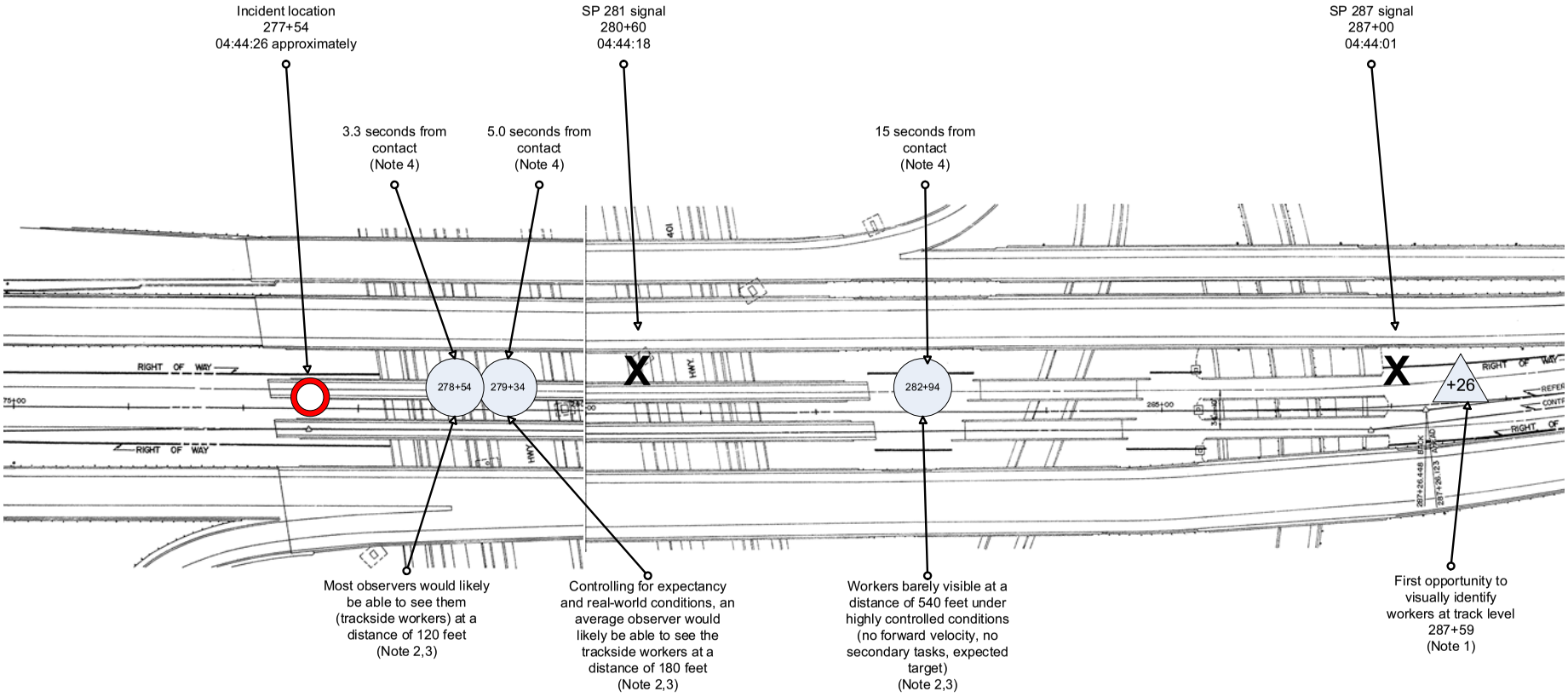


Map of Area

Yorkdale to Wilson Stations

Figure 2

Figure 3



Notes:
1: Information found within Toronto Police Service report
2: Information found within Report from Human Factors North, dated November 27, 2012 re: Internal Re-enactment of TTC Yorkdale Fatality
3: "had the visibility test been carried out in the reverse direction, with RT-4 progressively getting closer to the target, it is likely that the threshold visibility distance, and subsequent distances calculated, would be shorter
(Report from Human Factors North, dated November 27, 2012 re: Internal Re-enactment of TTC Yorkdale Fatality)
4: Time prior to contact determined by using CSS playback information (distance between signal block/time taken to travel through signal block show an average speed of approximately 40 kilometres/hour or 36 feet/second

Worker Visibility Distances

Showing conclusions from Human Factors North report
Dated 27NOV12

Figure 4

Workers' Perspective of RT-4 at Maximum Line of Sight – Original Headlights

Original Digital Photographs Available for Inspection Upon Request

Figure 5

Workers' Perspective of RT-4 at Maximum Line of Sight – LED Headlights

Original Digital Photographs Available for Inspection Upon Request

Figure 6

Operators Perspective from RT-4 at Last Chance to Stop Safely – Original Headlights

Original Digital Photographs Available for Inspection Upon Request

Figure 7

Operators Perspective from RT-4 at Maximum Line of Sight – Original Headlights

Original Digital Photographs Available for Inspection Upon Request

Figure 8

Operators Perspective from RT-4 at Maximum Line of Sight – LED Headlights

Original Digital Photographs Available for Inspection Upon Request

3.0 INVESTIGATION DETAILS

Investigation Team:	John O'Grady, Safety and Environment (Lead) Maria Holmes, Rail Cars and Shops Robert Poole, Rail Infrastructure Frank Ammirante, Rail Infrastructure
Company Name:	Toronto Transit Commission
Incident Location:	Spadina Line, Southbound Track at 277+54
Incident Title:	Yorkdale Fatality
Incident Date:	September 14, 2012
Incident Type:	Occupational Accident
MRPH Rating:	Catastrophic

3.1 LOSS OF CONTROL – DEFINED FAILURE

Loss of Control	Roadmaster and Track Mechanic struck by approaching work car RT-4.
Harm	The Roadmaster suffered fatal injuries, and succumbed to his injuries at the scene. Track Mechanic was severely bruised on both legs, ribs and chest area, and had laceration(s) to his head (20 staples). The train Operator suffered serious chest pains and was admitted to hospital. Each of the other 5 crew members recorded lost time injuries related to acute emotional trauma. Several other staff members who responded to the scene or at the Transit Control Centre (TCC) also recorded lost time injuries for acute emotional trauma.

3.2 EVIDENCE COLLECTION

In the course of conducting its investigation, the Incident Investigation Team (Team) supported the parallel investigations of the Ministry of Labour (MoL), Toronto Police Service (TPS) and the Track & Structures Joint Health and Safety Committee (JHSC). In total, 34 sets of documents have been provided to the MoL at their request.

The Team and the JHSC participated in interviews that were organized on behalf of the MoL with six workers who were at the scene. The seventh worker, the work car Operator, has not been cleared by his attending physician to participate in an interview at time of writing, however, the Team have obtained an audio tape of an interview with TPS taken September 14, 2012, from the Operator's hospital bed. In addition, the Team has arranged interviews with the Roadmaster's direct supervisor and the senior foreperson in charge of quality control and supervisory training. The Team independently interviewed the foreperson who prepared the job briefing, the Manager of Subway SRT Track, the Head of the Rail Infrastructure Department, the former night shift Roadmaster, two Emergency Response Commanders (ERCs, the first responders to the scene), the Manager of the Transit Control Centre and two Training Department staff.

An ergonomist from the MoL and an Incident Reconstructionist from TPS asked the Team to arrange for a detailed inspection of RT-4 (see Figure 1). This occurred on September 18, 2012. The Team has obtained the report of the TPS Incident Reconstructionist. The MoL report will be requested under the Freedom of Information legislation.

The Team has collected a large number of records, documents and photos related to the work performed that night. A plan of the accident scene was prepared to show the positions of the work cars and point of contact with the work crew (Figure 2). Other records include details of the training of various employees and maintenance of work car RT-4. These records have been systematically organized in a unique filing system.

The Team attempted to conduct a site inspection with the JHSC on October 17, 2012 but was denied access to track level due to a conflict with another work zone. The Team therefore conducted a secondary inspection of the sightlines on RT-4 at that time. On October 22, 2012 the Team organized a full scale incident re-creation at the request of the MoL, including participation of the JHSC. Ministry officials took detailed measurements of ambient light levels, headlight lumination and reflectivity from worker PPE at two locations. The first location is at the position where the Operator of RT-4 would have had to apply emergency brakes to avoid contact with the workers at track level and the other location is the calculated position at which brakes were actually applied. Later, the MoL officials took detailed measurements of the sight lines from the Operator's position in RT-4. An ergonomics consultant from Human Factors North attended at the Team's request and prepared a summary report.

At the request of the Team, staff from the Maintenance Engineering section (ME) of Rail Cars and Shops (RC&S) conducted a review to determine an appropriate standard for work car head lights (Problem Report #24885). The Team arranged a second site visit which was held on November 19, 2012. At this time photographic evidence was collected from both the perspective of the crew at track level and the work car Operator. A series of

images were recorded from the immediate site of the contact back in one second intervals. Again, due to difficulties in accessing track level, the Team was only able to collect photos to a point 17 seconds before contact, plus one more at the limit of the work car Operator's line of sight. Two sets of images were taken, one with the existing headlights and another with a test LED lamp system. On November 23, 2012 ME issued a report with recommendations to TTC management (PR #24885 Progress Report #3). A report from Human Factors North was delivered on November 27th, 2012 which analyzes the results of the site visit including visibility distances from the perspective of RT-4. (See Figure 3)

The Team has reached out to other transit agencies in an effort to gather the experience and best practices of these transit agencies. Ten transit agencies responded to a brief survey compiled into a report by consultant Brian McDonnell dated November 23, 2012. The Team also conducted an informal survey of transit agencies who have implemented a track level warning system known as ProTran. Finally the Team collected synthesis documents on track worker safety from U.S. government agencies and relevant standards from the American Public Transportation Association (APTA).

4.0 DATA ANALYSIS

4.1 SEQUENCE OF EVENTS

The Events and Conditions Sequence chart, attached as Appendix B, provides a detailed timeline of events and their context that night. The highlights are as follows:

- All personnel reported for duty at Greenwood before 10:30 PM on September 13, 2012
- A frog welding job on the southbound track near Wilson hostler was assigned to RT-4 under the direction of Welder Wayne Arnold
- An anchor bolt drilling job, on the northbound track, south of Highway 401 bridge, was assigned to RT-81 under the direction of Track Mechanic Celso Machado
- Both crews arrived on site without incident and began work as planned at approximately 2:30 AM
- At approximately 4:30 AM, Roadmaster Peter Pavlovski arrived at the RT-81 worksite to deliver parts
- Pavlovski and Machado proceeded north on the northbound track to inspect future work required to repair the grout pads and plates at the four corners of the bridge
- At the north end of the bridge, Pavlovski and Machado crossed onto the southbound, unprotected track, to continue their inspection
- Neither person contacted the TCC to request authorization for a walking inspection
- Pavlovski and Machado continued to the south end of the 401 bridge to complete their inspection
- At 4:28 AM, the crew of RT-4 cleared their work zone
- At 4:43 AM, RT-4 proceeded south from Wilson Station
- At 4:44 AM, both Pavlovski and Machado were standing on the southbound track, between the running rails, looking down at defects as RT-4 moved towards their location
- Machado looked up and saw RT-4 and made a last second leap to safety; he was contacted by the train in mid-air. Pavlovski was struck and killed by RT-4
- The Operator of RT-81, positioned on the northbound tracks, called the TCC and cut traction power immediately
- Emergency Services arrived on scene at approximately 5:03 AM.

4.2 EVENTS AND CONDITIONS SEQUENCE ANALYSIS

The Team applied several analytic tools in an effort to understand the incident and its causes. These are the Events and Conditions Sequence Chart, Barrier Analysis, Change Analysis and Behavioural Analysis. Each is discussed briefly below.

Events and Conditions Sequence Chart

This technique sets out the activities of each party to the incident in fine detail and documents conditions which explain the behaviour or provide context for it. A complete version of this analysis is presented as Appendix B. **It answers the question "What happened?"** The Team used the chart to organize facts which were extracted to examine a number of safety issues such as human factors, equipment, work environment and procedures. This detail is then used to identify causal factors which, if not present, would have prevented the incident from occurring or lessened its impact. The highlights of this analysis are summarised below. The number in parenthesis indicates the page in Appendix B where this item is recorded.

Human Factors

Fitness for duty is an important human factor to consider. There is no evidence to indicate drug or alcohol use among any of the workers involved in this incident.

The three members of the RT-4 crew were engaged in a conversation as they departed Wilson Station southbound (11). This may have distracted the work car Operator, especially given that he was not expecting the presence of workers at track level.

Following the end of his night shift on September 13, 2012, Roadmaster Pavlovski attended a regularly scheduled Production meeting (1). He discussed the need to inspect grout pad repairs on the 401 bridge with Roadmaster Pereira. Following this, he attended another meeting to discuss plans for RT-41 until approximately 12:15 PM (1). Thus Roadmaster Pavlovski was still working approximately six hours following the normal end of his shift. With only ten hours until he returned to work for the night shift, the Roadmaster's daily sleep pattern may have been affected and could have resulted in fatigue on the night of September 14, 2012, although this cannot be determined with certainty.

Work Environment

Conditions in the work environment may have had a role in the incident. Sound levels at the work site are influenced by the proximity of Highway 401 and the Allen Expressway. In addition the sounds from the compressor and drill on RT-81 would have contributed to the acoustic environment. Sound levels taken during the re-creation on October 22, 2012 were measured by the MoL at 66 dBA, a level sufficient to mask the approach of RT-4.

Street lights provide a limited level of light at the incident scene. Measured at 1 to 4.5 lux during the two re-creations, this is insufficient to illuminate the reflective vests, leg bands

and reflective patches on the hard hats of workers, absent headlights or other task lighting. The incident took place on tangent track with approximately 1000 feet of sightline. There was sufficient distance for RT-4 to stop if the Operator had been aware of, or detected, the workers. There was also sufficient time for the workers to seek safe refuge and signal to the train Operator if they had seen the work car. These are both causal factors to the incident (11).

Equipment

Three equipment issues were raised. First, there is no standard for the selection and aiming of work car headlights. On the night of the incident the headlights on RT-4 were not properly aligned. As a result, the headlights were less effective at projecting light towards the track and the workers' personal protective equipment (PPE).

The workers were both wearing the full complement of PPE - reflective vests, leg bands, and hard hats with reflective patches as well as having with them track level approved flashlights. Nevertheless, the work car Operator did not see them in time to stop.

The Operator's seat in RT-4 can be aligned and locked to face either direction of travel or at 90° to the direction of travel. Based on the evidence available; it appears that the Operator's seat was aligned with the direction of travel – southbound, giving the Operator the full opportunity to see the workers ahead. (11)

Procedures

Failure by the Roadmaster and Track Mechanic to call in a walking inspection to the TCC was a causal factor in the incident. (9) The Behavioural Analysis presented later will examine some of the factors that are seen to reward this non-compliant behaviour.

The minimum acceptable protection allowed under current Subway Rule Book (SRB) practices to access the southbound tracks would have been a walking inspection. The protection this affords is that the TCC will make a line call on the radio to announce a walking inspection. This protection relies on the affected train Operator(s) hearing the announcement, remembering the location and actively observing for the presence of the workers. The only visual cues would come from PPE and hand signals given by the track crew. During non-revenue hours a walking inspection does not require any track level warning devices such as the blue light.

The SRB does not explicitly state a rule to require a dedicated watchperson for a walking inspection. The SRB states, as other information, *"For each work crew at track level, at any given time, one qualified employee has the sole responsibility of giving clearly visible approved hand signals to approaching vehicles using an approved signalling device"* (SRB Section 3.5). There is no evidence that the Roadmaster and Track Mechanic agreed which one of them was to take this responsibility. Neither worker at track level provided the required hand signals to the Operator of RT-4.

To summarize, the events and conditions analysis identified three causal factors. A change to any of them could have prevented this incident. The three causal factors are:

1. The two person track crew did not notify the Transit Control Centre of their intention to enter the southbound track for a walking inspection.
2. Both the Roadmaster and the Track Mechanic were not aware of the approaching work car RT-4 in time to avoid contact.
3. The work car Operator was not aware of the presence of workers at track level in time to avoid contact.

4.3 BARRIER ANALYSIS

The Team then conducted several other types of analysis. **These aim to answer the question of "Why did this happen?"**

The first analysis tool is barrier analysis. In this technique the Team identifies safety barriers available to prevent each of the three causal factors. **Barrier Analysis asks the question why each control did not prevent the incident?** The results are detailed in Appendix C.

No Walking Inspection Request to the Transit Control Centre

This safety barrier failed because it was not used. This barrier is weak as it does not protect the workers from contact by a train, but merely provides a potential warning to work car Operators. It became apparent to the Team during the many interviews, that it is part of the culture of non-revenue culture operations for workers, including supervisory staff, to cross into unprotected areas for short periods of time. Typically this is done with the best of intentions to improve productivity. The function of maintaining track in a state of good repair is safety critical work and staff does what is necessary to achieve their nightly objectives. Among the reasons for "a quick look" would be to provide a first-hand evaluation of defects that need to be repaired or to inspect the quality of work that has already been completed.

Some of the impediments to call the TCC requesting a walking inspection are:

- The perception of low probability of mishap since there are minimal work car movements at night and in most cases, the location of those work cars is identified on the run sheet
- The perception that a walking inspection offers limited protection absent the blue light at night. Note, if the blue light were required, the need to place and retrieve it would be another impediment
- The potential for the TCC to deny access and therefore prevent workers from accomplishing their objectives
- The length of time it takes to actually place the call to the TCC, obtain permission and subsequently, call out upon departure

- In the incident location area, the PAX phone was dysfunctional; to the extent that the PAX system is not reliable, then it will not facilitate calls to the TCC

While any of these reasons may seem trivial in hindsight, the context is one of a chronic race against time to complete work within a short window of opportunity at night. There is an expressed belief among many of those interviewed that the SRB is geared toward revenue operations and does not reflect the unique circumstances present during non-revenue hours. For this reason its rules do not carry the weight that would be expected.
The SRB provides latitude for interpreting the activities that may make use of walking inspections as the only protection. Again, the definition does not have the force of a rule. It allows visually inspecting, troubleshooting to locate a fault and track patrol among other activities. During revenue service, walking inspections are indicated by a blue light at the previous station, but this procedure is not required at night. The SRB does not provide a boundary between work and inspection, neither task is clearly defined.

Since walking inspections lack both track level warning devices and a dedicated watchperson, they rely solely on workers' vigilance as the control. This control failed.

