Appendix E

Transportation Systems Analysis

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TRANSPORTATION SYSTEMS ANALYSIS

E.1 Background

The proposed Canadian National Railway Company and Grand Trunk Corporation (collectively, CN or the Applicants) acquisition of EJ&E West Company, a wholly owned non-carrier subsidiary of Elgin, Joliet and Eastern Railway Company (EJ&E) would result in train traffic route changes across individual rail line segments. These changes could affect vehicle delays at highway/rail at-grade crossings and passenger rail service on rail line segments that carry both freight and passenger train traffic.

E.2 Transportation Systems Methodology

The Applicants are proposing to acquire control of EJ&E West Company and to use the EJ&E rail line to connect all five of CN's rail lines in Chicago (the Proposed Action). The Board's Section of Environmental Analysis (SEA) evaluated the potential effects of the Proposed Action and other alternatives on traffic and transportation. SEA used the methodology presented herein to evaluate the potential traffic and transportation effects of the Proposed Action, including:

- Effects on local, regional, and national roadway systems resulting from projected increases and decreases in rail traffic on rail line segments and new rail line connections
- Effects on emergency vehicle response and potential delays
- Effects on navigation operations
- Effects on airports

As part of the overall transportation analysis, SEA conducted a comprehensive literature review of applicable technical and legislative topics and, as needed, conducted field reconnaissance. SEA evaluated transportation issues according to accepted engineering practices, consistent with those used in other studies.

E.2.1 Applicable Regulations and Guidance

SEA performed the analyses in accordance with the Board's regulations in 49 Code of Federal Regulations (CFR) 1105.7 (e) (2), which requires a description of the effects due to the Proposed Action on local, regional, and national transportation systems.

E.2.2 Screening Process

SEA identified areas of potential impact through a threshold screening process. Table E.2-1 on the next page, summarizes the applicable transportation analysis thresholds.

Table E.2-1. Transportation Analysis Thresholds	
Transportation Impact Area	**Analysis Threshold(s)**
Truck-to-Rail/Rail-to-Truck Diversions	All anticipated diversion of freight from truck to rail or rail to truck will be documented for current and future operations.
Train Operations	Increase in average travel time by more than 10%.
Expected Delay at Highway/Rail At-Grade Crossings (existing and new construction)	1) Expected 2015 traffic volumes greater than 2,500 average daily traffic (ADT) on intersecting roadways; or 2) Change of three or more trains per day on roadways with greater than 2,500 ADT.
Intermodal Facilities	1) Increase of 50 or more trucks per day; or 2) An ADT increase of 10% or more on access roads.
Proposed Commuter Rail Passenger Service	Increase of 3 or more trains per day on rail lines required to implement commuter rail service.
Emergency Vehicle Response	Increase of 8 or more trains per day on segments with community facilities within 2 miles.
Navigation	Increase of 3 or more freight trains per day.

E.2.3 Data Sources

SEA used the following data sources for the analysis of transportation effects:

- Federal Railroad Administration (FRA) crossing inventory database. This database includes information about highway/rail at-grade crossings, ADT at highway/rail at-grade crossings, condition of intersecting roadways (paved or unpaved), crossing guard treatments, number of roadway lanes at highway/rail at-grade crossings, location of crossing (county or state), location of bridges, and train speed.
- State, county, and local departments of transportation for ADT data for affected roadways
- Illinois Commerce Commission (ICC) database for existing traffic and train delay data
- The Applicants' proposed operating plan. This plan provides information on the proposed increase or decrease in number of freight trains per day and the proposed increase or decrease in gross ton-miles per day.
- Metra's future operating plans with respect to commuter rail service
- Metra's current plans for Star Line operation on EJ&E rail lines
- AMTRAK and NICTD current and future operating plans with respect to inter-city passenger rail operations
- The Applicants' average operating speeds on EJ&E project segments that may be affected by future Metra operations.
- Operating agreements between freight railroads
- Track charts
- Locomotive power characteristics
- Emergency service provider facilities and operations
- Gary/Chicago International Airport existing and future development plans
- US Corps of Engineers and Coast Guard navigable waterway data
- Field investigations

E.2.4 Vehicle Traffic Data Compilation

To characterize the existing vehicle traffic data at the highway/rail at-grade crossings, SEA used several data sources:

- FRA Crossing Inventory Database
- State, county and local department of transportations and local metropolitan planning organization databases
- Illinois Commerce Commission (ICC) database for existing traffic and train delay data

SEA used Illinois Department of Transportation's (IDOT) ADT data as the primary source for vehicle traffic. It was determined that IDOT traffic volume data reflected the most recent counts reported by local agencies. Therefore, IDOT's data was used in most cases followed by the county's, and then the ADT from the villages/municipalities as available.

