Caltrain 2025 Preliminary Hazard Analysis Worksheets
December 2009

The following are the detailed Preliminary Hazard Analysis (PHA) worksheets developed for the Caltrain 2025 Preliminary Hazard Analysis. The format for the worksheet is given followed by worksheets for the PHA scenarios:

A. EMU collision with auto driving around crossing gate
B. EMU collision with highway truck driving around crossing gate
C. EMU collision with pedestrian at grade crossing
D. EMU collision with auto at non-gated maintenance of way crossing
E. EMU collision with auto fouling tracks at gated grade crossing
F. EMU collision with highway truck fouling tracks at gated grade crossing
G. EMU in shared corridor strikes fright cargo that has dislodged
H. EMU collision with FRA-compliant locomotive
I. EMU collision with flat immovable object
J. EMU collision with object (derailed train)

For a summary of the PHA analysis process and a description of the results, see Caltrain’s Waiver Request to FRA to Operate Mixed Traffic on the Caltrain Corridor, Chapter 4.

Format of PHA Worksheets
The PHA analysis is summarized into worksheets for each scenario. A sample worksheet can be found as Table 1.

The format of the PHA worksheets is as follows:

(1) PHA No: Hazard reference number
(2) Hazard Scenario – Description of the hazard circumstances
(3) Level – A scenario subset indicating speed at which the collision occurs
(4) No. – Hazard reference number subset number
(5) Hazard Description - Description of each postulated hazard
(6) Potential Cause – Description of those causal factors that create the hazardous condition
(7) Effect on the EMU - Description of the probable effect on the train passengers and crew and equipment in terms of severity
(8) Probability/Severity – The probability and severity of the hazardous condition for the development of the Initial HRI
(9) Initial HRI – the Hazard Risk Index for the existing (2008) operating environment BEFORE the application of any mitigation measure

(10) Effect on the Motorist/Pedestrian - Description of the probable effect on the motor vehicle drive and passenger and vehicle or pedestrian in terms of severity in motorist/pedestrian scenarios

(11) Probability/Severity – The probability and severity of the hazardous condition relating to the Motorist/Pedestrian for the development of the Initial HRI

(12) Motorist/Pedestrian Initial HRI – the Hazard Risk Index for the existing (2008) operating environment BEFORE the application of any mitigation measure

(13) Controlling Measures – Practicable mitigation measures to be taken to reduce the severity and/or likelihood (probability) of the hazard condition

(14) Residual HRI – the Hazard Risk Index of the operating environment that is expected to result AFTER the application of the combined mitigation measures

(15) Resolution and Remarks Final HRI – The combination of the measures taken to reduce the severity/probability of the hazard condition AND the measures implemented through the Systemwide Grade Crossing Improvement Program
### Table 1 - Sample PHA Worksheet

<table>
<thead>
<tr>
<th>PHA NO.:</th>
<th>(1)</th>
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<tbody>
<tr>
<td>Hazard Scenario:</td>
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<td>Level:</td>
<td>(3)</td>
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<tr>
<td>REV NO.:</td>
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**CALTRAIN 2025**  
**PRELIMINARY HAZARD ANALYSIS**

| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |

**HAZARD CAUSE/EFFECT**

**MITIGATION OPTIONS**

**CORRECTIVE ACTION**

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**Reviewed** By:  
**Approved** By:
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<tbody>
<tr>
<td>A.1</td>
<td>Auto driving around or through crossing gate is struck by EMU traveling up to 70 MPH</td>
<td>2 quadrant gate system does not restrict motorist’s action of driving around crossing gate</td>
<td>Minor injuries requiring medical treatment away for the scene of the accident</td>
<td>Occasional Marginal</td>
<td>18</td>
<td>Loss of Life Major injuries Loss of Motor Vehicle</td>
<td>Occasional Critical</td>
<td>7</td>
<td>If space permits, install 60’ median barrier If space permits, install 60’ curb with channelization devices If configuration feasible, install 4 quadrant gates with presence detection Increase education and human enforcement Photo Enforcement</td>
<td>13</td>
<td>Expected residual HRI improvement is for the railroad carried people and equipment that results from the reduced probability to Remote.</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Minor damage to exterior of vehicle. Occupied volume not compromised</td>
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**CALTRAIN 2025**
PRELIMINARY HAZARD ANALYSIS