Crew Not Aware of Approaching Work Car in Time

The Roadmaster and Track Mechanic each had twenty two years of track level experience. This was their nightly work environment and the hazard of moving trains was well known to them. Both employees were aware that RT-4 was working just north of them and was expected to clear before the imminent start of revenue service.

During the investigation, workers explained that they use their sense of sight, sound and feel to detect the approach of trains. The Team treated each of these as potential safety barriers and examined why the barriers failed to alert such experienced track level workers.

Sight

Vision is the primary sense that workers are trained to use for train detection. Three safety barriers are used to improve the visibility of work cars, namely running lights, headlights and colour. All three were functional on September 14th, 2012. In that particular location, however, the presence of street lighting to the north of the 401 bridge worked against the effectiveness of the work car lighting. At the incident site, the view to the north features many point sources of light which mimic the colour and intensity of the work car lights. Figure 4 shows the approaching RT-4 from the workers' perspective at the maximum line of sight, approximately 26 seconds before impact. The work car headlights and running lights are just four points in a virtually continuous horizon of similar point sources of light. Figure 5 shows the same view with the new LED headlights which are dramatically brighter.

In addition, since the work car was travelling directly toward the workers, its movement would not immediately be detectable at a glance. A dedicated watchperson could be expected to notice the addition of the RT-4 lights when they first came into view, but they would be easy to overlook at a quick glance. The Team calculates that the work car would have been in the line of sight of the crew for approximately 26 seconds. Thus, with the primary focus on the track inspection, and lacking a dedicated watchperson, the work car could approach undetected.

Sound

As part of their on-the-job training and experience, workers are given cues to hear approaching trains, although it is not a formally sanctioned safety barrier. As noted earlier under Work Environment this is a relatively noisy site, with many sources of environmental sounds, even at night. By contrast, the electric propulsion in the work car is comparatively quiet and the continuously welded rail further dampens transient sound emanating from the track. TTC does not add artificial sound to its vehicles. The horn was functional and the work car Operator claimed to sound it, but not until he was too close to avoid contact. If the workers relied on sound to detect the oncoming work car, the environmental conditions rendered this method ineffective.

Feel

The piston effect of air movement through tunnels was not available since this work was in an open cut.

Ground or rail borne vibration is another sensory cue that is used to supplement formal safety barriers. In testimony, some workers discussed the ability to detect slight vibration in the rail or the invert which helped to alert them to train approach. The presence of heavy truck traffic on Highway 401 and the Allen Expressway, when added to the drilling work of RT-81, may have interfered with this subtle and unofficial sensory cue.

Procedures

The most effective procedural barrier available to the two workers would have been to agree that one of them take the role as watchperson, even without having the benefit of an approved walking inspection. This safety barrier was not used.

The decision by the Roadmaster to conduct the inspection was unplanned in the sense that it was not recorded on the run sheet. It was contingent on the time available following delivery of the rubber pads to RT-81. The Roadmaster had already visited three other worksites after leaving Greenwood at about 2:00 AM. From the testimony of the Track Mechanic, the Roadmaster intended to inspect the grout pads by himself. The Track Mechanic volunteered to accompany the Roadmaster. The SRB does not prohibit walking alone at track level. Rule 3.1.4 states *"Under normal circumstances, do not walk alone on the mainline track".*

The Roadmaster had discussed the work on the 401 bridge with Roadmaster Pereira following the Production meeting on the morning of September 13, 2012. There were concerns with a previous repair effort on the grout pad at what became the incident scene. Furthermore, earlier customer complaints had been registered over the length of time taken in the overall bridge repair program.

The grout pads on the northbound track were protected by the RT-81 work zone. Since the drill on RT-81 is on the north end, these grout pads were closest to the location where the Roadmaster delivered the rubber pads. This may have been a factor in choosing to walk north in the northbound, which later would lead the Roadmaster and Track Mechanic to walk with their backs to traffic on the southbound tracks.

Further, the text of the SRB does not require a watchperson for a walking inspection. Rules in section 3.5 set out duties for signalling trains which are distinct from the rules for a watchperson in 6.9.1, *"Until you are replaced by another qualified watchperson, do not perform any other duties than those of a watchperson."* There is no such singular duty placed on the person responsible for train hand signals in a walking inspection. The SRB does not set any rule for deciding who should perform that function. On the other hand, SRB Figure 3-2 shows a watchperson walking ahead of a three person walking inspection with a red flag. There is no rule to support this Figure. Since the context is blue light layout, it would seem not to apply to non-revenue hours. The lack of a supporting rule renders Figure 3-2 ambiguous which is symptomatic of a wider problem with the SRB rules.

Based on all the above, it is reasonable to conclude that the Roadmaster considered the grout pad to be a problem and was motivated to resolve it in a timely way. He had only a brief window of opportunity to determine an appropriate course of action due to his arrival at RT-81 at approximately 4:35 AM, just prior to the end of nightly maintenance. The SRB is framed in such a way that a dedicated and productive supervisor could justify the quick inspection of a track defect in order to plan a timely resolution. The Team has heard ample testimony to conclude that this is a common practice, if not an expectation, in the work culture.

To summarize, the safety barriers in place to ensure the track crew was aware of an approaching train are all low on the hierarchy of safety controls, relying as they do, on individuals following certain behaviours. None of the barriers remove the risk, put any type of shielding in place nor even provide a positive warning. The SRB procedures enable the risk taking behaviour which is seen to be an important element in the efficient management of track work.

Work Car Operator Not Aware of Presence of Workers at Track Level

This causal factor is the obverse of the previous one. The work car Operator has a duty to see and avoid contact with personnel at track level. The four generic factors that the Team considered are sight, sound, human factors and procedures.

Sight

The Operator had five controls to help him see workers foul of the track. The first is the work car headlights. While the headlights did function, on each end of the work car, one of the lamps was not aimed squarely down the track. The Operator testified that RT-4 was his normal assignment and he had tried without success to rectify the headlight alignment. A review of the pre/post trip inspection records for RT-4 for the period September 2011 to September 2012 did not support this allegation.

Given the condition of the headlights, the central question in this barrier analysis is *"Could the work car Operator see the workers in time to stop?" Human Factors North report #2 responds directly to this question.* The workers become ever more visible after the threshold of visibility at 540 feet. Adjusting for factors such as expectancy, and variations in visual acuity, the average person could see the workers at about 180 feet. At 40 km/h the measured distance for emergency braking for RT-4 was 114 feet. Accounting for reaction time, this is approximately the final moment to assure a safe stop. Figure 6 shows the Operator's perspective at this distance. The Team judges that a professional work car

Operator would be a better than average observer and should have seen the workers, even with the skewed headlight. A vision test is included as part of the Operator recertification program. This Operator was current with his certification and therefore had acceptable vision.

At the time of the incident, the TTC lacked an internal standard for the lumination and aiming of work car headlights. RC&S has since identified a comparable standard in the U.S. Federal Railway Administration and adapted it to TTC train speeds and stopping distances. RC&S have identified a lamp that meets this standard. This lamp was the subject of on-site testing on November 19, 2012. Using the new proposed TTC standard, the workers were visible for the entire 972 foot line of sight available to the Operator and would have given the Operator a better opportunity to see the workers. Figure 7 shows the accident scene from the perspective of the Operator at the maximum line of sight, 26 seconds before impact, using the original headlights and Figure 8 shows the same perspective with the new LED system.

The second control is the reflective PPE worn by the workers. Each was wearing the prescribed PPE including vest, hard hat and leg bands. This PPE was effective, but its visibility is a function of the luminance and alignment of the light beam. As noted above the new headlights will improve visibility significantly. The Team did not explore changes to worker PPE as this issue has been the subject of recent internal reviews.

A related potential barrier is the ambient light available to reflect vertically off the workers. TTC has a lighting standard of 10 lux in open cuts. The actual ambient lighting has been measured at between 1 and 4.5 lux. The right of way does not have any lighting installed by TTC. Lighting is provided by nearby street lights. In that sense the suggested barrier was not available to this work crew. It should be noted that it is not the intent of the lighting standard to illuminate workers nor that 10 lux would be sufficient to do so.

The other potential lighting controls are blue lights and track level warning lights which were not applicable for this incident. Track level approved flashlights found on scene were not used during this incident to warn the Operator of the work crew's presence.

Sound

The only sound control identified would have been a line radio message from the TCC. This was not available since the workers at track level did not call in a walking inspection. There is no protocol by which the TCC will contact an individual train to alert the Operator of a walking inspection just ahead. Similarly, the work car Operator is not required to acknowledge that the call has been received

Human Factors

The operator's testimony to police was that he'd had a recent day off and a good night's sleep and did not feel fatigued.

Reliance on work car Operator attentiveness is an informal control. The Operator was not using a cell phone or other prohibited device. The Operator was involved in a conversation with the other two workers seated in the cab of RT-4.

In his testimony, the Operator states that "....I have noticed the first bridge and it's not very long. It's only about 50 feet, 50, 60 feet long … and I approached and I looked and I saw it, *but it looked like there was something there* … but I didn't get to see it 'till I got about 15, 20 feet and I noticed it was two people … hunched over the tracks ..." The Operator did not sound the horn, but continued southbound at an average speed of 40 km/h. Distraction may have played a role in this incident.

Procedures

Wayside markers and signals authorize train speed and the work car operation. Based on Central Signal System (CSS) data, RT-4 appears to comply with these controls at all material times.

Because the subway operates on an exclusive right of way, all train operations are governed by signals and wayside markers. Operators are trained to respond to these visual cues in order to maintain safe operations. There are bright and visually dominant signals surrounding the incident site. The Operator's attention may have been drawn to this cue first and detracted his attention from the unexpected presence of workers at track level. As previously stated, the work car Operator had reason to react defensively and did not.

In summary, of the controls in place to alert the Operator of workers at track level, the most powerful are still only weak administrative controls, being visual or auditory cues. The current train headlights provide sufficient light to allow an attentive Operator to stop in time. Improvements to the headlights would provide an additional time margin for the train to stop and/or the workers to flee to safety.

4.4 CHANGE ANALYSIS

The purpose of change analysis is to examine the conditions that led to the incident for any variations from an ideal state or work of a similar nature that did not result in an injury. **Change Analysis asks the question "What was different this night"?** The results are contained in Appendix D.

The change analysis served to confirm the findings of the Events and Conditions Chart and the Barrier Analysis. The main changes and their results are as follows:

- Track crew did not seek authorization for a walking inspection this night with the result that the TCC was not prompted to make the line call to alert the work car Operator
- The track crew did not make clear hand signals to the work car this night with the result that the work car did not stop in time
- This was a particularly dark and noisy location making train detection more challenging
- Each of the three workers was not attentive to the hazard with the result that the contact was made

The change analysis reveals nothing was particularly different. The conclusion drawn is that the conditions and behaviours were within the norms of the work culture.

4.5 BEHAVIOUR ANALYSIS

Behaviour analysis explains behaviour in terms of motivation. **Why do individuals choose not to follow established rules?** The answer lies in the consequences of following a rule. Good rules result in consequences that happen soon, are certain and have positive results. The results of an Antecedent, Behaviour, Consequence (ABC) analysis on the Roadmaster, the Track Mechanic and the Operator of RT-4 are presented in Appendix E.

Roadmaster

The Roadmaster is the senior management official on duty in the subway at night. He is responsible for ensuring that the many dispersed work crews accomplish their nightly tasks and for direct supervision of forepersons, their assistants as well as the workers supervising sites without management staff including the RT-81 and RT-4 crews.

Being on site, the Roadmaster has a role in evaluating the track defects and how to repair them. He is the main liaison with the TCC to ensure coordination of power cuts and impassable work zones. If serious problems arise with other work crews such as Signals or Electrical, he is the primary point of contact, even though they are not in his chain of command. Mechanical problems with work cars are referred to him. The underlying context is the short time available, the human factors that accompany night shift and the many uncertainties that accompany heavy rail maintenance.

Given these antecedents the Roadmaster's decisions on not calling the TCC to gain track access are readily explainable as discussed earlier under the Barrier Analysis heading "*Crew Not Aware of Approaching Work Car in Time-Procedures"*. The Roadmaster is virtually certain of immediately meeting his objectives by acting on his own. The consequence of following the SRB will be to insert delay, uncertainty and potentially a frustration of his objectives. Further, the protection afforded by a walking inspection is limited.

The Roadmaster's actions are a natural response to his work environment and the need to accomplish his many and varied duties.

Track Mechanic

The Track Mechanic accompanied his supervisor the Roadmaster. He stated that he did not want the Roadmaster to go alone. The grout repair work, thought to be substandard, had been done by the Track Mechanic earlier and in testimony to the Team he explained why this had happened.

The work of RT-81 could continue temporarily without him, because the drilling was underway. Faced with the same constraints of time and judging the risk to be low, the Track Mechanic also chose to access the southbound track without calling in a walking inspection. Therefore two people are now at track level without authorization from the TCC. It is less obvious why he did not act more proactively to watch for RT-4, however, he did testify that he habitually looked over his shoulder while walking with his back to the oncoming traffic. In the end, the Track Mechanic was watchful enough to save his life by leaping and avoiding direct contact with RT-4.

Work Car Operator

The ABC analysis simply supports earlier observations about the Operator's role. He was travelling at authorized speed following the signal system indications. His motivation to return to Greenwood before revenue service runs out is consistent with TTC practices. The Operator did not use defensive driving strategies despite observing the RT-81 work zone and seeing something ahead on the track. He continued operating as though not expecting anything ahead at track level. He was engaged in conversation with two other workers. The Operator testified that he had reported the improper aim of one of the headlights but there is no evidence that he used the work car check system designed to identify and repair defects.

5.0 JUDGEMENTS OF NEED AND RECOMMENDATIONS

The Team has organized the judgements of need and recommendations according to the three identified causal factors. These are:

1. The two person track crew did not notify the Transit Control Centre of their intention to enter the southbound track for a walking inspection.

2. Both the Roadmaster and the Track Mechanic were not aware of the approaching work car RT-4 in time to avoid contact.

3. The work car Operator was not aware of the presence of workers at track level in time to avoid contact.

The barrier analysis identified root causes for each causal factor. The Team developed its recommendations based on these root causes. In considering the root causes, some had a direct impact given the specific facts of this incident while others point to underlying issues in the work culture and management systems that gave rise to the actions that led to the incident. The Team has separated these two streams for discussion purposes.

Beyond that, there is a much wider ranging and long term response available to reconsider the basic rules of work and the governance of these rules. The latter should be seen as a long term program for sustainable culture change as addressed in Section 5.4.

5.1 NO WALKING INSPECTION REQUEST TO THE TRANSIT CONTROL CENTER

Discussion

The Events and Conditions Sequence analysis reveals that one of the controls available to the track crew was a walking inspection (SRB 3.3) authorized by the TCC. This barrier was not used, but instead the two person crew went onto the unprotected southbound track without authorization.

Short duration access to unprotected track is a fact of life in the culture of non-revenue maintenance. Among the possible reasons for this behaviour are two direct root causes and two underlying root causes (See Appendix C and Figure 9 page 27):

Direct Root Causes

- It consumes precious time to gain approval from TCC
- There is a potential for TCC to refuse to allow access

Underlying Root Causes

- The track workers assumed this to be a low risk behaviour
- Protection afforded by this control is weak

We will discuss each in turn.

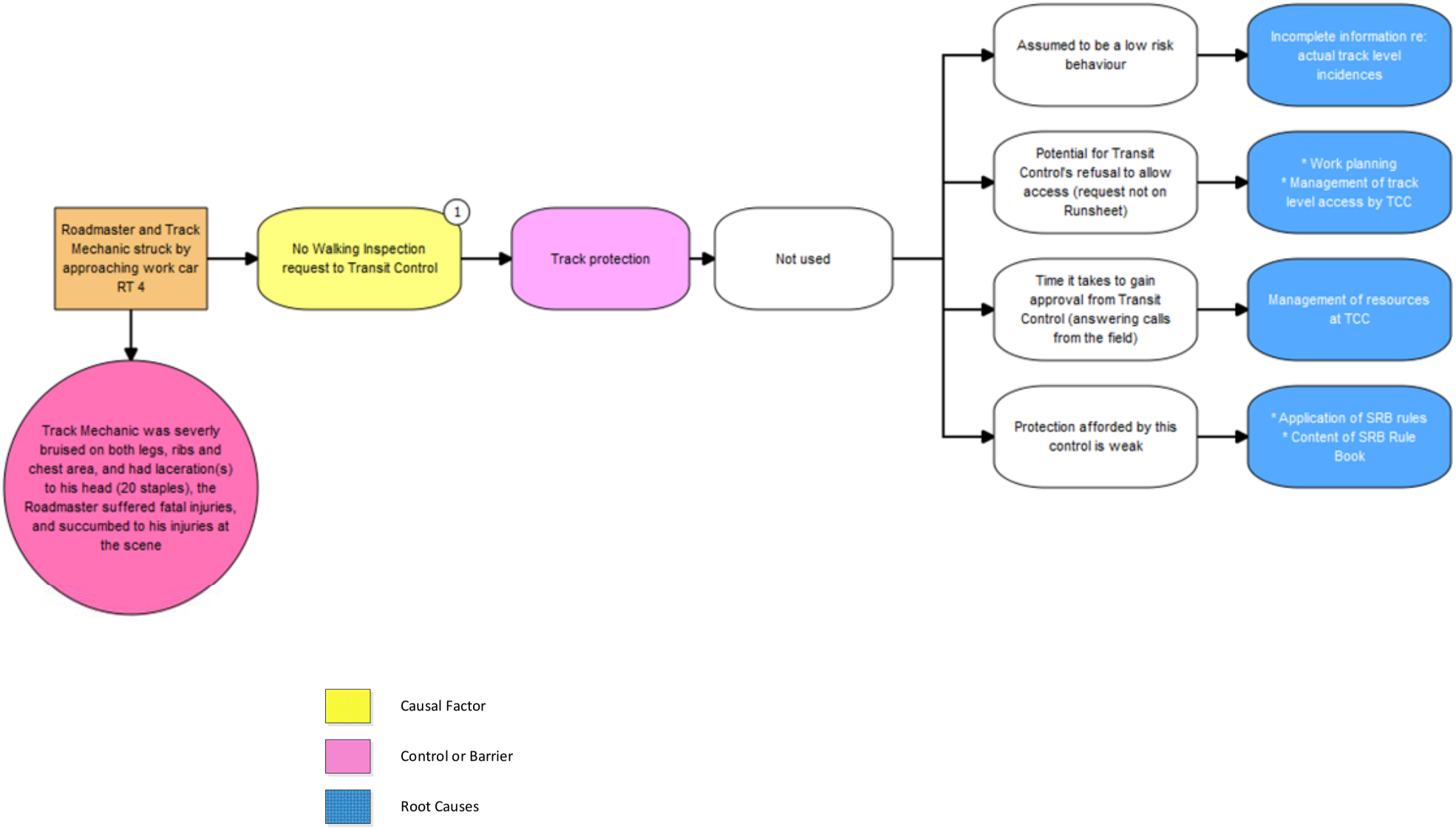
Direct Root Causes – The Interplay of Time and Rules

Understanding these two root causes leads to a consideration of the finite time available in the nightly maintenance window. At TTC, the tight time window for track maintenance work is a constant constraint. By all accounts the limited amount of time is being aggravated as the system grows and ages, requiring more maintenance work. Further, the introduction of new technology such as Automatic Train Control (ATC), also consumes track level time to install and maintain.