Because the ADTs received from the various sources varied from year to year, SEA determined that a certain growth percentage for each year would be applied to traffic counts to normalize them all to common analysis years, 2007, 2015 and 2020. Table E.2-2 below, shows the percentage used to grow the existing traffic counts up to future traffic in each county.

Table E.2-2. Yearly Traffic Growth Factor

County	Percentage Used for Growth Forecast
Lake (Illinois)	3.0
Western Cook	2.0
Southeastern Cook	1.0
DuPage	3.0
Will	3.0
Lake (Indiana)	3.0

SEA applied the growth rates listed in Table E.2-2 for each county to forecast the ADT for various years ranging from the late 1980s to 2006, to the year 2007. In Illinois the growth percentages for Lake and Cook Counties were suggested by the county engineering offices, while the others were estimated considering the growth of the region, adjacent roadway traffic growth that has both an old ADT and a newer ADT obtained from state and local transportation agencies, and the factors used in neighboring counties.

Additional factoring was performed in Lake County, Indiana because of the age of the traffic count data. There was limited historic count data for a number of crossings, some crossings had traffic counts dating to the late 1980's. To adjust these counts up to 2007, growth factors from adjacent crossing locations were applied to these outdated numbers.

E.2.5 Analytical Methods

E.2.5.1 Transportation Effects at Highway/Rail At-Grade Crossings

SEA quantified traffic delays and delay increases or reductions at all highway/rail at-grade crossings due to increased and decreased freight train traffic and speeds on CN and EJ&E rail line segments affected by the Proposed Action. SEA applied the analysis thresholds of 1) expected 2015 traffic volumes greater than 2,500 average daily traffic (ADT) on intersecting roadways, or 2) change of three or more trains per day on roadways with greater than 2,500 ADT and 3) crossings closer than 800 feet apart.

The threshold was applied to 2015 expected traffic demand. SEA used ADT and forecast travel demand information from state, county or local agency databases to determine traffic volumes at highway/rail at-grade crossings. Complete grade crossing impact assessments were performed only on crossings that would exceed the analysis threshold. Total delay increases or reductions were calculated for all crossings in the database regardless of automobile demand or changes in train operations. The complete grade crossing assessment for all analyzed crossings can be viewed in Attachment E1. Information on rail crossings that did not exceed SEA's analysis threshold can be viewed in Attachment E2.

Factors in the vehicle delay analysis include:

- The number of trains per day before and after the Proposed Action
- The estimated time it takes for a train to pass the highway/rail at-grade crossing
- Existing and projected roadway traffic volumes

SEA calculated several values for each highway/rail at-grade crossing included in the analysis. SEA examined existing conditions, no action and conditions under the Proposed Action for the following parameters:

- Blocked crossing time per train
- Average delay per delayed roadway vehicle
- Number of vehicles delayed per day
- Vehicle queue length
- Average delay for all vehicles
- Total vehicle traffic delay
- Traffic level of service (LOS)

The following sections describe the SEA methods used to measure roadway vehicle delay at highway/rail at-grade crossings.

Blocked Crossing Time per Train

SEA estimated the time required for a train to cross the intersecting roadway. This time is called the blocked crossing time. SEA used this measurement in later calculations to determine the length of time drivers wait when trains pass through a highway/rail at-grade crossing.

Average train speed is a major factor in this calculation. This speed is dependent not only on track conditions and train operating characteristics, but also on intersecting commuter and freight rail traffic. For example, trains on the EJ&E track may have to wait for other commuter or freight trains on intersecting tracks to clear before they can proceed. Waiting times will be factored into the average speed values. In this way, automobile delays experienced at crossings blocked by trains, waiting to cross other tracks, may be evaluated.