**Performed By:** H. Saporta

**Reviewed By:** M. Bailey

**Approved By:** R. Doty
## GENERAL DESCRIPTION

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<tbody>
<tr>
<td>B.1</td>
<td>Highway truck drives around crossing gate and is struck by EMU traveling up to 60 MPH</td>
<td>2 quadrant gate system does not restrict driver’s action of driving around crossing gate</td>
<td>Minor injuries and limited major injuries.</td>
<td>Remote Serious</td>
<td>17</td>
<td>Loss of Life Major injuries</td>
<td>Remote Critical</td>
<td>13</td>
<td>If space permits, install 60’ median barrier</td>
<td></td>
<td>Expected residual HRI improvement is for the motorist and motor vehicle risk reduction that results from the reduced probability to Improbable.</td>
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<td></td>
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<td>Major damage to exterior of vehicle. Occupied volume not compromised.</td>
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<td></td>
<td></td>
<td>Major injuries</td>
<td></td>
<td></td>
<td>If space permits, install 60’ curb with channelization devices</td>
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<td></td>
<td></td>
<td></td>
<td>Loss of Motor Vehicle</td>
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<td></td>
<td>If configuration feasible, install 4 quadrant gates with presence detection</td>
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<td>Increase education and human enforcement</td>
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<td>Photo Enforcement</td>
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### HAZARD CAUSE/EFFECT

- **B.1**
  - **Potential Cause**: 2 quadrant gate system does not restrict driver’s action of driving around crossing gate. Minor injuries and limited major injuries. Major damage to exterior of vehicle. Occupied volume not compromised.
  - **Effect on EMU**: Remote Serious
  - **Probability Severity**: Remote Critical
  - **Motor Vehicle Initial HRI**: 13
  - **Mitigation Measures**: If space permits, install 60’ median barrier. If space permits, install 60’ curb with channelization devices. If configuration feasible, install 4 quadrant gates with presence detection. Increase education and human enforcement.
  - **Residual HRI**: 16
    - **Resolution and Remarks Residual HRI**: Expected residual HRI improvement is for the motorist and motor vehicle risk reduction that results from the reduced probability to Improbable.
### GENERAL DESCRIPTION

<table>
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<tr>
<th>No.</th>
<th>Hazard Description</th>
<th>Potential Cause</th>
<th>Effect on EMU</th>
<th>Probability Severity EMU Initial HRI</th>
<th>Effect on Ped</th>
<th>Probability Severity Ped Initial HRI</th>
<th>Mitigation Measures</th>
<th>Resolution and Remarks</th>
</tr>
</thead>
</table>
| C.1 | Pedestrian ignores grade crossing warning devices and steps/stands in path of EMU traveling up to 79 MPH | a) Pedestrian ignores warning devices  
b) Crossing gate or other mechanisms do not impede pedestrian travel  
c) Pedestrian stands within dynamic envelope of passing train | None | Occasional  
Negligible | Loss of life or major injuries | Occasional  
Critical | Pedestrian gates  
Swing gates  
Increased education and enforcement  
Fencing and/or plantings to channel pedestrians  
Tactile warning strips  
STOP HERE sidewalk markings | 13 | Expected residual HRI improvement is for the pedestrian risk reduction that results from the reduced probability to Remote.  
24 | Expected residual HRI improvement is for the railroad carried people and equipment that results from the reduced probability to Remote. |

### HAZARD CAUSE/EFFECT

- **Probability**: Occasional
- **Severity**: Negligible
- **Effect on EMU**: Loss of life or major injuries
- **Probability**: Occasional
- **Severity**: Critical

### MITIGATION OPTIONS

- **Mitigation Measures**: Pedestrian gates  
Swing gates  
Increased education and enforcement  
Fencing and/or plantings to channel pedestrians  
Tactile warning strips  
STOP HERE sidewalk markings

### CORRECTIVE ACTION

- **Residual HRI**: 13
- **Final HRI**: 24

**CALTRAI 2025 PRELIMINARY HAZARD ANALYSIS**

**Performed By:** H. Saporta  
**Reviewed By:** M. Bailey  
**Approved By:** R. Doty
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<tbody>
<tr>
<td>D.1</td>
<td>Unauthorized motor vehicle enters ROW at Maintenance of Way crossing and is struck by train traveling up to 70 mph</td>
<td>a) Gate or other barrier not provided Minor injuries requiring medical treatment away from the scene of the accident Minor damage to exterior of vehicle. Occupied volume not compromised</td>
<td>Remote Marginal</td>
<td>Loss of life or major injuries Remote Critical</td>
<td>21</td>
<td>13</td>
<td>Install pipe gate with high security lock and fencing placed a minimum of 15 feet to each side of the gate Increase education and enforcement</td>
<td>16</td>
<td>Expected residual HRI improvement is for the motorist and motor vehicle risk reduction that results from the reduced probability to Improbable.</td>
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<td>b) MOW crew fails to request permission to enter ROW</td>
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**CALTRAIN 2025**