The tight maintenance window has a profound impact on the work culture. Therefore the effective use of maintenance time is critical. Safety can only be effectively woven into this work if the imperative of time is acknowledged. Time is the ultimate resource and the decision to obey a rule will be intuitively based on a time/effectiveness calculation. The response time by the TCC will vary based on call traffic at that moment. During peak activity, waiting for a TCC response can take longer than the time needed for a “quick look” on the other bound. In the behavioural analysis this is an important factor to explain the motivation of the track crew. Unauthorized access provides soon, certain and positive behavioural incentives.

During non-revenue hours, the TCC supports maintenance forces by coordinating work car movements and power cuts. For issues of track access, the TCC is cast in the role of gatekeeper using the nightly run sheet and the SRB as the keys. They are required to

Figure 9



Yorkdale Fatality Investigation
Causal Factor 1
Root Cause Analysis

deny the access request if it does not meet the rules. But do the methods and safety rules add unhelpful or unnecessary burdens given the reality of time constraints during non-revenue maintenance?

Despite many efforts, the run sheet remains a fluid listing of work right up to the assignment of crews. RT-4 was originally scheduled to work on the south Yonge line on September 14, 2012, but was reassigned to Wilson. The late changes require judgements to be made in real time by both track supervisors and the TCC. The appropriate type of work zone is not identified on the run sheet given to the TCC but is conveyed to the crew in the job briefing by the foreperson. The Rail Infrastructure Production Planner telephones the TCC with the final published run sheet and, with all participants (including Wayside Dispatchers, Tower Controllers and the Assistant Manager of the TCC) goes through the run sheet line by line. Any questions, conflicts or concerns can be raised then and discussed. Work zones may or may not be discussed, dependant on the situation. Work planning methods that lead to late changes create challenges for the TCC in the exercise of its role.

TTC, like most railway companies, puts a heavy reliance on rules based safety. The SRB is our unified code, governing both rail operations and track maintenance. There are tensions in bridging these two domains. Many maintenance staff have shared with the Team, their perception that the primary objective of the SRB is to manage revenue train operations. Some other transit agencies such as Boston, Washington, Maryland and the New Jersey River Line set out maintenance of way rules in a separate document.

As one example, during non-revenue hours, the signal system can be employed to protect minor work zones, through simple track occupancy, as the crew of RT-81 did. This would not be possible during revenue service. The criteria for selection of work zones in SRB 5.4 are open to interpretation. For example, there are a number of criteria listed, any one of which triggers the need for an impassible work zone. Consider the following criterion:

SRB 5.4 *"If any of the criteria for a more restrictive work zone are met, the more restrictive work zone is required.*
Criterion 8 – (If the work) *Needs equipment or vehicles on either track that cannot be moved to allow traffic to pass".* (then an impassible work zone is required)

The interpretation used by the crew of RT-81 is that since the work car can be moved, it does not trigger this criterion and a minor work zone will suffice. In this layout there are no track level warning lights on the southbound track. Underlying this interpretation is an implicit hazard analysis that the occupancy of the work car itself will cause the signal system to display a red aspect with train stop protection for two signal blocks behind the work zone. The additional protection afforded by a double red portable train stop is seen to be redundant and an unnecessary burden, especially because of the limited time available in night maintenance.

In another interpretation of the same rule, the simple presence of a drill mounted work car triggers the need for an impassable work zone because the work car cannot be moved while actively drilling, if the work is to be accomplished. If RT-81 was set up according to this interpretation of the SRB, this would have required a solid yellow light in the southbound track 1000 feet north of the incident site, at the approximate limit of the line of

sight between RT-4 and the Roadmaster. The solid yellow light is a training based control (Work Car Operator Resource Book - Initial Section D4-1) to tell the Operator of RT-4 to slow to 15km/h. As an agency, the TTC cannot tolerate different interpretations of the same rule.

The use of rules must account for the specific situations of non-revenue track maintenance. When they don't, rule violations are the predictable result. When accessing the work zone of RT-81 at the start of this incident the Roadmaster violated the plain language of SRB 3.1.2 "*You must get permission from TCC to go to track level".* Management staff interpret this not to apply when entering *established* work zones. Otherwise supervisory visits, quality assurance checks and other management oversight responsibilities could be compromised.

If all rules do not receive rigid adherence, then the rule book itself gradually loses status. Work zone definitions weaken, for example one worker testified that their crew called in a moving work zone which technically does not exist. Despite calling in a minor work zone, the RT-81 crew did not actually set out any track level warning lights. When the Roadmaster arrived at RT-81, he did not correct the deficient minor work zone layout. If it is understood that the signal system is providing the protection, why put out unnecessary warning devices?

Because supervisory staff do cross to the unprotected track for inspection, workers acknowledged they too feel enabled to cross over for various reasons. Work zone boundaries become porous.

In this culture, workers select the protection they feel is adequate, rather than the protection prescribed by the SRB. The danger is that the individual work crew may not have all the information needed to make an integrated risk assessment. Further, the situation can change and other stakeholders may rely on a mistaken set of facts. For example, in the evidence, RT-4 called in an impassible both ways but only installed track level warning devices in one direction. Meanwhile a signal crew was refused a minor work zone and was granted a walking inspection by the TCC in both directions to the north of RT-4 because of the impassible being called in both ways. The signal crew may have been exposed to more risk on the mistaken assumption that they were protected by this non-existent impassible work zone.

Although we do not condone the failure by the track level workers to call in a walking inspection, this decision is understandable in the context of non-revenue work culture. In considering how to address such a broad issue, the Team believes there are some specific tasks that can be undertaken immediately to better coordinate the roles of Rail Infrastructure and the Transit Control Centre and improve the information available to all stakeholders.

Longer term actions to address these issues are discussed in section 5.4 below.

Judgement of Needs – <u>Direct</u> Root Causes for No walking inspection request to the TCC

1. <u>An integrated review</u> of the practices and procedures of the TCC and Rail Infrastructure (RI) for non-revenue maintenance is required. In the spirit of business

partnership, this review should have the goal to identify how the TCC can provide a more value added service to its clients in RI to facilitate the safety and productivity of night maintenance. At the same time, RI needs to have a run sheet that is reliable in real time, on which TCC can base decisions on access control. This collaboration could build on recent inter-departmental improvements such as the dispatch of work cars. It would be a tribute to Roadmaster Pavlovski who spearheaded this dialogue.

This review should have three dimensions. First is timeliness. How can the needs for power cuts, track access and train movements be organized with a view to maximizing the utility of the scarce resource of time during the maintenance window? Second is effectiveness. Do the controls exercised really improve the workers' margin of safety enough to influence their behaviour toward compliance? Finally, current resource levels should be off the table. First let's determine our needs, and then plan for resources to fulfill these needs.

Recommendation #1

The Deputy Chief Operating Officer-Rail (DCOO) should conduct a review of the interface between the Transit Control Centre and Rail Infrastructure practices to ensure they support maintenance activities with particular emphasis on non-revenue maintenance, to the degree consistent with safe revenue operations.

<u>Underlying</u> Root Causes – Perception of Low Risk and Weakness of Controls

Track workers learn how to detect train movement and, through experience, expect to be able to safely conduct quick inspections on unprotected track. The absence of relevant information on incidents can lead to an underestimation of the level of risk. The TTC investigates serious incidents, especially those causing injury, but there is less emphasis on investigating minor lost time injuries and near miss incidents.

There is a range of opinion on the prevalence of near miss incidents. Our survey of other transit properties revealed that all respondents have a specific program to capture near miss incidents. Most, but not all, are conducted under a *"no name - no blame"* regime to encourage reporting among represented employees. Without a deliberate focus on reporting near misses, there is incomplete information available to supervisors and workers to assess the actual risk of behaviour such as unauthorized track access. Without a standard approach to identifying root cause of both injuries and near miss incidents, management lacks important information on which to set priorities.

The protection afforded by a walking inspection during non-revenue hours is weak. Since blue lights are not used, the only systemic protection offered is a line call to all Operators. This level of protection may not be worth the time it consumes to obtain. This too reflects revenue service conditions more than non-revenue maintenance. During revenue service, it is not practical for the TCC to request and receive acknowledgement from each of the 40+ Operators each time they make a line call. The situation at night is quite different. In this incident a single radio call to RT-4 would have alerted the Operator to the track crew. In the alternative it may be more feasible during non-revenue hours to require Operators to acknowledge radio calls.

Judgement of Needs – Underlying Root Causes for Perception of Low Risk and Weakness of Controls

2. One reason the track workers could judge this to be a low risk behaviour is misinformation. TTC lacks a uniform process for reporting near misses and for conducting root cause analysis of both injuries and near miss incidents. For this reason accurate information on the actual hazards of track maintenance and the prevalence of track level incidents is not readily disseminated to supervisors and workers. There is a need to implement a uniform program to report, investigate and communicate the causes of injuries and hazardous situations encountered in the workplace.

   Recommendation #2

   The CEO should establish a timeline by which all groups in TTC implement a uniform process for reporting, investigating and communicating safety incidents.

3. The current system in place requires TCC to initiate a line call to advise all work car Operators of a walking inspection, which includes location. The Team has identified this control as a weak one, as this is a simple one way flow of information from TCC. It would be more effective with a closed loop to ensure receipt of the information by the operator.

   Recommendation

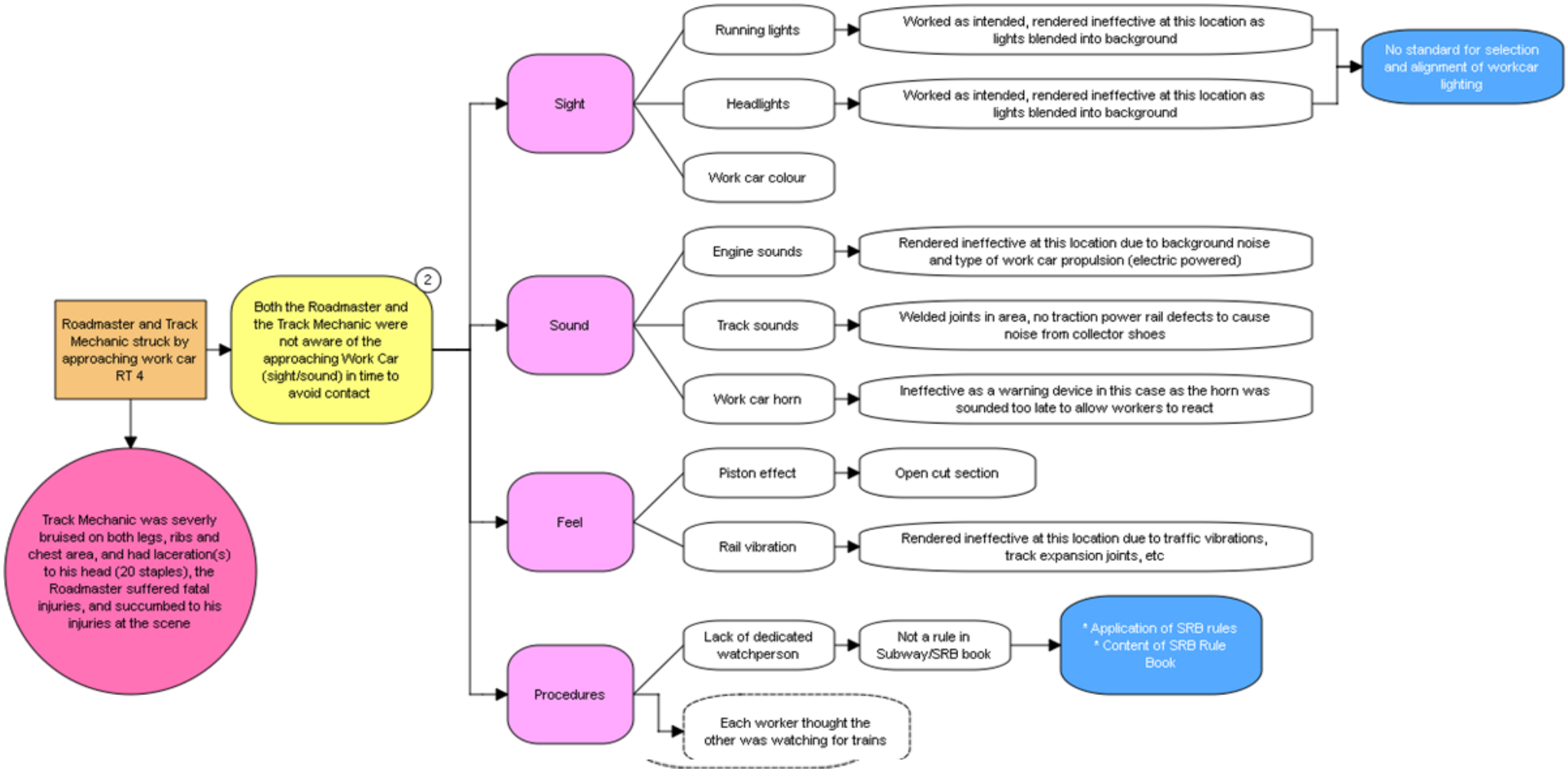
   This issue should be addressed in recommendation #1.

5.2 BOTH THE ROADMASTER AND THE TRACK MECHANIC WERE NOT AWARE OF THE APPROACHING WORK CAR IN TIME TO AVOID CONTACT

Discussion

The Events and Conditions Sequence analysis found that failure to detect the approaching work car was a causal factor. The specific safety barriers that failed include sensory cues of sight, sound and feeling as well as the procedural failure of the lack of a dedicated watchperson. There were two direct root causes identified and one underlying issue (See Appendix C and Figure #10, Page 32):

Figure 10



Yorkdale Fatality Investigation
Causal Factor 2
Root Cause Analysis

Direct Root Causes

- Lack of a standard for work car headlights
- SRB rules for watchpersons.

Underlying Issue

- Barriers not yet available at the TTC include technology devices for worker detection including interactive track level warning devices and engineered safety devices such as a portable signaling shunt.

<u>Direct</u> Root Causes – Headlights and Watchpersons

There is no engineering specification for work car head lights in TTC or in any known government regulation in Canada. The lack of a standard for selection and alignment of headlights is seen to be a root cause for this incident. Rail Cars and Shops (RC&S) has now developed and tested a proposed specification. As shown in Figures 5 and 8, the impact of LED lighting is dramatic both in colour contrast and lumination intensity. As such this lighting system would increase work car detectability by track workers significantly. This project should proceed as recommended by RC&S.

The SRB does not specifically require a watchperson for walking inspections and contains ambiguity between the text and figure illustrating walking inspections. The activities allowed under a walking inspection are only described in general terms and there is considerable room for interpretation on the boundary between the definition of “work” and “inspection”.

Greater efforts are needed to alert and protect workers performing maintenance at track level.

Judgement of Needs – <u>Direct</u> Root Causes for Headlights and Watchpersons

4. Neither worker saw the work car in time to avoid contact, although the Track Mechanic jumped with the slimmest of margins to save his life. Both the running and head lights on the work car were functional and in the accident re-creation both were visible through the entire line of sight. One headlight was not aligned properly, but, from the track worker point of view, was still clearly visible. The headlights were ineffective because their colour tone and lumination intensity is mimicked in this location by background streetlights.

   Recommendation #3

   The DCOO implement the recommendations in Rail Cars and Shops Problem Report 24885.

5. Neither worker specifically took on the task of watchperson. The SRB is unclear on this point as noted above and this lack of clarity is seen as a root cause of the incident. The team acknowledges, however, that the track crew was operating outside the

bounds of the SRB, and so the addition of more rules is not seen to be an effective response. Nevertheless, some interim response is warranted pending a more holistic consideration of the entire set of rules and technological fixes available.

Recommendation #4

The Chief Operating Officer (COO) consider, as an interim measure, that walking inspections require a dedicated watchperson pending the outcome of the recommendation on warning technologies in #6 below and the more global review of rules in Section 5.4. Emphasis on the need for individual vigilance through a slogan such as "*Any time is train time*" **would reinforce the notion that the watchperson is an integral element of all track level crews.**

Underlying Root Causes

The workers did not hear the work car because it produced less noise than ambient environmental noise in this location. A number of transit agencies and railways have introduced warning technologies to alert train Operators and track workers of each other. These include Los Angeles, Atlanta (pilot), Union Pacific Rail Road and Rail Corp (Sydney). Other transit agencies such as New York have examined some of these technologies and decided not to proceed at this time, or in the case of Washington, to discontinue the test.

Judgement of Needs - Underlying Root Causes- Technology for Worker Detection

6. At TTC, the Signals Engineering group has developed a Work Area Warning system based on the speed control system. At this time it is designed to alert train Operators but not track level workers. The use of warning technology may be another issue for which an application during non-revenue hours may warrant a closer examination. Any decision must be based on sound engineering, operational and safety analysis.

Recommendation #5

The COO prepare a review of the applicability of new technological advances in track level warning devices for maintenance work.

5.3 WORK CAR OPERATOR NOT AWARE OF PRESENCE OF WORKERS AT TRACK LEVEL

Discussion

The Events and Conditions Sequence analysis identified as a causal factor, the Operator's lack of awareness of the track workers' presence. The safety barriers that failed, include the sensory cues of sight and sound, Operator attentiveness, and procedures relating to work car Operator training and operations. The root causes identified are as follows (See Appendix C and Figure 11, Page 36):

Direct Root Causes

- Workcar headlights (see recommendation #4)
- Application and content of Subway Rule Book (see recommendation #9)
- Operator performance and training.