SEA applied the following equation, developed by Stanford Research Institute (SRI),[1] to estimate blocked crossing time for the highway/rail at-grade crossings:

$$Dc = \frac{L}{V \times 88} + 0.50$$

[1] SRI. Prepared for the Federal Railroad Administration and the Federal Highway Administration. August 1974, RP-31, Volume 3, Appendix C.

where:

Dc	=	Time required for the train to pass the highway/rail at-grade crossing (minutes). It includes time for gate closing and opening and is also referred to as the total time the crossing indication is activated or the blocked crossing time per train.
L	=	Length of the train (feet)
V	=	Train speed (miles per hour)
88	=	Conversion factor from miles per hour to feet per minute
0.50	=	Time required for gate closing and opening prior to and after the passage of the train (minutes)

Average Delay per Delayed Vehicle

The average delay per delayed vehicle is the average amount of time that a driver would be delayed at a highway/rail at-grade crossing as a result of a single train event. It assumes a uniform arrival of vehicles. Figure E.2-1 illustrates the relationship between arriving and departing vehicles.

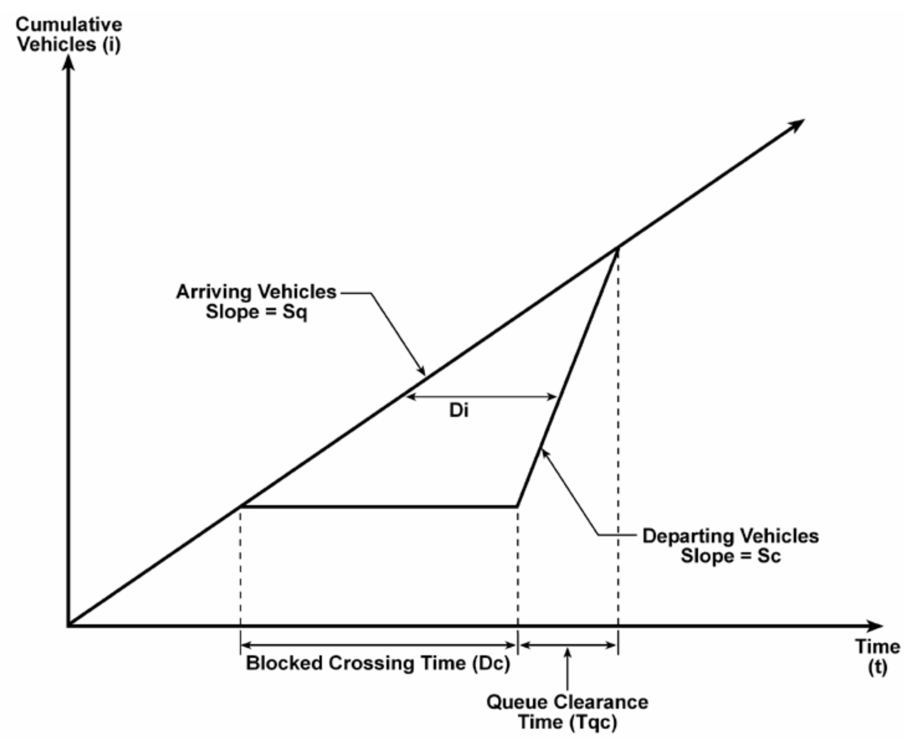

Figure E.2-1. Vehicle Delay Analysis (Single Train Event)

Vehicles arrive at a constant rate of *Sq* as shown by the constant slope of the arrival curve. When the blocked crossing period begins, vehicles begin to queue because none are being discharged. When the blocked crossing period ends, queued vehicles begin to depart at the constant vehicle departure rate of *Sc*. The departure rate continues until the departure curve intersects the arrival curve, signifying the dissipation of the queue. The arrival and departure curves then coincide until the next train event. From this model:

- The delay for vehicles (*i*), noted as *Di*, is given by the time scale (horizontal) difference between the arrival and departure curves.
- The aggregate delay for all vehicles passing through the crossing is the area between the arrival and departure curves.
- The number of vehicles that incur delay as a result of the train is equal to the number of vehicles that arrive when the crossing is blocked (Dc) and the queue is clearing (Tqc).
- The average delay per delayed vehicle (*Da*, not shown in Figure E.2-1) is equal to the aggregate delay divided by the number of vehicles that are delayed. Assuming uniform arrivals, the equation for the average delay per delayed vehicle can be derived as follows:

$$
\begin{aligned}
Da &= \frac{\text{Aggregate Delay}}{\text{Delayed Vehicles}} \times 1.3 \\
&= \frac{0.5 \times Sq \times Dc \times (Dc + Tqc)}{Sq \times (Dc + Tqc)} \times 1.3 \\
&= 0.5 \times Dc \times 1.3
\end{aligned}
$$

where:

Da = Average delay per delayed vehicle (minutes)

Sq = Average arrival rate of traffic (vehicles per minute per lane)

Dc = Blocked crossing time per train (minutes)

Tqc= Queue clearance time (minutes)

0.5 = Factor used in the calculation of the area of a triangle

1.3 = Factor which is widely used in the traffic engineering profession to account for initial deceleration, queue move-up time, and final acceleration of vehicles that are delayed

Number of Vehicles Delayed Per Day

The number of vehicles delayed per day equals the number of drivers in a 24-hour period that would be stopped for trains at highway/rail at-grade crossings. SEA estimated the number of vehicles delayed per day per crossing from the following equation:

$$T_D = \frac{\text{Dc x N x ADT}}{1{,}440}$$

where:

T_D = Vehicles delayed per day

Dc = Blocked crossing time per train (in minutes)

1,440 = Minutes per day

N = Trains per day

ADT = ADT for highway/rail at-grade crossing

Vehicle Queue Length

The vehicle queue is the estimated number of vehicles in line at the end of the blocked crossing time of a single train event. The vehicle queue is equal to the number of vehicles that arrive during the blocked crossing time (*Dc*). SEA estimated the vehicle queue during the peak hour of roadway traffic. SEA assumes the peak-hour traffic is equal to 10 percent of the ADT volume—a typical assumption used by traffic engineers. SEA estimated the vehicle queue at the end of the blocked crossing time from the following equation:

$$Q = ADT \ x \ 0.1 \ x \ \frac{0.6}{60} \ x \ \frac{Dc}{NL/2}$$

where:

Q = Vehicle queue (number of vehicles)

ADT = ADT for highway/rail at-grade crossing

0.1 = Ten percent factor to convert ADT to peak-hour traffic

0.6 = 60 percent factor to convert two-way traffic to peak-direction traffic

60 = Factor to convert traffic volume per hour to traffic volume per minute

Dc = Time required for the train to pass the highway/rail at-grade crossing, including time for gate closing and opening, in minutes

NL = Highway lanes at the highway/rail at-grade crossing as reported by the FRA database

2 = Factor to convert total number of roadway lanes to number of lanes in peak direction

Average Delay for All Vehicles

The average delay for all vehicles is the estimated average delay experienced by all drivers at the affected highway/rail at-grade crossing. The average delay includes both drivers who would and would not be delayed by trains. The average delay for all vehicles (*Dv*), including vehicles not delayed by train traffic, is most easily defined as the aggregate delay incurred by vehicles that are delayed divided by the total traffic at the crossing. Because of this, SEA used the following equation for calculating the average delay for all vehicles:

$$Dv = \frac{(Td \times Da) \times 2}{ADT}$$

where:

Dv = Average delay for all vehicles (minutes per vehicle)

Td = Vehicles delayed per day

Da = Average delay per delayed vehicle (minutes)

ADT = Average daily traffic for the highway/rail at-grade crossing, in vehicles per day

2 = Factor which approximates a 95 percent confidence level that the peak delay would not exceed the average. This practice is generally accepted in traffic engineering analyses to produce a conservative estimate of delay.

Total Traffic Delay

SEA estimated the total vehicular delay effects at highway/rail at-grade crossings. SEA applied an average delay per vehicle factor to the total crossing travel demand to yield a regional total delay at the highway/rail at-grade crossings due to train operations.

Traffic Level of Service

SEA estimated the vehicle delay effects at highway/rail at-grade crossings using the LOS concept at signalized intersections, as documented in the *Highway Capacity Manual* (HCM).[2] Use of the HCM procedures for signalized intersections is acceptable for the following reasons: 1) the absence of a similar measure of efficiency for highway/rail at-grade crossings, and 2) similarities between signalized intersection operation and highway/rail at-grade crossing operation. The blocked crossing time at a highway/rail at-grade crossing operation is represented by the red phase of a traffic signal. When the blocked crossing period begins, vehicles begin to queue. When the blocked crossing period ends, queued vehicles begin to depart at the constant vehicle departure rate until the queue dissipates.