**PRELIMINARY HAZARD ANALYSIS**

**Performed By:** H. Saporta

**Reviewed By:** M. Bailey

**Approved By:** R. Doty
### GENERAL DESCRIPTION

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<tbody>
<tr>
<td>E.1</td>
<td>EMU traveling up to 70 MPH strikes auto fouling tracks</td>
<td>a) Auto stops on tracks due to traffic back-up from adjacent intersection controlled by traffic signals</td>
<td>Minor injuries requiring medical treatment away for the scene of the accident</td>
<td>Probable Marginal</td>
<td>12</td>
<td>Loss of life</td>
<td>Probable Critical</td>
<td>5</td>
<td>Presence sensing device interfaced with traffic controller to clear traffic when train approaches crossing</td>
<td>13</td>
<td>Expected residual HRI improvement is for the motorist and motor vehicle risk reduction that results from the reduced probability to Remote.</td>
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<td></td>
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<td>Minor damage to exterior of vehicle. Occupied volume not compromised</td>
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<td></td>
<td></td>
<td>Major injuries</td>
<td></td>
<td></td>
<td>Provide sufficient queuing for traffic between grade crossing and adjacent intersection</td>
<td>21</td>
<td>Expected residual HRI improvement is for the railroad carried people and equipment that results from the reduced probability to Remote.</td>
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<tbody>
<tr>
<td>E.1</td>
<td>EMU traveling up to 70 MPH strikes auto fouling tracks</td>
<td>b) Auto stops on tracks due to traffic back-up from adjacent intersection controlled by stop sign.</td>
<td>Minor injuries requiring medical treatment away for the scene of the accident Minor damage to exterior of vehicle. Occupied volume not compromised</td>
<td>Probable Marginal</td>
<td>12</td>
<td>Loss of life Major injuries Loss of vehicle</td>
<td>Probable Critical</td>
<td>5</td>
<td>Provide sufficient queuing for traffic between grade crossing and adjacent intersection Install DO NOT STOP ON TRACKS sign Pavement markings clearly indicating fouling area Increase Do Not Stop on Tracks education and enforcement Evaluate crossing for potential sight obstructions Eliminate stop sign on railroad crossing road Coordinate traffic control device upgrades</td>
<td>13</td>
<td>Expected residual HRI improvement is for the motorist and motor vehicle risk reduction that results from the reduced probability to Remote.</td>
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<tbody>
<tr>
<td>E.1</td>
<td>EMU traveling up to 70 MPH strikes auto fouling tracks</td>
<td>c) Auto stops on tracks due to construction activity ahead</td>
<td>Minor injuries requiring medical treatment away for the scene of the accident</td>
<td>Probable</td>
<td>Marginal</td>
<td>Loss of life</td>
<td>Probable</td>
<td>Critical</td>
<td>Coordinate construction activities with local jurisdiction and utilities so as to provide sufficient queuing between tracks and construction activity</td>
<td>Expected residual HRI improvement is for the motorist and motor vehicle risk reduction that results from the reduced probability to Remote.</td>
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### HAZARD CAUSE/EFFECT

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<td>EMU traveling up to 70 MPH strikes auto fouling tracks</td>
<td>c) Auto stops on tracks due to construction activity ahead</td>
<td>Minor injuries requiring medical treatment away for the scene of the accident</td>
<td>Probable</td>
<td>Marginal</td>
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<td>Critical</td>
<td>Coordinate construction activities with local jurisdiction and utilities so as to provide sufficient queuing between tracks and construction activity</td>
<td>Expected residual HRI improvement is for the motorist and motor vehicle risk reduction that results from the reduced probability to Remote.</td>
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### MITIGATION OPTIONS