Underlying Root Cause

- No advance warning of the presence of workers

Direct Root Causes – Workcar Headlights

The ergonomic analysis concluded that the illumination from the existing headlights and ambient light was sufficient for the Operator to see the track crew in time to stop RT-4 if he was looking directly at their location. The margin of safety is reduced by looking elsewhere, not expecting workers at track level and being distracted. The LED test headlights discussed above cast a much brighter light such that the track crew is visible at twice the distance, in this case, through the entire 972 foot line of sight. This provides a greater margin for Operator error. The alignment of the headlights is a more important issue for the Operator than for the track crew. Lacking a standard for both selection and alignment of work car headlights is considered a root cause of the incident. This root cause is addressed in Recommendation #4.

Direct Root Causes – Subway Rule Book

This root cause identifies the lack of hand signals and/or track warning lights discussed under “No Walking Inspection Request” above (see recommendation #8 and #9).

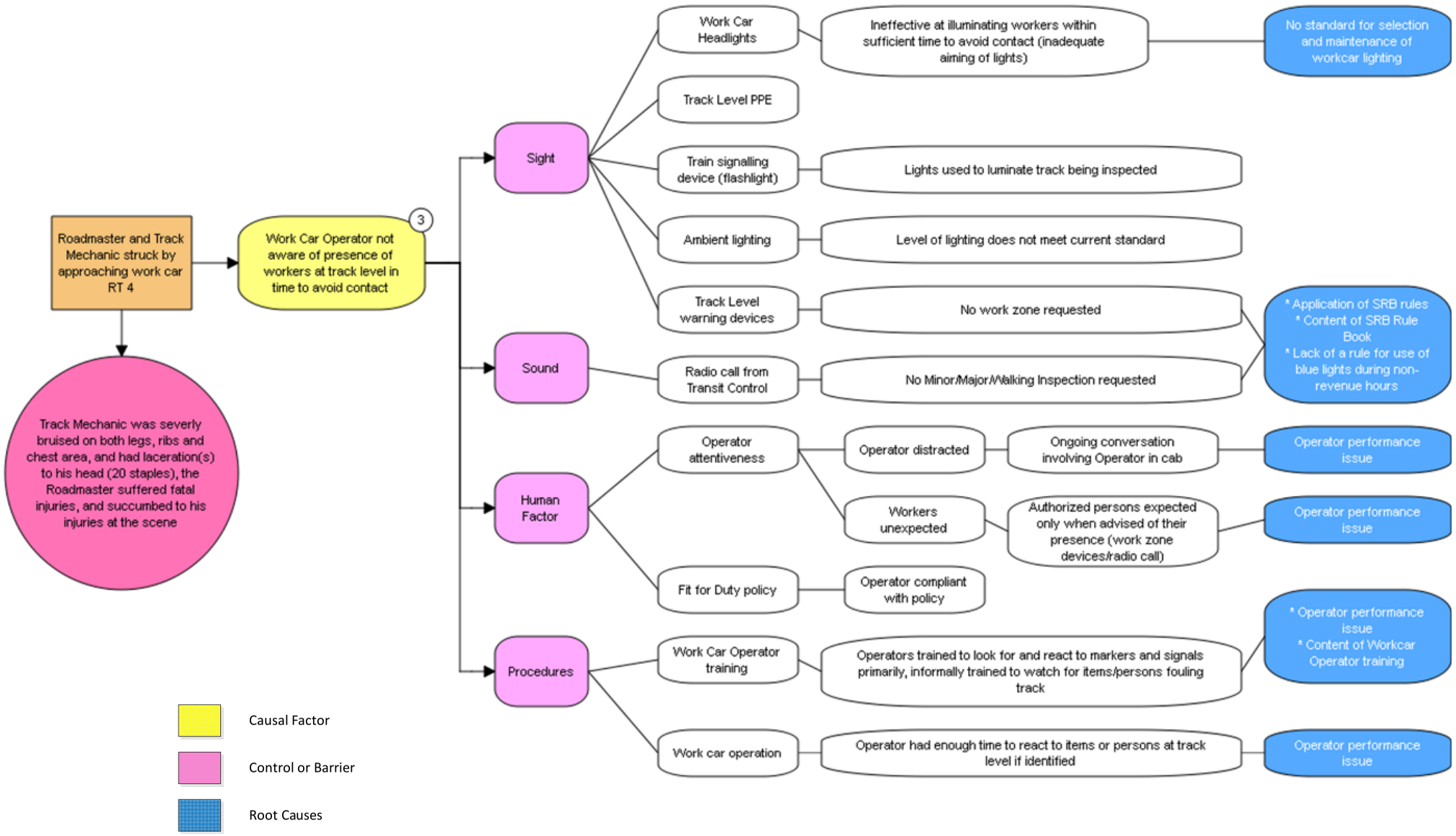
Direct Root Cause – Operator Inattentiveness

There was sufficient time for the operator of RT-4 to stop, but no margin for error. The fact that he did not observe the track workers in time to stop indicates inattentiveness.

Judgement of Need – Direct Root Cause Inattentiveness

7. The Operator’s inattentiveness is explained by his conversation with the other occupants of the work car cab, aggravated by the unexpected presence of the track crew. There is no expectation that the other workers in the cab assist as lookouts for the Operator. There is guidance regarding distractions from co-workers while operating work cars, in the Training Department’s Work Car Operator Initial Resource Book, Section D2-3. The Operator’s performance is seen to be a root cause given that he stated “it looked like there was something there” at no less than 700 feet from the incident site, but maintained an average speed of 40 km/h and did not look directly ahead to see what it was, until much too late.

Figure 11



Yorkdale Fatality Investigation
Causal Factor 3
Root Cause Analysis

The procedural barrier failed in that the Operator was using the signal and wayside marker system for guidance with insufficient attention to the potential for people or objects foul of the rail. The subway is a closed system but not an impermeable one. In addition to track workers, Operators should expect occasionally to find items such as fallen trees, trespassers and animals foul of the rail. This aspect of training and operations is a contributing factor to the incident.

There is a need for a program to improve work car Operator attentiveness.

Recommendation #6

The DCOO should undertake a complete review of work car operator duties with a view towards understanding any policy, work methods, procedures, or physical barriers/impediments and ergonomic issues, that may lead to distraction or inattentiveness on behalf of these Operators.

<u>Underlying</u> Root Cause - No advance warning of the presence of workers

Discussion

A visible warning device such as a blue light was not required for walking inspections during non-revenue hours. This barrier was therefore not available. This was an informed decision made at the advent of the blue light technology. The placement of these warning lights is considered impractical and time consuming during non-revenue hours. More recently, the Round Table discussions on track safety held in the fall of 2012 revealed a continuing lack of consensus among track workers on the blue light as a barrier. The reasons for this ambivalence need to be clearly identified and evaluated.

Judgements of Need for <u>Underlying</u> Root Causes - Operator Awareness

8. One factor for the resistance to the blue light technology is the effort and time required to install and remove them. This difficulty could be overcome by a hard wired system which could be remotely controlled. It does not exist today although it is a line item in the capital budget. Such an installation would have safety and productivity benefits during revenue service as well.

   Here is an opportunity to provide another warning system to work car operators during non-revenue service.

Recommendation #7

The DCOO should ensure that the rules and procedures for use of the improved blue light system, including its use during non-revenue hours, are thoroughly evaluated through the process recommended in Section 5.4 and integrated with the capital project.

5.4 SUBWAY RULE BOOK

Discussion

The three workers directly involved in this incident collectively had over 50 years of track level experience. They understood the rules but did not follow them to the letter or in spirit. In light of this, it is appropriate to consider the assumptions, structure and relevance of rules that govern track level access and the system in which these rules are developed, approved and enforced.

Judgement of Needs – Subway Rule Book Needs Better Focus on Maintenance Work

9. It needs to be recognized that non-revenue maintenance work is qualitatively different from work during revenue service. It requires specific risk assessments and controls. The Team judges that there is a need to conduct a first principles review of the SRB and related guidance documents with the goal of rebuilding the credibility of the rules both with supervisors and workers in the maintenance forces. This review should consider the option of a unique track worker safety program document separate from, but consistent with, the SRB. The review must ensure that risks are adequately addressed while accounting for the time constraints that supervisors and workers face in controlling the hazards while getting the work done. The principles governing this review should be:

    - No increase to the level of acceptable risk
    - Time efficient. Workers view a good rule as one that is worth following (effective), an excellent rule is also easier to follow than to flout (efficient)
    - Follow a safety hierarchy to look first for risk elimination, then engineering controls before relying on rules adherence and passive warnings
    - Take advantage of existing infrastructure such as signal and speed control systems
    - Account for the shoulder periods when revenue trains may also be active

Recommendation #8

The COO should conduct a first principles review of the SRB and related documents to identify changes needed to ensure they reflect the specific needs of non-revenue night maintenance.

10. The ongoing management of the SRB must be sustainable and more transparent with the involvement of all stakeholders. Rail Transportation protocol *PD 013, Subway/SRT and Streetcar Rulebooks*, provides a good starting framework, but it is almost unknown among stakeholders. The ongoing management process of the SRB should actively seek suggestions with the goal of continual improvement and responsiveness. To this end the keeper of the SRB should receive regular audits on the degree of compliance with rules and the effectiveness of the existing set of controls. This information should provide the basis for a regular scheduled update

in response to reported weakness of the existing controls. There is an urgent need to appoint some system to render authoritative rulings on contradictory interpretation of rules so that everyone has a common understanding.

Recommendation #9

The COO should establish a formal governance process for the SRB that is inclusive of all stakeholders, fosters continuous improvement, provides authoritative interpretations on rules and maintains an effective enforcement regime.

-END-

APPENDIX A

INVESTIGATION TERMS OF REFERENCE

Appendix A

Terms of Reference

YORKDALE FATALITY

September 14, 2012

SPONSOR

Brian Leck, General Counsel for Chief Executive Officer, Andy Byford.

BACKGROUND

At 4:44 AM on Friday September 14, 2012 Roadmaster Peter Pavlovski was struck and killed by workcar RT 4 in the southbound track on the Spadina subway line south of the Highway 401 bridge. Track worker Cel Machado suffered a head injury and train operator George Giannakopoulos was hospitalized with chest pains.

A track crew was working nearby on the northbound track under protection of a minor work zone. None of these workers were injured in the incident.

OBJECTIVES

To assist counsel to determine if the Commission exercised due diligence, whether it took every reasonable precaution to ensure the safety of its workers, and whether its safety procedures (including Subway Rule Book), training, supervision and enforcement, and equipment were in compliance with the Occupational Health and Safety Act. To assist counsel to advise the Commission on issues of civil, statutory and criminal liability The investigation will determine the immediate and root causes of the fatal incident and recommend corrective actions to prevent a recurrence. Specifically the investigation will:

1. Prepare a detailed time line in the form of an events and conditions chart to determine precisely what took place and the context for the actions of each of the participants involved in the work that night.
2. Prepare an analysis of the requirement for, presence of and effectiveness of the safety barriers that were in place to protect the injured and deceased employees to determine which controls if any, proved to be inadequate and, to the extent possible, why they failed. The TTC experience in track level incidences, near misses and precursors will be examined in this context.
3. Review the process and rules governing work at track level, in particular the criteria, design and set-up of work zones in different settings. Survey other major transit properties and regulatory agencies to establish best practices, technology and other measures for track worker safety. Conduct a gap analysis to identify potential recommendations (or further study) if deemed appropriate.

SCOPE

The investigation will focus on three groups, namely the work crew doing track maintenance on the northbound track with RT 81, the presence of Peter Pavlovski and Cel Machado on the southbound track and the movement of the other track crew in RT 4. The investigation may consider other track level work in order to verify that its findings have broader applicability or to test the underlying rules, process and management of track level maintenance/inspection work.

MEMBERSHIP

John O'Grady, Head Safety and Environment, Lead Investigator
Maria Holmes, Safety Consultant Rail Cars & Shops, Rail Operations Lead
Robert Poole, Safety Consultant Rail Infrastructure, Rail Infrastructure Lead
Frank Ammirante, Supervisor Subway & SRT Track, Management Lead

RESOURCES

Team members will be dedicated to the investigation until October 5, 2012. At that time we will review the needs of the team with the CEO and COO and establish their time commitment going forward. The completion of the investigation will be the top priority for team members. Additional time resources will be required in the form of interviews, fact finding, tests and accident scene reconstruction from personnel throughout the Commission and these requests will be given the highest priority by all Heads.

Some resources may be required to ensure timely interviews with witness employees or employees who are on WSIB claim. Note one employee lives in Niagara Region.

Some resources may be required to obtain documents or to survey best practices in other transit agencies and government jurisdictions. This may require the redirection of staff resources among the departmental safety consultants and the S&E Department. These needs will be discussed with the sponsor and COO as required. There may be a need to respond to the MoL ergonomics evaluation of RT4 with our own ergonomic consultant investigation. A lockable office will be dedicated to the team for the duration of the investigation at 1920 Yonge Street.

The team recommends engagement of specialist external legal counsel to support this investigation and potential legal actions arising therefrom. The team may seek support from an external peer reviewer.

INFORMATION COLLECTION

The team plans to interview all surviving crew members to reconstruct the immediate events of the work-night. There may be a need to interview other employees who worked with Peter Pavlovski earlier that night to gain insight into his motives and plans for attendance at the scene. It may be necessary to interview others in RI and related departments to corroborate

the normal work practice and possible deviation from established work methods and rules.

The team also plans to interview management and workers in RI Department on their experience about current track level safety practice and insights into opportunities for improvement. This will include the perspective of other stakeholders in the track maintenance business such as the Transit Control Centre, Training and Engineering and Construction.

The team will review any outputs from the Safety Stand Down being planned for Q4 2012 within TTC, previous analysis into the safety culture of this work group and seek to understand the lessons learned from their CARE and JHSC teams. In addition we will collate the work of the Track Level SIP team and assess the state of this effort.

The team will gather information from the considerable efforts recently undertaken by the US FTA, TCRP and affiliated groups on track level safety. We will gather a sample of guidance documents and experience with technology from other transit agencies internationally.

The team will probably sponsor a recreation of the incident using RT 4 at the accident location at night.

SCHEDULE

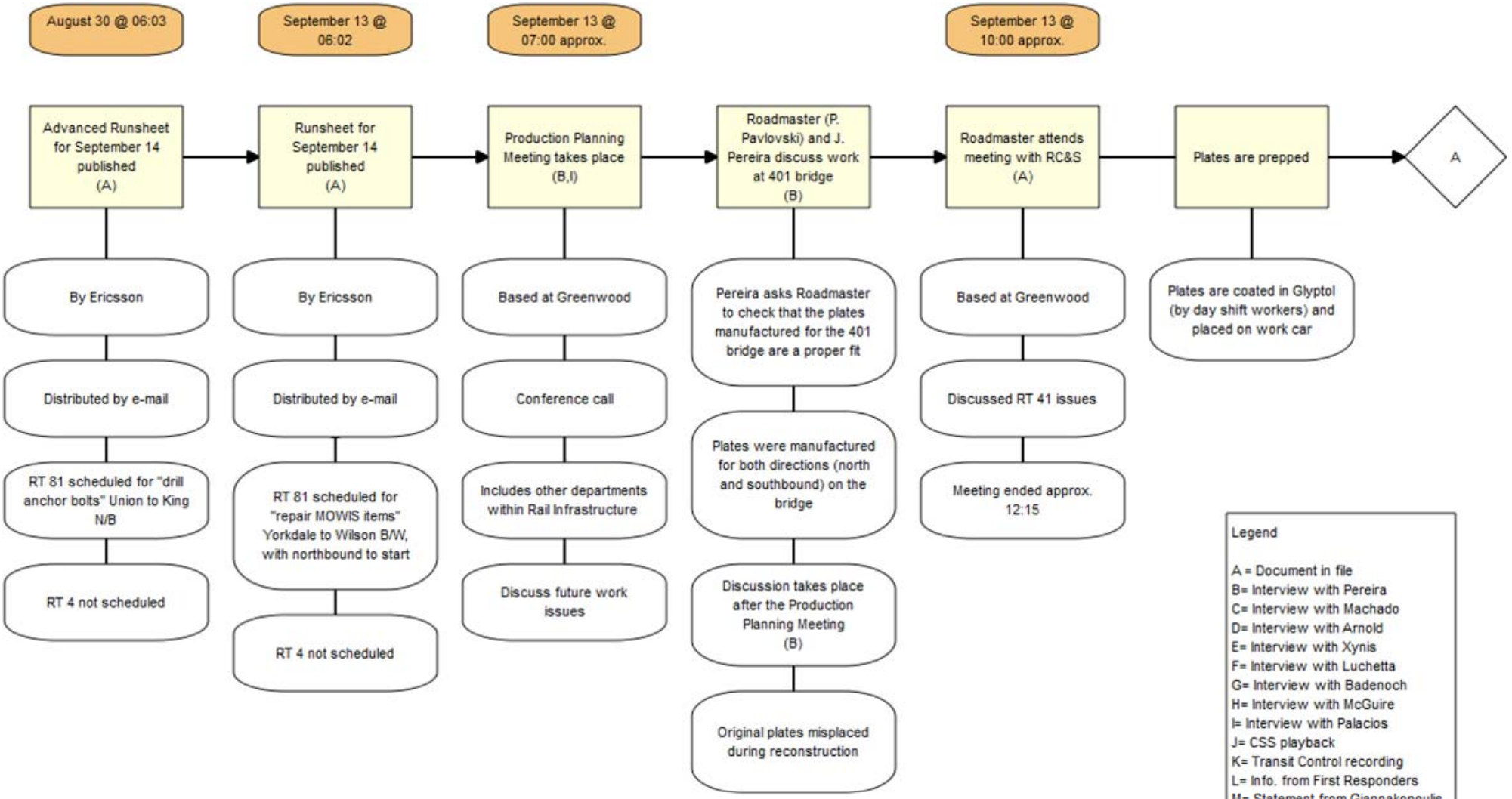
The team will endeavor to meet the following timelines, noting that the collection of data is dependent on the availability of others, including some workers who are currently not at work pending recovery. At all times we will be available to brief the Sponsor and COO on what is currently known and will schedule regular updates if requested.