The LOS for signalized intersections is defined in terms of delay and is expressed as a letter grade ranging from LOS A (free flowing) to F (severely congested). Specifically, the 1997 update to the HCM uses average control delay per vehicle. Control delay includes initial deceleration delay, queue move-up time, and final acceleration delay. Table E.2-3 below, presents the range of control delay for each LOS.

Table E.2-3. Control Delay for Each LOS

LOS	Control Delay per Vehicle (seconds)
A	≤ 10.0
B	> 10.0 to ≤ 20.0
C	> 20.0 to ≤ 35.0
D	> 35.0 to ≤ 55.0
E	> 55.0 to ≤ 80.0
F	> 80.0

SEA calculated the average delay per delayed vehicle and average delay for all vehicles. A factor of 1.3 was applied to the calculated delay to account for initial deceleration, queue move-up time, and final acceleration. These calculated delays per vehicle can then be directly compared to the LOS thresholds from the HCM.

E.2.5.2 Criteria of Significance for Transportation Effects at Highway/Rail At-Grade Crossings

SEA will assign significant impact status to crossings if the Proposed Action would result in an increase in average delay for all vehicles that would reduce the LOS from a level D or better to a level E or worse.

[2] Transportation Research Board. *Highway Capacity Manual*. Special Report 209, Third Edition, updated 1997.

SEA notes that the determination of significant impact using the criteria described above is not in itself an indicator of the need for mitigation. Rather, the analysis of delay at highway/rail at-grade crossings should serve as an initial screening process. At locations where the criteria of significance would be met, a more detailed site-specific analysis involving the appropriate state and local agencies will be performed to evaluate the various factors which contribute to highway/rail at-grade crossing blockages and to determine the potential need for mitigation measures.

E.2.5.3 Roadway Operations near Highway/Rail At-Grade Crossings

In addition to the evaluation of vehicle delays and LOS at the EJ&E and CN highway/rail at-grade crossings, SEA also evaluated roadway operations along the roads that cross the rail lines. Discussed in Attachment E1, SEA evaluated the roadway operations without regard to the at-grade crossing operations. The purpose of the additional evaluation was to identify roadway conditions in two ways: 1) to determine the level LOS for study roadways away from the crossing location; and 2) to broadly evaluate the overall mobility of each community in the area

SEA obtained roadway characteristics, such as number of lanes, functional classification, area type and traffic counts to determine the LOS of each roadway that crosses the rail lines. An LOS analysis was completed for each roadway, using available traffic volume information and the unique characteristics of each facility in the vicinity of the crossing.

The community's roadway network, which includes the number of crossings, the crossing type, and the network's connectivity, as well as the land-use mix and density, were factors in the evaluation of the overall mobility of each community. SEA estimated forecasted traffic volumes for 2015 by applying a growth rate to the 2007 roadway volumes. The growth rate was developed based on the assumptions explained in Section E.2.4.

Roadway LOS

SEA determined the roadway LOS by examining the vehicles per day (vpd) on the roadways that cross the rail lines via highway/rail at-grade crossings. The daily capacity per lane was derived from the methodology stated in the 2000 *Highway Capacity Manual* (HCM) (Transportation Research Board 2000).[3] This analysis assumed two area types and two functional classifications. Table E.2-4 below, illustrates roadway capacities for different types of roadways, based on the area type and functional classification of the roadway.

Table E.2-4. Roadway Capacity per Area Type and Classification

Area Type	Classification	Capacity (vpd/lane)
Urban/Suburban	Arterial	9,800
Urban/Suburban	Collector	6,800
Rural	Arterial	7,800
Rural	Collector	5,900

The daily capacity of a roadway is calculated by multiplying the number of lanes on the roadway by the capacity values shown in Table E.2-4. For example, if a roadway has four lanes and is an urban arterial then the daily capacity is 4 lanes x 9,800 vpd/lane = 39,200 vpd. The LOS is determined by calculating the volume to capacity (V/C) ratio, which is the daily volume on the roadway divided by the total capacity. The relationship between LOS and V/C is stated in Table E.2-4. For example, if a roadway accommodates 42,000 vpd and the capacity is 39,200 vpd, then the V/C would be 42,000 vpd/39,200 vpd = 1.07. According to the HCM standards shown in Table E.2-5 below, the example roadway would show an LOS F because the V/C ratio is greater than 1.0.