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<td>E.1</td>
<td>EMU traveling up to 70 MPH strikes auto fouling tracks</td>
<td>c) Auto stops on tracks due to construction activity ahead</td>
<td>Minor injuries requiring medical treatment away for the scene of the accident</td>
<td>Probable</td>
<td>Marginal</td>
<td>Loss of life</td>
<td>Probable</td>
<td>Critical</td>
<td>Coordinate construction activities with local jurisdiction and utilities so as to provide sufficient queuing between tracks and construction activity</td>
<td>Expected residual HRI improvement is for the motorist and motor vehicle risk reduction that results from the reduced probability to Remote.</td>
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### CORRECTIVE ACTION

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<td>E.1</td>
<td>EMU traveling up to 70 MPH strikes auto fouling tracks</td>
<td>c) Auto stops on tracks due to construction activity ahead</td>
<td>Minor injuries requiring medical treatment away for the scene of the accident</td>
<td>Probable</td>
<td>Marginal</td>
<td>Loss of life</td>
<td>Probable</td>
<td>Critical</td>
<td>Coordinate construction activities with local jurisdiction and utilities so as to provide sufficient queuing between tracks and construction activity</td>
<td>Expected residual HRI improvement is for the motorist and motor vehicle risk reduction that results from the reduced probability to Remote.</td>
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### CALTRAIN 2025

PRELIMINARY HAZARD ANALYSIS

Performed By: H. Saporta
Reviewed By: M. Bailey
Approved By: R. Doty
**CALTRAIN 2025**

**PRELIMINARY HAZARD ANALYSIS**

<table>
<thead>
<tr>
<th>GENERAL DESCRIPTION</th>
<th>HAZARD CAUSE/EFFECT</th>
<th>MITIGATION OPTIONS</th>
<th>CORRECTIVE ACTION</th>
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<tr>
<td>E.1</td>
<td>EMU traveling up to 70 MPH strikes auto fouling tracks</td>
<td>d) Auto fails to stop at stop bar and front end fouls tracks</td>
<td>Minor injuries requiring medical treatment away for the scene of the accident</td>
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<td>Minor damage to exterior of vehicle. Occupied volume not compromised</td>
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**PHO NO.:** E.1  
**Hazard Scenario:** Collision with Auto Fouling Tracks at Gated Grade Crossings  
**Level:** EMU Traveling Up To 70 MPH  
**REV NO.:** 2

**Performed By:** H. Saporta  
**Reviewed By:** M. Bailey  
**Approved By:** R. Doty
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<tbody>
<tr>
<td>E.1</td>
<td>EMU traveling up to 70 MPH strikes auto fouling tracks</td>
<td>e) Auto stalls or is stuck on tracks</td>
<td>Minor injuries requiring medical treatment away for the scene of the accident</td>
<td>Remote Marginal</td>
<td>21</td>
<td>Loss of life</td>
<td>Remote Critical</td>
<td>13</td>
<td>Practicable effective means of mitigation are not available to reduce the probability of collision with an auto stuck on track due to stall or abandoned</td>
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<td>f) Abandoned auto on tracks</td>
<td>Minor damage to exterior of vehicle. Occupied volume not compromised</td>
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<td></td>
<td>Major injuries</td>
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<tr>
<td>E.1</td>
<td>EMU traveling up to 70 MPH strikes auto fouling tracks</td>
<td>g) While in the grade crossing, the motorist misjudges turn into parallel road way and enters ROW</td>
<td>Minor injuries requiring medical treatment away for the scene of the accident, Minor damage to exterior of vehicle, Occupied volume not compromised</td>
<td>Remote Marginal</td>
<td>21</td>
<td>Loss of life, Major injuries, Loss of vehicle</td>
<td>Remote Critical</td>
<td>13</td>
<td>Increase the level of roadway illumination at the crossing to better illuminate the railroad environment</td>
<td>Other additional practicable and more positive means of mitigation are not available to significantly reduce the probability of motorists turning from the crossing onto the track. Increasing the illumination of the area is not considered sufficient to reduce the probability of the mishap to improbable.</td>
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</table>
**PHN NO.:** F.1  
**Hazard Scenario:** Collision with Highway Truck Fouling Tracks at Gated Grade Crossings  
**Level:** EMU Traveling Up To 70 MPH  
**REV NO.:** 2

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**CALTRAIN 2025**  
**PRELIMINARY HAZARD ANALYSIS**