Preliminary Events and Conditions Chart	October 5, 2012
Final ECC & Preliminary Barrier Analysis	October 26, 2012
Review of external practice	November 9, 2012
Final Draft Report with recommendations	November 30, 2012
Final report with management corrective actions and submission of advice from counsel	December28, 2012

Final Version: Approved by Andy Byford September 24, 2012

APPENDIX B

EVENTS AND CONDITIONS SEQUENCE CHART/BARRIER ANALYSIS


August 30 @ 06:03
September 13 @ 06:02
September 13 @ 07:00 approx.
September 13 @ 10:00 approx.
Advanced Runsheet for September 14 published (A)
Runsheet for September 14 published (A)
Production Planning Meeting takes place (B,I)
Roadmaster (P. Pavlovski) and J. Pereira discuss work at 401 bridge (B)
Roadmaster attends meeting with RC&S (A)
Plates are prepped
A
By Ericsson
Distributed by e-mail
RT 81 scheduled for "drill anchor bolts" Union to King N/B
RT 4 not scheduled
By Ericsson
Distributed by e-mail
RT 81 scheduled for "repair MOWIS items" Yorkdale to Wilson B/W, with northbound to start
RT 4 not scheduled
Based at Greenwood
Conference call
Includes other departments within Rail Infrastructure
Discuss future work issues
Pereira asks Roadmaster to check that the plates manufactured for the 401 bridge are a proper fit
Plates were manufactured for both directions (north and southbound) on the bridge
Discussion takes place after the Production Planning Meeting (B)
Original plates misplaced during reconstruction
Based at Greenwood
Discussed RT 41 issues
Meeting ended approx. 12:15
Plates are coated in Glyptol (by day shift workers) and placed on work car
Legend
A = Document in file
B= Interview with Pereira
C= Interview with Machado
D= Interview with Arnold
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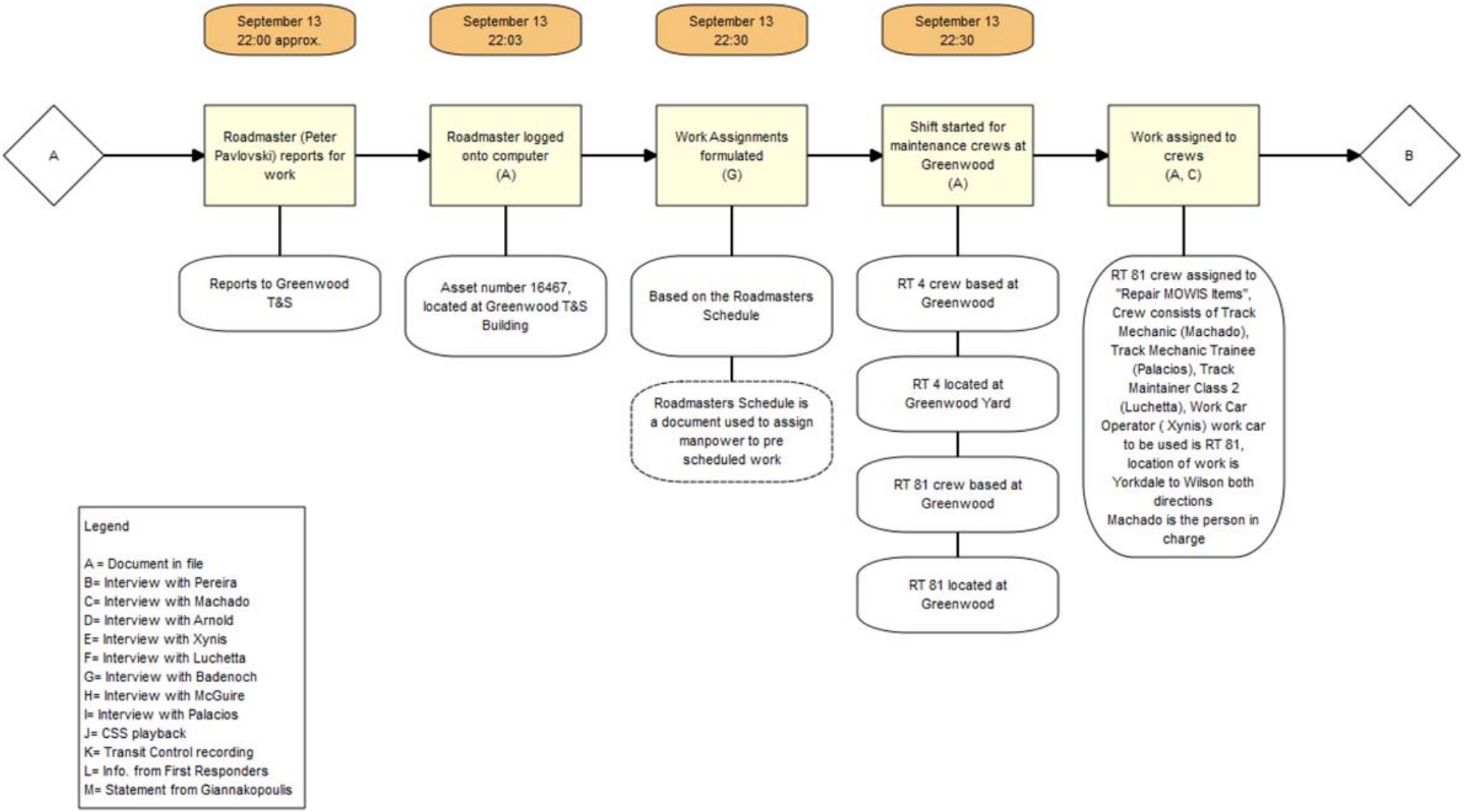
J= CSS playback
K= Transit Control recording
L= Info. from First Responders
M= Statement from Giannakopoulis


September 13 22:00 approx.
September 13 22:03
September 13 22:30
September 13 22:30
A
Roadmaster (Peter Pavlovski) reports for work
Roadmaster logged onto computer (A)
Work Assignments formulated (G)
Shift started for maintenance crews at Greenwood (A)
Work assigned to crews (A, C)
B
Reports to Greenwood T&S
Asset number 16467, located at Greenwood T&S Building
Based on the Roadmasters Schedule
Roadmasters Schedule is a document used to assign manpower to pre scheduled work
RT 4 crew based at Greenwood
RT 4 located at Greenwood Yard
RT 81 crew based at Greenwood
RT 81 located at Greenwood
RT 81 crew assigned to "Repair MOWIS Items", Crew consists of Track Mechanic (Machado), Track Mechanic Trainee (Palacios), Track Maintainer Class 2 (Luchetta), Work Car Operator (Xynis) work car to be used is RT 81, location of work is Yorkdale to Wilson both directions
Machado is the person in charge
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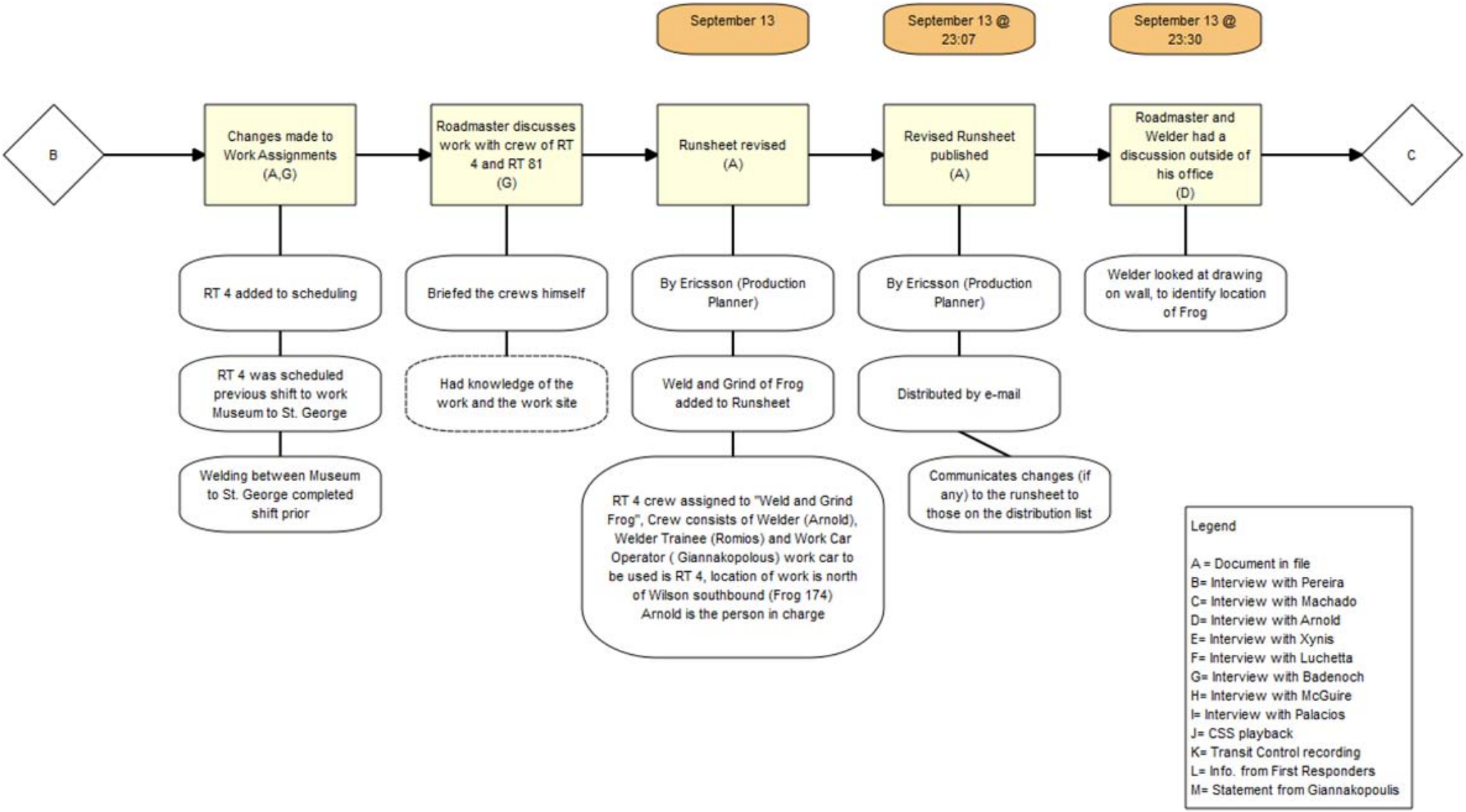
September 13
September 13 @ 23:07
September 13 @ 23:30
B
Changes made to Work Assignments (A,G)
Roadmaster discusses work with crew of RT 4 and RT 81 (G)
Runsheet revised (A)
Revised Runsheet published (A)
Roadmaster and Welder had a discussion outside of his office (D)
C
RT 4 added to scheduling
Briefed the crews himself
By Ericsson (Production Planner)
By Ericsson (Production Planner)
Welder looked at drawing on wall, to identify location of Frog
RT 4 was scheduled previous shift to work Museum to St. George
Had knowledge of the work and the work site
Weld and Grind of Frog added to Runsheet
Distributed by e-mail
Welding between Museum to St. George completed shift prior
RT 4 crew assigned to "Weld and Grind Frog", Crew consists of Welder (Arnold), Welder Trainee (Romios) and Work Car Operator (Giannakopolous) work car to be used is RT 4, location of work is north of Wilson southbound (Frog 174) Arnold is the person in charge
Communicates changes (if any) to the runsheet to those on the distribution list
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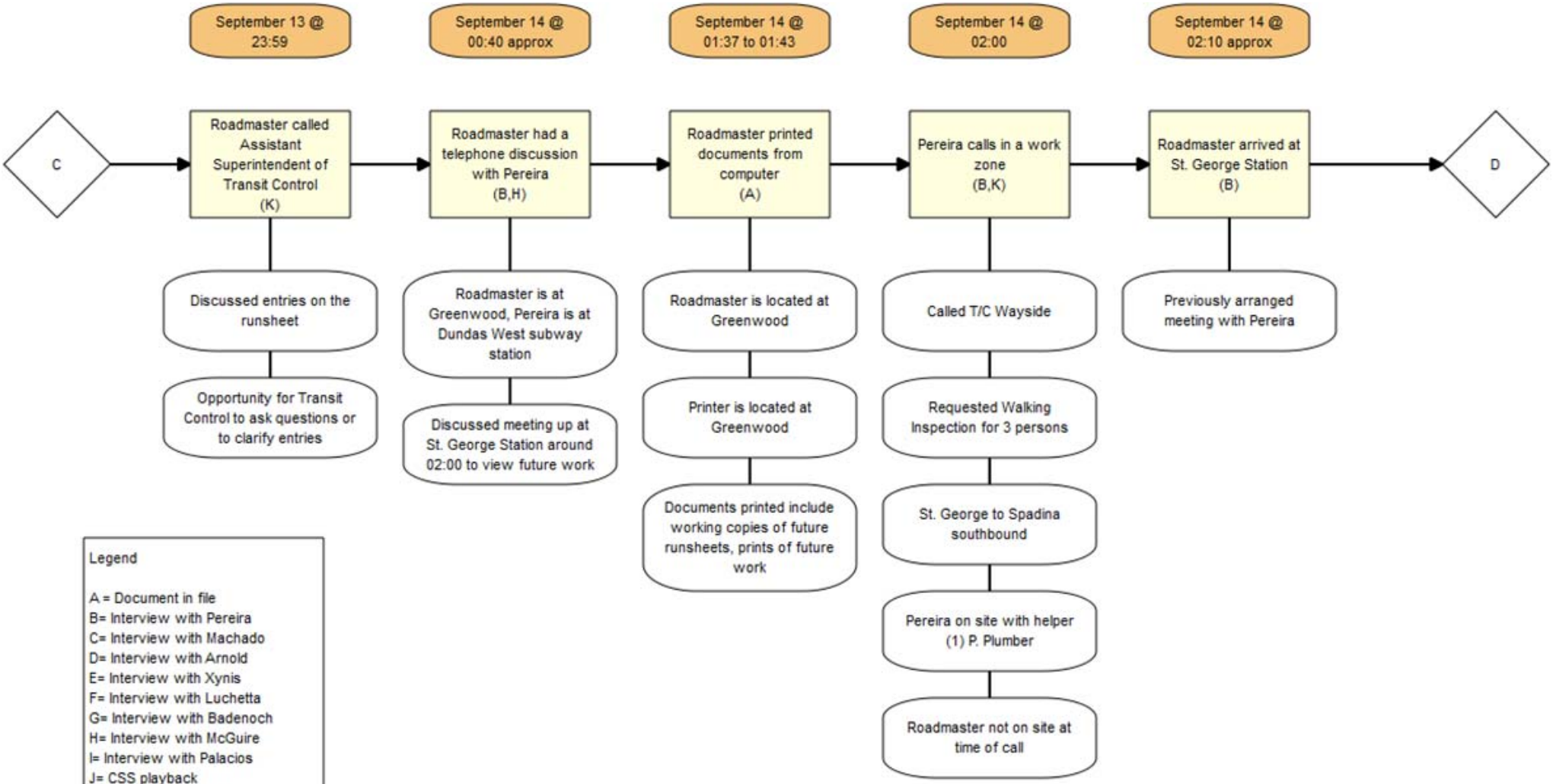
September 13 @ 23:59
September 14 @ 00:40 approx
September 14 @ 01:37 to 01:43
September 14 @ 02:00
September 14 @ 02:10 approx
C
Roadmaster called Assistant Superintendent of Transit Control (K)
Roadmaster had a telephone discussion with Pereira (B,H)
Roadmaster printed documents from computer (A)
Pereira calls in a work zone (B,K)
Roadmaster arrived at St. George Station (B)
D
Discussed entries on the runsheet
Opportunity for Transit Control to ask questions or to clarify entries
Roadmaster is at Greenwood, Pereira is at Dundas West subway station
Discussed meeting up at St. George Station around 02:00 to view future work
Roadmaster is located at Greenwood
Printer is located at Greenwood
Documents printed include working copies of future runsheets, prints of future work
Called T/C Wayside
Requested Walking Inspection for 3 persons
St. George to Spadina southbound
Pereira on site with helper (1) P. Plumber
Roadmaster not on site at time of call
Previously arranged meeting with Pereira
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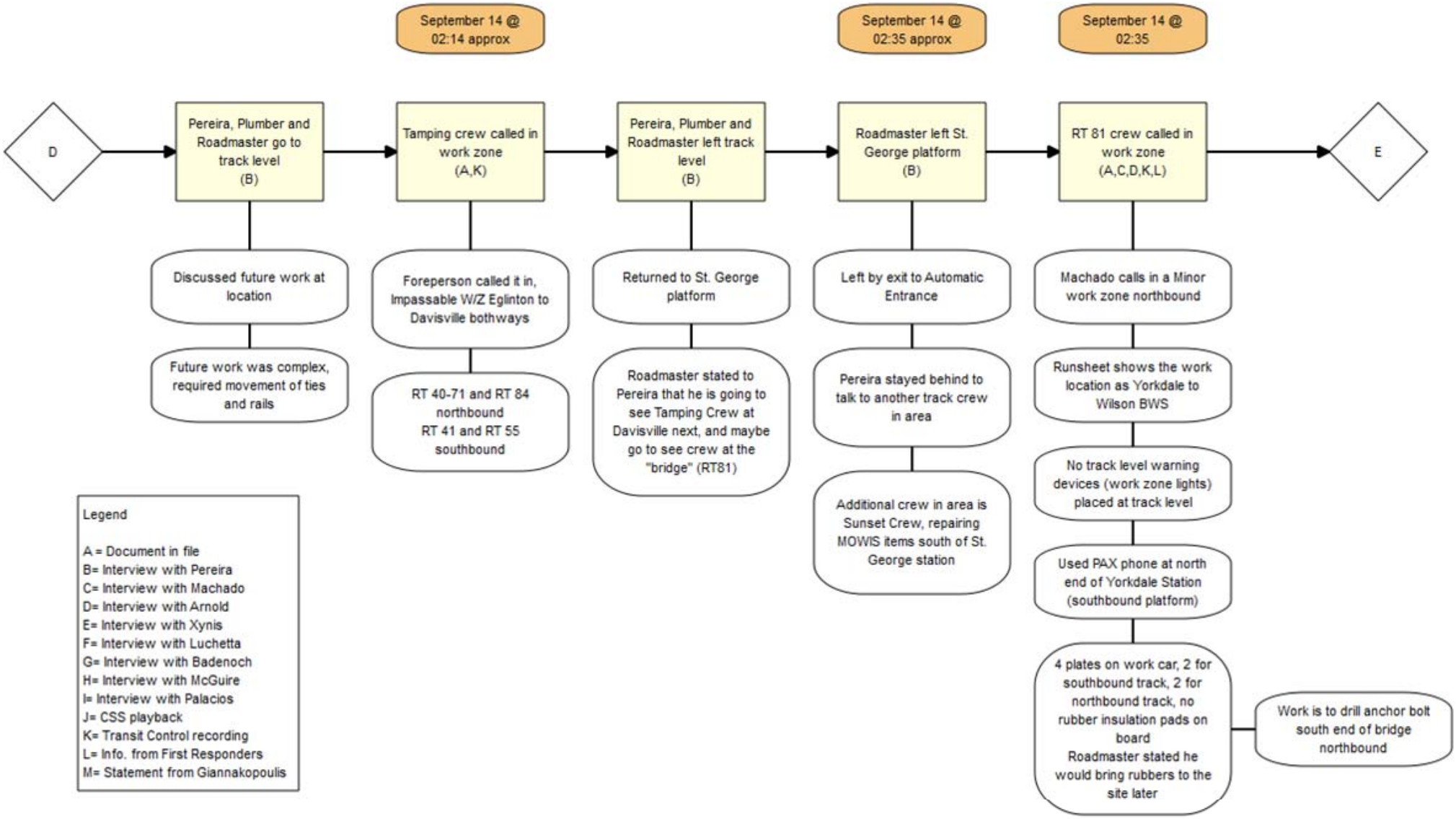
September 14 @ 02:14 approx
September 14 @ 02:35 approx
September 14 @ 02:35
D
Pereira, Plumber and Roadmaster go to track level (B)
Tamping crew called in work zone (A,K)
Pereira, Plumber and Roadmaster left track level (B)
Roadmaster left St. George platform (B)
RT 81 crew called in work zone (A,C,D,K,L)
E
Discussed future work at location
Future work was complex, required movement of ties and rails
Foreperson called it in, Impassable W/Z Eglinton to Davisville bothways
RT 40-71 and RT 84 northbound
RT 41 and RT 55 southbound
Returned to St. George platform
Roadmaster stated to Pereira that he is going to see Tamping Crew at Davisville next, and maybe go to see crew at the "bridge" (RT81)
Left by exit to Automatic Entrance
Pereira stayed behind to talk to another track crew in area
Additional crew in area is Sunset Crew, repairing MOWIS items south of St. George station
Machado calls in a Minor work zone northbound
Runsheet shows the work location as Yorkdale to Wilson BWS
No track level warning devices (work zone lights) placed at track level
Used PAX phone at north end of Yorkdale Station (southbound platform)
4 plates on work car, 2 for southbound track, 2 for northbound track, no rubber insulation pads on board
Roadmaster stated he would bring rubbers to the site later
Work is to drill anchor bolt south end of bridge northbound
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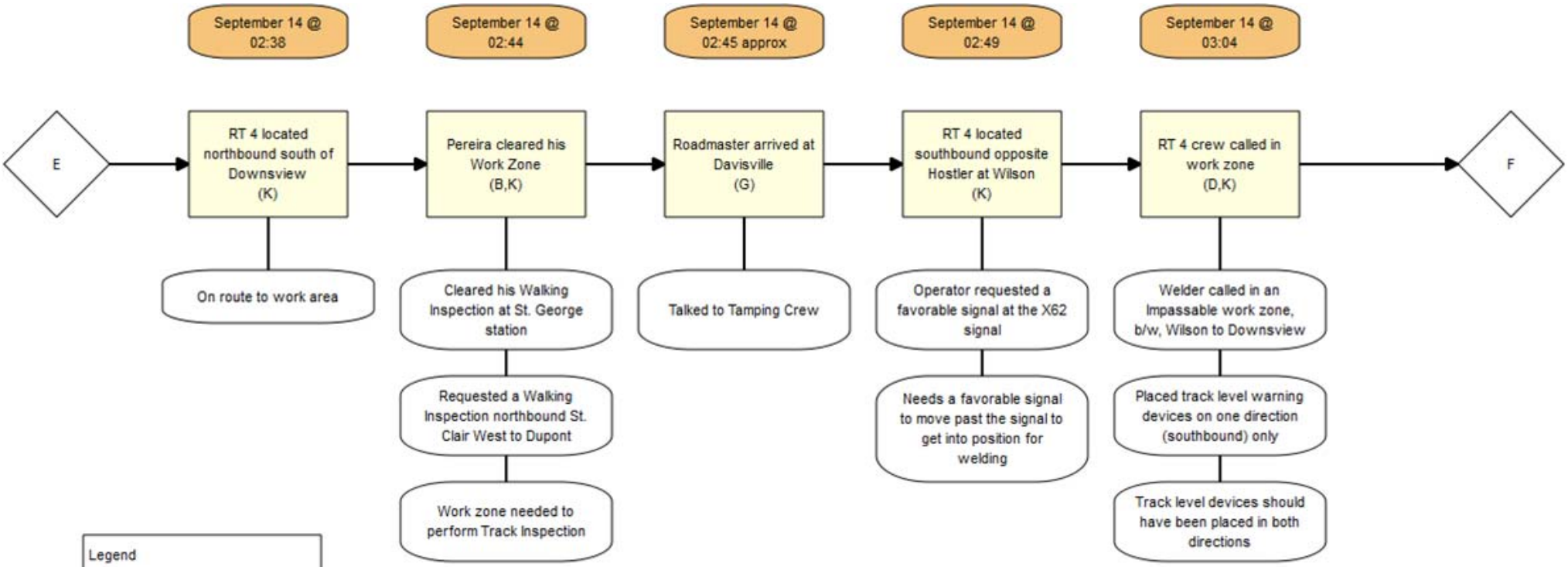