Table E.2-5. V/C Thresholds per LOS Grade					
A	B	C	D	E	F
0.3	0.45	0.65	0.85	1.0	>1.0

LOS analysis results and overall mobility conditions appear for the CN and EJ&E rail lines.

E.2.5.4 New Construction Transportation Effects Analysis

As part of the Proposed Action, the Applicants would construct rail line improvements to provide efficient routing of train traffic. The primary construction project associated with the Proposed Action is new rail connections between proposed rail lines and existing rail lines.

Transportation impacts of new rail connections are related to highway/rail at-grade crossings. New rail connections can result in either physical change to existing highway/rail at-grade crossings or construction of new highway/rail at-grade crossings. The physical changes to existing crossings would involve adjusting locations of grade crossing warning devices and would not involve adding new track to the crossing. Because new rail connections would have effects on highway/rail at-grade crossings that are similar to crossings along existing rail line segments, SEA used the same analytical methods for existing crossings and proposed locations.

SEA applied the same criteria of significance for new rail connections and new construction facilities as those that will be used to determine significant impacts at existing highway/rail at-grade crossings.

E.2.5.5 Emergency Vehicle Response

In some communities, fire, police, and emergency medical service vehicles must cross rail lines at highway/rail at-grade crossings in order to respond to emergencies. Because blocked highway/rail at-grade crossings can delay emergency vehicles (as well as volunteers in volunteer emergency service areas), SEA evaluated the extent of potential delays projected to result from the Proposed Action. Because of the wide variation in local conditions and the randomness of emergency response vehicle events and their interaction with freight train movements, SEA did not quantify the effects from the Proposed Action on emergency vehicle response on a system-wide basis.

SEA employed an analysis threshold of an increase or decrease in freight train traffic of eight or more trains per day to determine which highway/rail at-grade crossings would require an analysis of potential effects on emergency vehicle response time. Decreases in train traffic will have a positive impact on response times and will be evaluated.

The effects on emergency services due to the proposed acquisition were determined by analyzing emergency facilities along rail lines that meet the effect threshold. The intent was to identify emergency response service provider areas and evaluate any changes in service that might result. The study area was described by defining a study corridor along the rail lines two miles either side of the effected rail segments.

A four mile wide study corridor along the EJ&E Rail Line and segments of the CN Rail Line was tested to determine the density and coverage of service. A four mile wide corridor was designated because it defines a zone in which rail operations have a reasonable probability of interacting with emergency service vehicles. Beyond two miles the multitude of routes available and the influence of other factors tend to diminish the probability that CN/EJE rail operations would interfere with emergency vehicles on any frequent basis.

This statement is confirmed through analysis of the proximity of service providers. Ninety-eight emergency service provider jurisdictions are crossed by the 348 miles of railroad included in the proposed action. Data describing each provider's facility locations were collected and included a total of 135 police stations, 377 fire stations and 84 hospitals serving these 98 providers.

Of the total facilities listed for each agency, 104 police stations, 239 fire stations and 41 hospitals fell within the four mile study corridor. These represent 77% of the police stations, 63% of the fire stations and 49% of the hospitals. Therefore, it was determined that this corridor includes all of the facilities that could be affected by railroad operations and form the network of emergency facilities appropriate for analysis of acquisition effects. A more in-depth discussion of emergency response by community can be viewed in Attachment E3. Figures E-1 and E-2 provide the locations and proximities of emergency services along the EJ&E and CN rail line.

For those highway/rail at-grade crossings that meet or exceed the threshold for increases in freight train traffic and lie within the four mile wide study corridor, SEA analyzed effects on emergency vehicle response by evaluating the following site-specific conditions:

- Geographic layout of the area, including locations of hospitals, police and fire stations, and population of the emergency response service area
- Existing highway and road networks
- Locations of nearby grade-separated crossings
- Types of emergency services provided
- Service area covered by emergency service providers
- Emergency dispatch procedures
- Available communications technology
- Number of emergency vehicles crossing tracks on a typical day
- Emergency service routes
- Typical procedures when an emergency vehicle driver arrives at a blocked crossing
- Typical train speeds