**Performed By:** H. Saporta  
**Reviewed By:** M. Bailey  
**Approved By:** R. Doty

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<tr>
<th>GENERAL DESCRIPTION</th>
<th>HAZARD CAUSE/EFFECT</th>
<th>MITIGATION OPTIONS</th>
<th>CORRECTIVE ACTION</th>
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<tbody>
<tr>
<td>F.1</td>
<td>EMU traveling up to 70 MPH strikes truck fouling tracks</td>
<td>a) Truck stops on tracks due to traffic back-up from adjacent intersection controlled by traffic signals</td>
<td>Minor injuries and limited major injuries. Major damage to exterior of vehicle. Occupied volume not compromised.</td>
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**Residual HRI**

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Expected residual HRI improvement is for the railroad carried people and equipment that results from the reduced probability to Improbable.
**CALTRAIN 2025**
**PRELIMINARY HAZARD ANALYSIS**

**GENERAL DESCRIPTION**

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<tbody>
<tr>
<td>F.1</td>
<td>EMU traveling up to 70 MPH strikes truck fouling tracks.</td>
<td>b) Truck stops on tracks due to traffic back-up from adjacent intersection controlled by stop sign.</td>
<td>Minor injuries and limited major injuries. Major damage to exterior of vehicle. Occupied volume not compromised.</td>
<td>Remote Serious</td>
<td>17</td>
<td>Loss of life Major injuries Loss of vehicle</td>
<td>Remote Critical</td>
<td>13</td>
<td>Provide sufficient queuing for traffic between grade crossing and adjacent intersection Install DO NOT STOP ON TRACKS sign Pavement markings clearly indicating fouling area Increase Do Not Stop on Tracks education and enforcement Evaluate crossing for potential sight obstructions Coordinate traffic control device upgrades or eliminate stop sign for railroad crossing traffic</td>
</tr>
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</table>

**Performed By:** H. Saporta  
**Reviewed By:** M. Bailey  
**Approved By:** R. Doty  

**Residual HRI Resolution and Remarks**
- Expected residual HRI improvement is for the motorist and motor vehicle risk reduction that results from the reduced probability to Improbable.
- Expected residual HRI improvement is for the railroad carried people and equipment that results from the reduced probability to Improbable.
# CALTRAIN 2025
## PRELIMINARY HAZARD ANALYSIS

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<tbody>
<tr>
<td>F.1</td>
<td>EMU traveling up to 70 MPH strikes truck fouling tracks</td>
<td>c) Truck stops on tracks due to construction activity ahead</td>
<td>Minor injuries and limited major injuries. Major damage to exterior of vehicle. Occupied volume not compromised.</td>
<td>Remote Serious</td>
<td>17</td>
<td>Loss of life Major Injuries Loss of vehicle</td>
<td>Remote Critical</td>
<td>13</td>
<td>Coordinate construction activities with local jurisdiction and utilities so as to provide sufficient queuing between tracks and construction activity Increase Do Not Stop on Tracks education and enforcement Employ construction methods that do not result in queuing or reduces queuing Employ “Flag Persons” at the crossing to regulate the flow of traffic and control queuing</td>
<td>16</td>
<td>Expected residual HRI improvement is for the motorist and motor vehicle risk reduction that results from the reduced probability to Improbable.</td>
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<td>Expected residual HRI improvement is for the railroad carried people and equipment that results from the reduced probability to Improbable.</td>
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</tbody>
</table>

### HAZARD CAUSE/EFFECT

- **No.**
- **Hazard Description**
- **Potential Cause**
- **Effect on EMU**
- **Probability Severity**
- **EMU Initial HRI**
- **Effect on Motor Vehicle**
- **Probability Severity**
- **Motor Vehicle Initial HRI**

### MITIGATION OPTIONS

- **Controlling Measures**
- **Residual HRI**
- **Resolution and Remarks**

### CORRECTIVE ACTION

- **Performed By:** H. Saporta
- **Reviewed By:** M. Bailey
- **Approved By:** R. Doty
**PHN NO.:** F.1  
**Hazard Scenario:** Collision with Highway Truck Fouling Tracks at Gated Grade Crossings  
**Level:** EMU Traveling Up To 70 MPH  
**REV NO.:** 2

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**CALTRAIN 2025**  
**PRELIMINARY HAZARD ANALYSIS**