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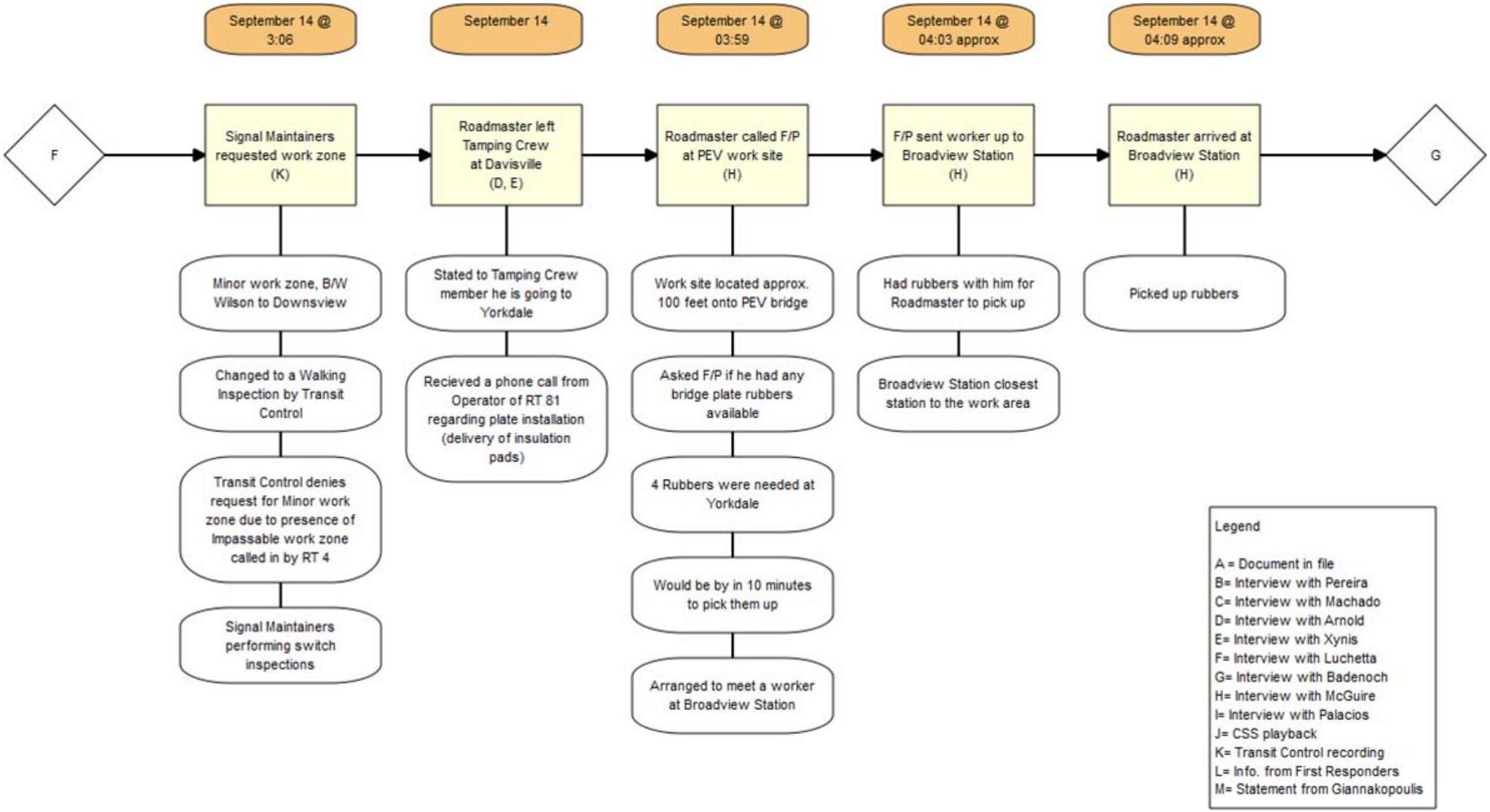
September 14 @ 3:06
September 14
September 14 @ 03:59
September 14 @ 04:03 approx
September 14 @ 04:09 approx
F
Signal Maintainers requested work zone (K)
Roadmaster left Tamping Crew at Davisville (D, E)
Roadmaster called F/P at PEV work site (H)
F/P sent worker up to Broadview Station (H)
Roadmaster arrived at Broadview Station (H)
G
Minor work zone, B/W Wilson to Downsview
Changed to a Walking Inspection by Transit Control
Transit Control denies request for Minor work zone due to presence of Impassable work zone called in by RT 4
Signal Maintainers performing switch inspections
Stated to Tamping Crew member he is going to Yorkdale
Recieved a phone call from Operator of RT 81 regarding plate installation (delivery of insulation pads)
Work site located approx. 100 feet onto PEV bridge
Asked F/P if he had any bridge plate rubbers available
4 Rubbers were needed at Yorkdale
Would be by in 10 minutes to pick them up
Arranged to meet a worker at Broadview Station
Had rubbers with him for Roadmaster to pick up
Broadview Station closest station to the work area
Picked up rubbers
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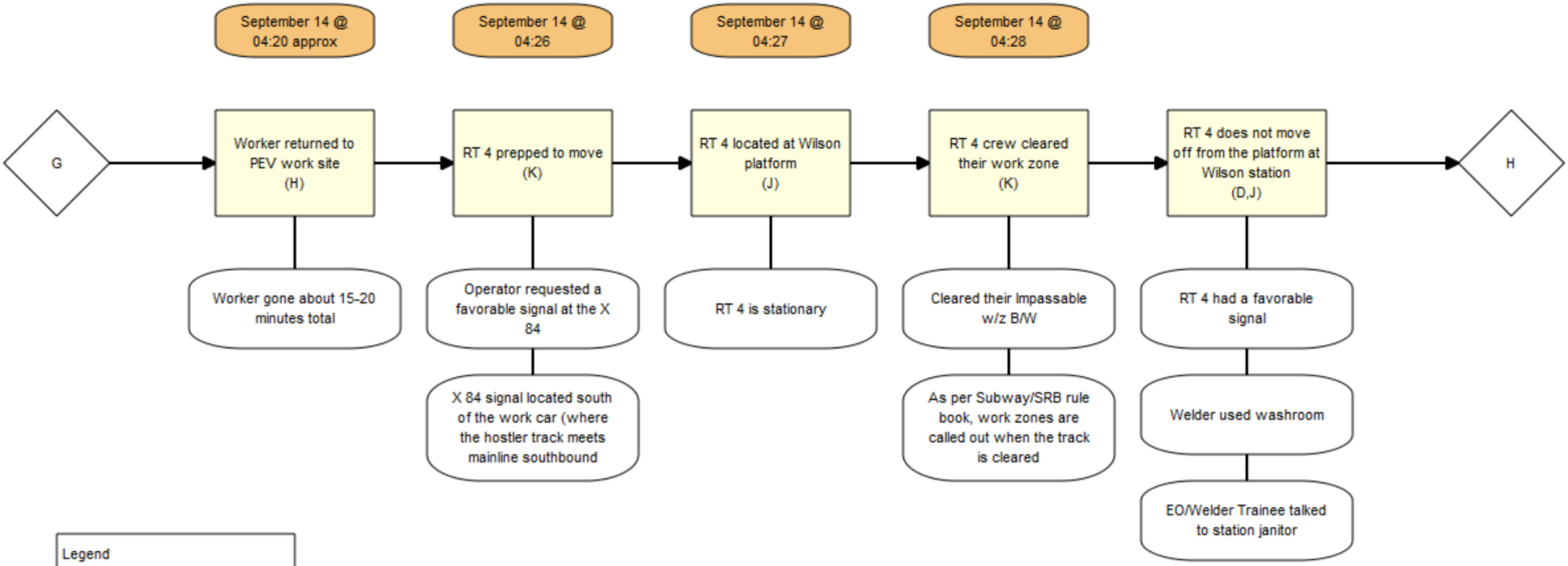

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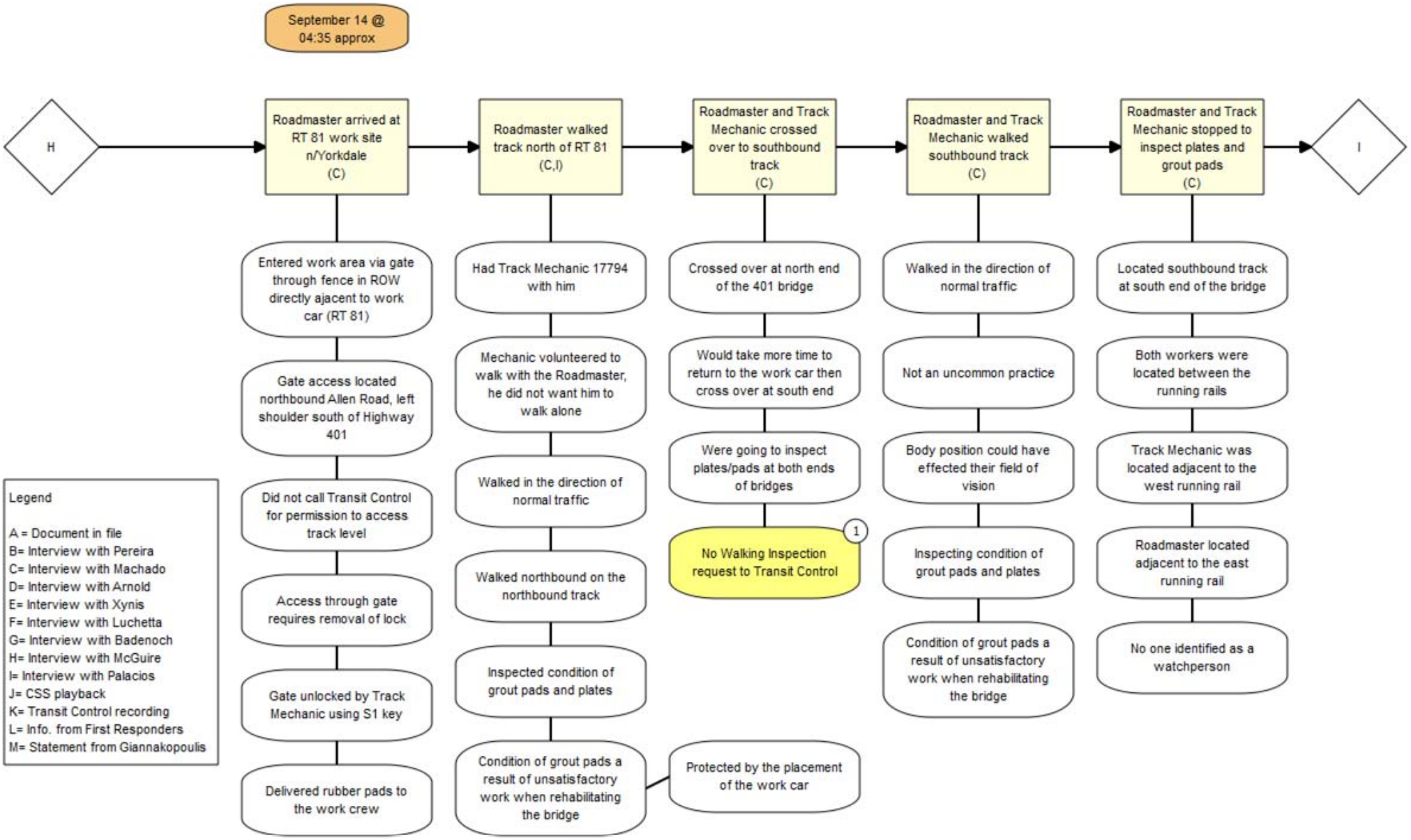
September 14 @ 04:35 approx
H
Roadmaster arrived at RT 81 work site n/Yorkdale (C)
Roadmaster walked track north of RT 81 (C,I)
Roadmaster and Track Mechanic crossed over to southbound track (C)
Roadmaster and Track Mechanic walked southbound track (C)
Roadmaster and Track Mechanic stopped to inspect plates and grout pads (C)
I
Entered work area via gate through fence in ROW directly ajacent to work car (RT 81)
Gate access located northbound Allen Road, left shoulder south of Highway 401
Did not call Transit Control for permission to access track level
Access through gate requires removal of lock
Gate unlocked by Track Mechanic using S1 key
Delivered rubber pads to the work crew
Had Track Mechanic 17794 with him
Mechanic volunteered to walk with the Roadmaster, he did not want him to walk alone
Walked in the direction of normal traffic
Walked northbound on the northbound track
Inspected condition of grout pads and plates
Condition of grout pads a result of unsatisfactory work when rehabilitating the bridge
Protected by the placement of the work car
Crossed over at north end of the 401 bridge
Would take more time to return to the work car then cross over at south end
Were going to inspect plates/pads at both ends of bridges
No Walking Inspection request to Transit Control
1
Walked in the direction of normal traffic
Not an uncommon practice
Body position could have effected their field of vision
Inspecting condition of grout pads and plates
Condition of grout pads a result of unsatisfactory work when rehabilitating the bridge
Located southbound track at south end of the bridge
Both workers were located between the running rails
Track Mechanic was located adjacent to the west running rail
Roadmaster located adjacent to the east running rail
No one identified as a watchperson
Legend
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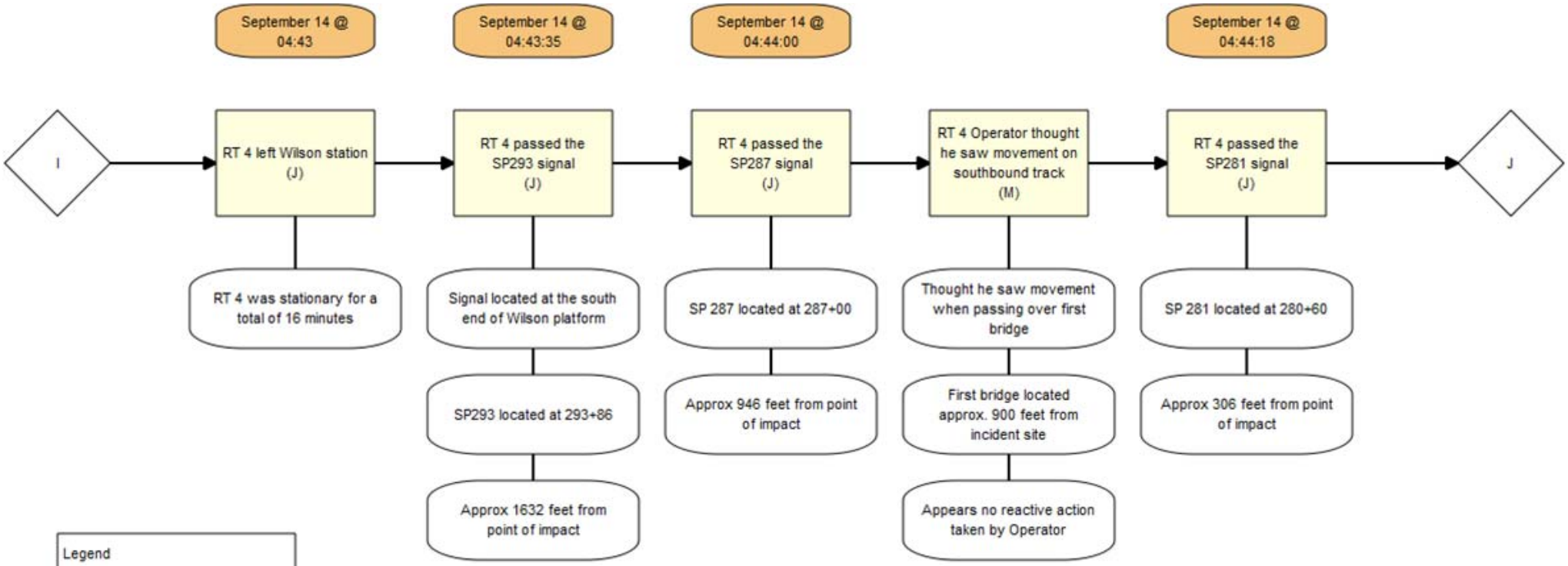

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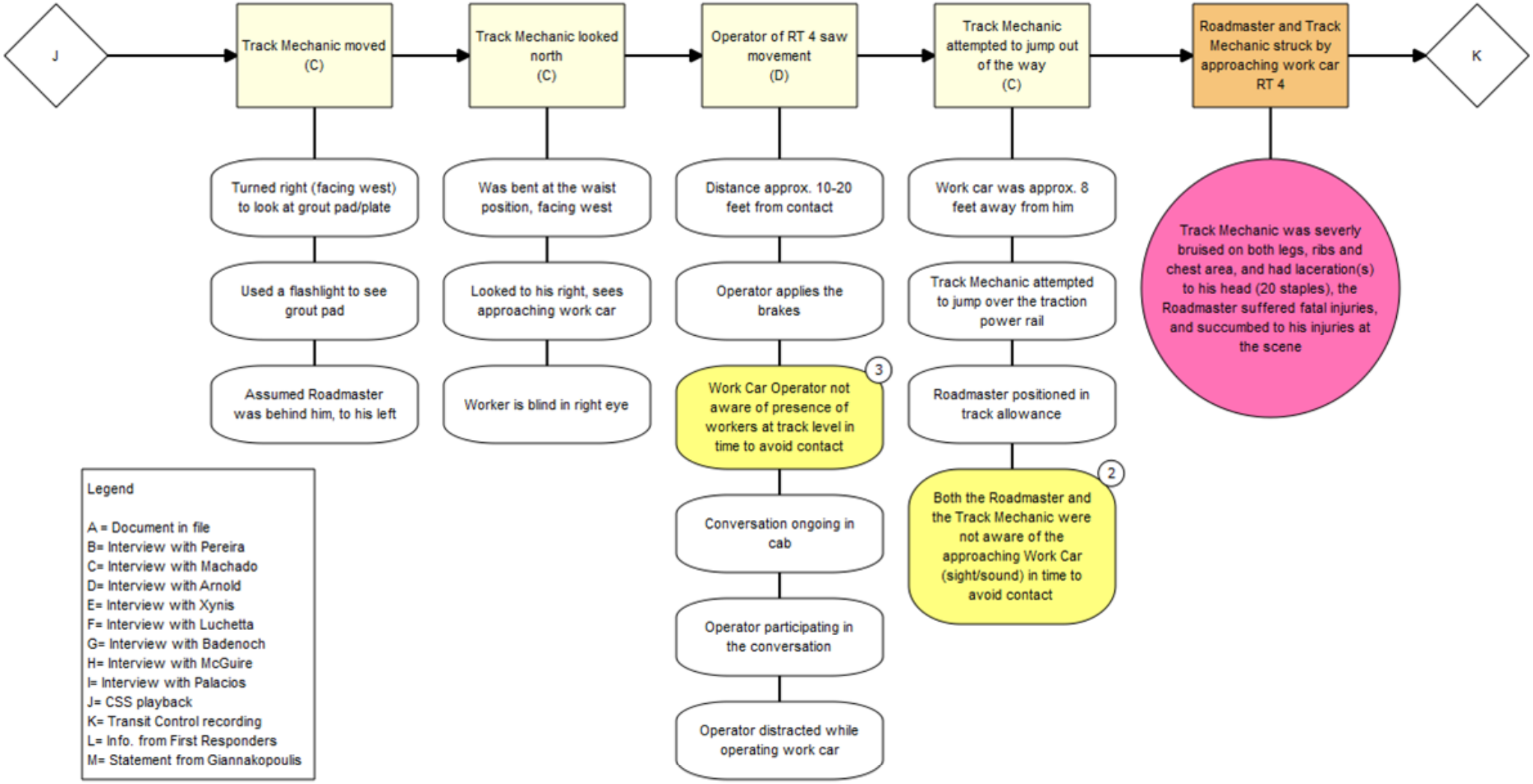
J
Track Mechanic moved
(C)
Track Mechanic looked north
(C)
Operator of RT 4 saw movement
(D)
Track Mechanic attempted to jump out of the way
(C)
Roadmaster and Track Mechanic struck by approaching work car RT 4
K
Turned right (facing west) to look at grout pad/plate
Used a flashlight to see grout pad
Assumed Roadmaster was behind him, to his left
Was bent at the waist position, facing west
Looked to his right, sees approaching work car
Worker is blind in right eye
Distance approx. 10-20 feet from contact
Operator applies the brakes
3
Work Car Operator not aware of presence of workers at track level in time to avoid contact
Conversation ongoing in cab
Operator participating in the conversation
Operator distracted while operating work car
Work car was approx. 8 feet away from him
Track Mechanic attempted to jump over the traction power rail
Roadmaster positioned in track allowance
2
Both the Roadmaster and the Track Mechanic were not aware of the approaching Work Car (sight/sound) in time to avoid contact
Track Mechanic was severly bruised on both legs, ribs and chest area, and had laceration(s) to his head (20 staples), the Roadmaster suffered fatal injuries, and succumbed to his injuries at the scene
Legend
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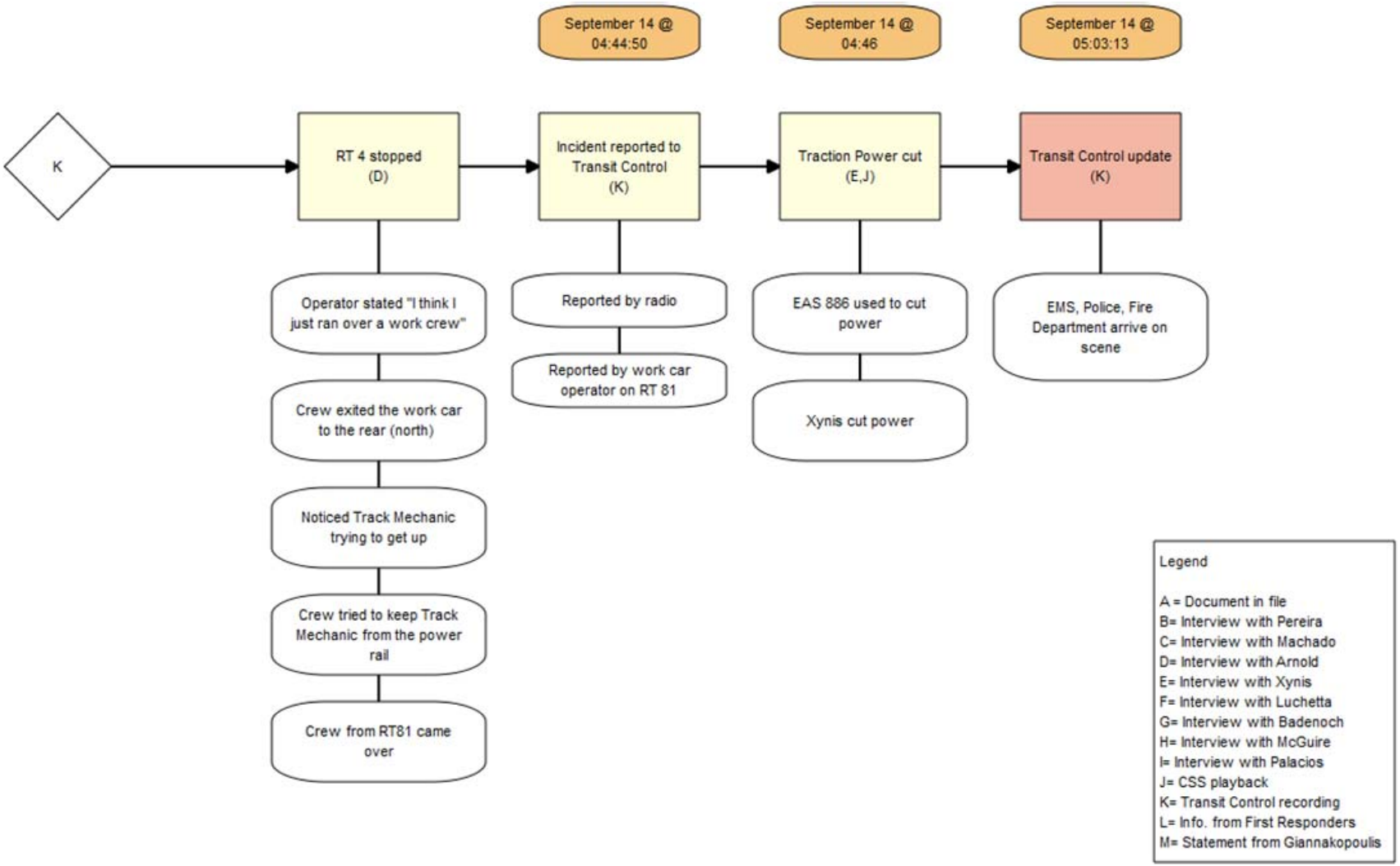
September 14 @ 04:44:50
September 14 @ 04:46
September 14 @ 05:03:13
K
RT 4 stopped (D)
Incident reported to Transit Control (K)
Traction Power cut (E,J)
Transit Control update (K)
Operator stated "I think I just ran over a work crew"
Reported by radio
EAS 886 used to cut power
EMS, Police, Fire Department arrive on scene
Crew exited the work car to the rear (north)
Reported by work car operator on RT 81
Xynis cut power
Noticed Track Mechanic trying to get up
Crew tried to keep Track Mechanic from the power rail
Crew from RT81 came over
Legend
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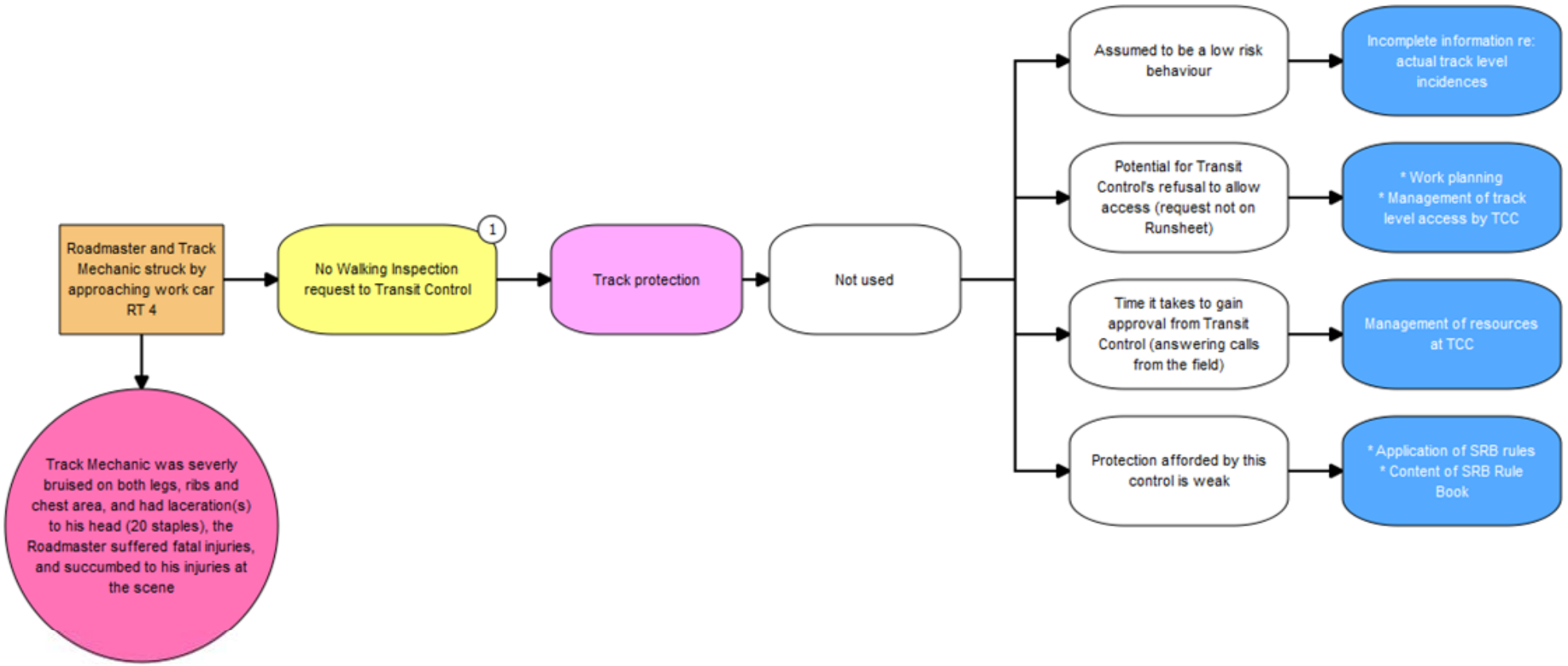
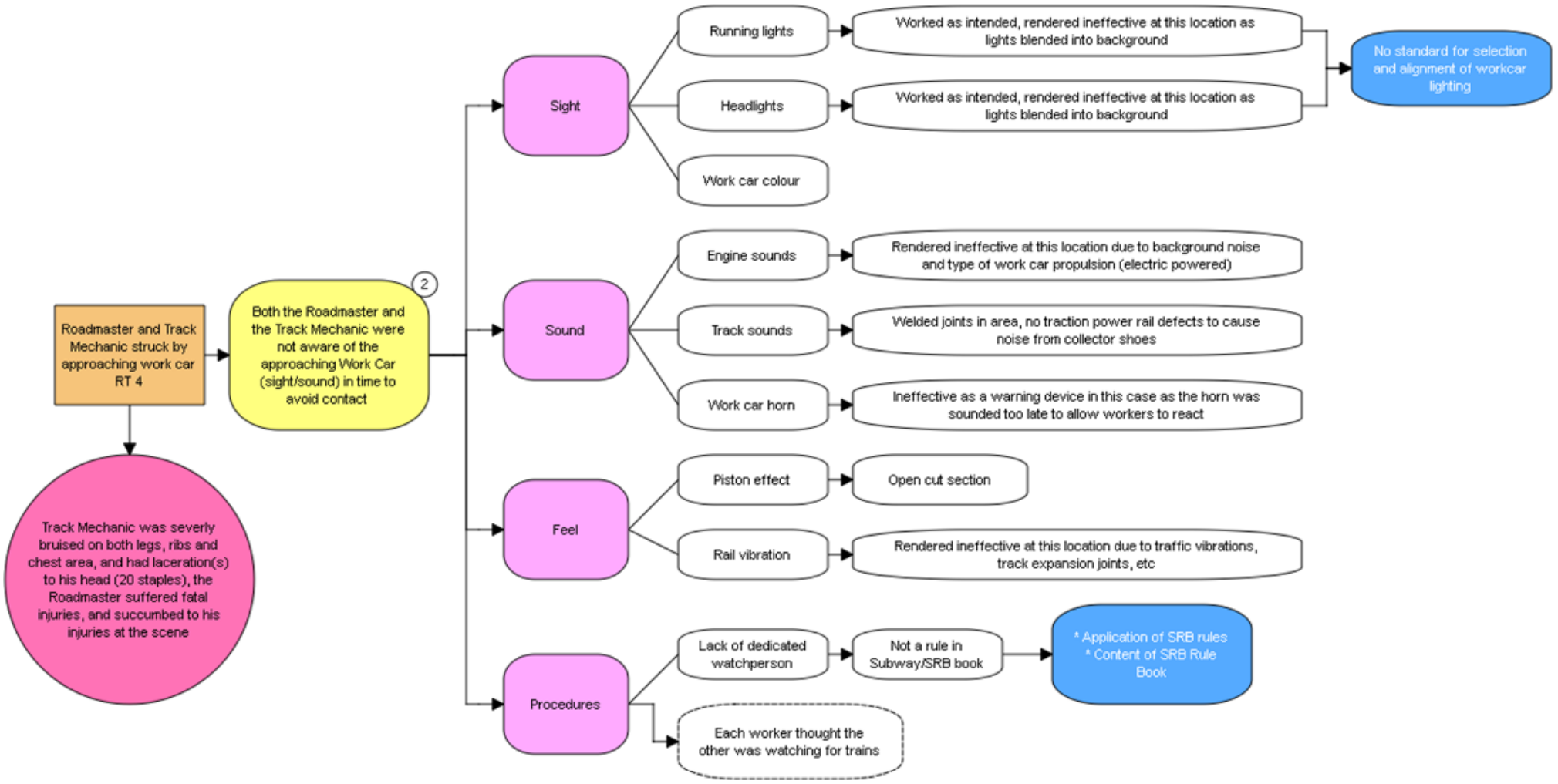
APPENDIX C

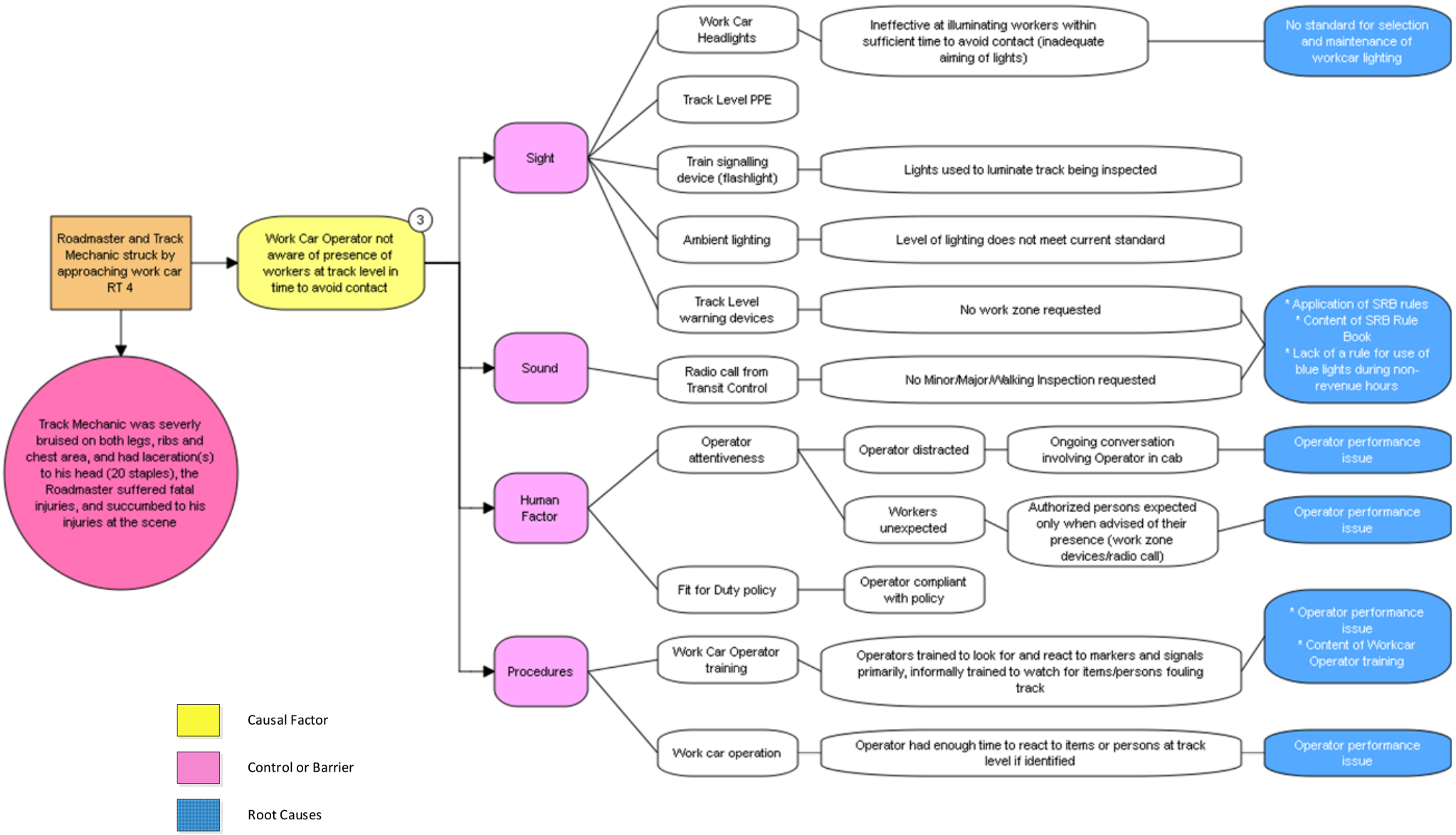
BARRIER ANALYSIS



Yorkdale Fatality Investigation
Causal Factor 1
Root Cause Analysis



Yorkdale Fatality Investigation
Causal Factor 2
Root Cause Analysis



Yorkdale Fatality Investigation
Causal Factor 3
Root Cause Analysis

APPENDIX D

CHANGE ANALYSIS

YORKDALE FATALITY CHANGE ANALYSIS WORKSHEET

Factors	Incident Situation	Prior, Ideal or Incident Free Situation	Difference	Evaluation of Effect
WHAT Conditions, occurrences, activities, equipment	PP and CM went to an unprotected section of track. Wearing all PPE, carrying flashlights. Inspecting deficiencies in the track.	PP or CM would have called Transit Control for permission to access track. Transit Control would have made a line announcement to advise of walking inspection. Operator on RT4 would have been looking for workers at track level.	PP and CM did not call Transit Control as required. One person is required to call Transit Control to request permission for access to the track.	If PP or CM had called Transit Control the Operator on RT4 may have known that there were workers at track level. By not calling, the Operator did not know that there were workers at track level and was not looking for them. Both employees were struck by RT4.
WHEN Occurred, identified, facility status, schedule	September 14, 2012, 4:30 am.	September 14, 2012, 4:30 am.	No difference.	N/A
WHERE Physical location, environmental conditions	Yorkdale to Wilson, southbound, open cut over 401 bridge. Dark and noisy from highway adjacent and below.	Some sites are better lit more ambient light and quieter and meet TTC standard.	Makes visiblity more challenging from both track level and cab of RT4. More difficult to hear the approach of oncoming RT-4.	Harder for PP/CM to percieve approach of RT-4. More difficult for GG to see both workers at track level.
HOW Control chain, hazard analysis monitoring	PP and CM did not obtain permission to access to track level.	Permission received from Transit Control.	Transit Control advises line that walking inspection is taking place at specific location.	RT-4 Operator would have expected workers at track level and adjusted driving accordingly.
HOW Control chain, hazard analysis monitoring	No watch person assigned while at track level.	Watch person assigned.	Train would have been seen by watch person, signalled to either reduce speed, stop or proceed.	RT4 Operator would have responded to signals with blast of horn.
OTHER - Work Car headlights	No corporate standard for headlight lumination and alignment.	Headlights bright enough and properly aimed to detect objects far enough ahead.	More difficult for operator to see wokrers and for workers to distinguish the workcar from other lights in the environment.	Each party would more easilty have seen the other and avoided contact
OTHER - Attentiveness	Neither workers nor operator were attentive to the hazard	Any one of the three workers paying attention	Noone was aware of the impending hazard	Opportunity to avoid contact was lost and late braking resulted in fatality

APPENDIX E

BEHAVIOUR (ABC) ANALYSIS

A-B-C Analysis Worksheet for Road Master

Antecedents Reasons or factors that caused the behaviour to occur.	Behaviour An observable, undesirable act	Consequence Actual and possible outcomes as a result of the behaviour (both positive and negative)	S/L	C/U	+/-
Tight schedule, anticipated lack of timely response from TCC. Possible refusal from TCC for access to track level. Track access walking inspection not pre-planned on runsheet.	Went to track level (sb) without calling Transit Control to request authorization.	Obtains the needed information from site visit on adequacy of earlier repairs and if any further repairs are needed. No delay or refusal from Transit Control for track access. Task completed without delay	S	C	+
Watch person not required. Intended to go alone. Mechanic accompanied last minute.	Did not appoint person to watch for train. Not actively watching for trains himself.	Both workers can then inspect work.	S	C	+
	.	No delay/refusal from TCC for access to track level, task completed without delay.	S	C	+
		May get disciplined for not following procedure	L	U	-
Thought to be a small task, quick check. Complacency due to few injuries in the past.	Knew that RT4 was up at Wilson. Knew that Operator of RT4 would not have knowledge that there were workers at track level.	No injuries have happened in the past.	S	C	+
		Near Miss	L	U	-
		Injury.	L	U	-
		Fatality.	L	U	-

Consequence is: **S/L** – Sooner / Later **C/U** – Certain / Uncertain **+/-** – Positive / Negative

This analysis shows severe consequences to the Road Master's at-risk behaviour. The ability to complete the task without delay/refusal for access to track level had the greatest influence on the Road Master's behaviour.

A-B-C Analysis Worksheet for Road Master

Antecedents Reasons or factors that caused the behaviour to occur.	Behaviour An observable, undesirable act	Consequence Actual and possible outcomes as a result of the behaviour (both positive and negative)	S/L	C/U	+/-
Needed to deliver rubber mats for grout pads to crew of RT81. Access gate from Allen nearby and convenient.	Accessing northbound established work zone without permission (SRB 3.1.2).	Work can be quickly finished, less walking distance.	S	C	+
Able to check work zone set-up.		Supervises crew, part of duties. Can verify how the work is proceeding to see if future planning of work is required.	S	C	+
Not specifically addressed in the SRB/SRT Rule Book.		Discipline for action.	L	U	-
Work zone and crew already on site		Transit Control unaware of extra person on work site.	L	U	-
After walking north on the northbound less distance to cross over, than to return to RT-81 and access the south west corner and return to north west corner.	Chose to walk south on the southbound tracks.	Able to inspect all four corners of bridge.	S	C	+

Consequence is: **S/L** – Sooner / Later **C/U** – Certain / Uncertain **+/-** – Positive / Negative

This analysis shows severe consequences to the Road Master's at-risk behaviour. The ability to complete the task without delay/refusal for access to track level had the greatest influence on the Road Master's behaviour.

A-B-C Analysis Worksheet for Mechanic

Antecedents Reasons or factors that caused the behaviour to occur.	Behaviour An observable, undesirable act	Consequence Actual and possible outcomes as a result of the behaviour (both positive and negative)	S/L	C/U	+/-
Assume that he thought Roadmaster would call Transit Control if necessary. Decided to accompany his supervisor the Road Master on his inspection.	Did not call Transit Control to request Walking Inspection.	Obtains the needed information from site visit on adequacy of earlier repairs and if any further repairs are needed. No delay or refusal from Transit Control for track access. Task completed without delay.	S	C	+
		May get disciplined for not following procedure	L	U	-
Did not acknowledge the risk. *Expected to hear or see train.*	Did not watch for trains.	Both workers were available to inspect work.	S	C	+
Position of RT-81 work area??	Walked with back to oncoming train traffic.	Less time needed to complete task.	S	C	+
Thought to be a small task, quick check. Complacency, since few injuries have happened in the past.	Put himself in line of fire, knowing that Operator of RT4 would not have knowledge that he was there on unprotected track.	Near Miss	S	U	-
		Injury.	S	U	-
		Fatality.	S	U	-

Consequence is: **S/L** – Sooner / Later **C/U** – Certain / Uncertain **+/-** – Positive / Negative

This analysis shows severe consequences to the Mechanic's at-risk behaviour. The ability to complete the task without delay/refusal for access to track level had the greatest influence on the Mechanic's behaviour.

A-B-C Analysis Worksheet for Operator RT4

Antecedents Reasons or factors that caused the behaviour to occur.	Behaviour An observable, undesirable act	Consequence Actual and possible outcomes as a result of the behaviour (both positive and negative)	S/L	C/U	+/-
Engaged in conversation with co-workers.	Looking back and forth at co-workers.	Contact track workers/objects.	S	U	-
		Signal violation.	S	U	-
		Up to date on work related issues.	S	C	+
Reliant on notification from Transit Control or track level warning devices advising to look for workers at track level.	Did not anticipate workers to be on southbound tracks.	Can operate relying on wayside markers and signal lights.	S	C	+
Workers at track level should be visible -PPE, flashlights.	Going 40 km/h through area (within authorized limits).	Back to Greenwood Yard on time (Potential to be held up waiting for service to come out).	S	C	+
Operator not expecting to see anything at track level Vertical orientation of windshield causes some glare.	Operator saw something at track level @ about 900' but did not react defensively.	Contact something. Potential derailment.	S	U	-
RT-4 headlights not aligned properly. Operator testified that he reported defective headlight aim for many months and gave up.	Operator did not report headlight defect on Pre/Post Trip Checklist since September 2011.	May get reassigned if car held for repair. Forward vision less effective.	L S	U C	- -

Consequence is: **S/L** – Sooner / Later **C/U** – Certain / Uncertain **+/-** – Positive / Negative

The ability to operate the work car without having his full attention on the southbound tracks, engage in a full conversation with co-workers and return to Greenwood Yard on time have the greatest influence on the Operator's behaviour.

APPENDIX F

MANAGEMENT CORRECTIVE ACTION PLAN

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Section	Root Cause (Findings)	Recommendation	Management Response	Scheduled Completion
5.1	Direct Root Cause for No Walking Inspection Request to the Transit Control Centre	The DCOO should conduct a review of the interface between the Transit Control Centre and Rail Infrastructure practices to ensure they support maintenance activities with particular emphasis on non-revenue maintenance, to the degree consistent with safe revenue operations	Management agrees with this recommendation. With the establishment of a permanent, Track Level – Serious Injury Prevention Team scheduled for November 2013, a first priority assignment will be made to implement this recommendation.	Milestone: Team Established - November 2013
	Underlying Root Cause for Perception of Low Risk and Weakness of Controls	The CEO should establish a timeline by which all groups in TTC implement the uniform process for reporting, investigating and communicating safety incidents		Milestone: Full implementation corporate wide by Q3 2014 approved at SX meeting - October 9, 2013

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	Underlying Root Cause for Perception of Low Risk and Weakness of Controls - TCC line calls to advise work car Operators of walking inspections	This issue should be addressed in recommendation #1	This finding will be reviewed in more detail by the Track Level - Serious Injury Prevention Team, which will be established in November 2013. Work car operators are required to seek permission from Transit Control prior to moving from their work site once the work zone has been cancelled/ended. if there are crews in their path to the yard, they are advised of these and/or limited as to how far they can proceed. This was established in the Fall of 2012.	Milestones: Establishment of team - November 2013 Permission to move when work zone has been collapsed - Complete

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5.2	Direct Root Causes of Headlights and Watchpersons	The DCOO implement the recommendations in Rail Cars & Shops Problem Report - Rail Vehicle Headlight Study, # 24885.	Management agrees with this recommendation. Six work vehicles were test fitted with LED – headlights in late January, 2013, for the purposes of field testing. Positive Feedback received from user departments. Entire fleet is equipped. Recent feedback has indicated the need to have the lights dimmed when the work car is stationary, as they are too bright for employees working at track level in front of the train.	Standardization and installation of headlights on all work cars - Complete RC&S will be reviewing the latest feedback to enable dimming of the lights when the vehicle is stationary.

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	Direct Root Causes of Headlights and Watchpersons	The COO consider, as an interim measure, that walking inspections require a dedicated watchperson pending the outcome of the recommendation on warning technologies in #6 below and the more global review of rules in Section 5.4. Emphasis on the need for individual vigilance through a slogan such as “Any time is train time” would reinforce the notice that the watchperson is an integral element of all track level crews.	Management agrees with this recommendation. - Assess workforce impact of a dedicated watchperson added to existing maintenance activties. - Assess risk assessment improvement vs cost of the additional watchperson. - Review the feasibiity of incorporating the Watchperson duties through changes to existing work practices - Introduce slogan and discussion to workforce titled "Any Time is Train Time" in any direction.	 Complete Complete Milestone: February 28, 2014 (V. Rodriguez - RI) Complete. This initiative is to continue on a monthly basis with related topics being sent out along with supporting materials.

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	Underlying Root Cause – Technology for Worker Detection	The COO prepares a review of the applicability of new technological advances in track level warning devices for maintenance work.	Management agrees with this recommendation. An incremental process has been initiated to investigate and recommend an appropriate technology. ProTran has been identified as a useful technology for non-revenue operation (not appropriate for revenue operation). Other technologies including WAW and Trak-Safe will also be evaluated to determine their utility during both revenue and non-revenue hours of operation.	Milestones: Recommendation - May 31, 2014 Submission to 2015 budget
5.3	Direct Root Cause - Inattentiveness	The DCOO should undertake a complete review of work car operator duties with a view towards understanding any policy, work methods, procedures, or physical barriers / impediments, ergonomic issues that may lead to distraction or inattentiveness on behalf of these Operators.	Management agrees with this recommendation. A consultant, Human Factors North, has been retained to conduct an evaluation of the Work Car Operator duties.	Milestone: Consultant evaluation – January 31, 2014

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5.3	Underlying Root Causes – Operator Awareness	The DCOO should ensure that the rules and procedures for use of the improved blue light system, including its use during non-revenue hours, are thoroughly evaluated through the process recommended in Section 5.4 and integrated with the capital project.	Management agrees with this recommendation. The establishment of a permanent Operating Rules committee will review this recommendation inline with a first principles review of the Subway Rule Book.	Milestone: Establishment of Operating Rules Committee - November 2013
5.4	Subway Rule Book Needs Better Focus on Maintenance Work	The COO should conduct a first principles review of the SRB and related documents to identify changes needed to ensure they reflect the specific needs of non-revenue night maintenance.	Management agrees with this recommendation. A permanent rules committee, under the leadership of a full time staff position reporting to the DCOO will commence a first principles review.	Milestone: Establishment of Operating Rules Committee - November 2013
5.4	Subway Rule Book Needs Better Focus on Maintenance Work	The COO should establish a formal governance process for the SRB that is inclusive of all stakeholders, fosters continuous improvement, provides authoritative interpretations on rules and maintains an effective enforcement regime.	Management agrees with this recommendation. A permanent rules committee, under the leadership of a full time staff position reporting to the DCOO will commence a first principles review.	Milestone: Establishment of Operating Rules Committee – November 2013