Performed By: H. Saporta  
Reviewed By: M. Bailey  
Approved By: R. Doty

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<table>
<thead>
<tr>
<th>GENERAL DESCRIPTION</th>
<th>HAZARD CAUSE/EFFECT</th>
<th>MITIGATION OPTIONS</th>
<th>CORRECTIVE ACTION</th>
<th>RESIDUAL HRI</th>
</tr>
</thead>
<tbody>
<tr>
<td>F.1</td>
<td>EMU traveling up to 70 MPH strikes truck fouling tracks</td>
<td>d) Truck fails to stop at stop bar and front end fouls tracks</td>
<td>Minor injuries and limited major injuries. Major damage to exterior of vehicle. Occupied volume not compromised.</td>
<td>Remote</td>
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### CALTRAIN 2025
### PRELIMINARY HAZARD ANALYSIS

**PHNO:** F.1  
**Hazard Scenario:** Collision with Highway Truck Fouling Tracks at Gated Grade Crossings  
**Level:** EMU Traveling Up To 70 MPH  
**REV NO.:** 2

|-----|-------------------|----------------|--------------|------------------------------------|------------------------|-----------------------------------------------|----------------------|--------------|------------------------|
| F.1 | EMU traveling up to 70 MPH strikes truck fouling tracks | e) Truck stalls or is stuck on tracks  
   f) Abandoned truck on tracks | Minor injuries and limited major injuries.  
   Major damage to exterior of vehicle.  
   Occupied volume not compromised. | Remote  
   Serious | 17  
   Loss of life  
   Major injuries  
   Loss of vehicle | Remote  
   Critical | | | Practicable effective means of mitigation are not available to reduce the probability of a collision with a truck stuck on track due to stall or left abandoned there |

**Performed By:** H. Saporta  
**Reviewed By:** M. Bailey  
**Approved By:** R. Doty
### GENERAL DESCRIPTION

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<tr>
<td>F.1</td>
<td>EMU traveling up to 70 MPH strikes truck fouling tracks</td>
<td>g) While in grade crossing, truck driver misjudges turn into parallel road way and enters ROW</td>
<td>Minor injuries and limited major injuries.</td>
<td>Remote Serious</td>
<td>17</td>
<td>Loss of life</td>
<td>Remote Critical</td>
<td>13</td>
<td>Increase the level of illumination at and adjacent to the crossing to better show the railroad environment.</td>
<td>Other additional practicable effective means of mitigation are not available to significantly reduce the probability of motorists turning from the crossing onto the track. The identified mitigation is not considered to be sufficient to reduce the probability of this type of mishap to improbable.</td>
</tr>
</tbody>
</table>
## CALTRAIN 2025
### PRELIMINARY HAZARD ANALYSIS

**Hazard Scenario:** EMU in Shared Corridor Strikes Freight Cargo  
**Level:** EMU Traveling Up To 70 MPH

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<th>Probability Severity</th>
<th>EMU Initial HRI</th>
<th>Mitigation Measures</th>
<th>Residual HRI</th>
<th>Resolution and Remarks</th>
</tr>
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</table>
| G.1 | EMU in shared corridor strikes freight cargo that has dislodged | a) Freight shifts while in transport and encroaches the dynamic envelope of EMU on adjacent track  
   b) Freight shifts while in transport and falls into path of EMU on adjacent track | Minor injuries requiring medical treatment away for the scene of the accident  
   Minor damage to exterior of vehicle.  
   Occupied volume not compromised | Remote Marginal | 21 | Install presence sensing devices at strategic locations on the ROW. Upon detection of improperly extended lading, an alert is sent to the EMU operating engineer and the dispatcher.  
   Application of irregular load sensing equipment and temporal separation functions reduce the expected probability of such conditions within the operating environment to Improbable | 22 | Application of irregular load sensing equipment and temporal separation functions reduce the expected probability of such conditions within the operating environment to Improbable |
## H.1.1
Engineer fails to slow the train adequately and stop short of another train to avoid impact while under manual control subject to Restricted Speed

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<th>EMU Initial HRI</th>
<th>Effect on FRA Compliant</th>
<th>Probability Severity</th>
<th>FRA Compliant Initial HRI</th>
<th>Mitigation Measures</th>
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<th>Resolution and Remarks</th>
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<tr>
<td>H.1.1</td>
<td>Engineer fails to slow the train adequately and stop short of another train to avoid impact while under manual control subject to Restricted Speed</td>
<td>Train engineer inattention</td>
<td>Minor injuries and limited major injuries</td>
<td>Improbable</td>
<td>20</td>
<td>Minor injuries and limited major injuries</td>
<td>Improbable</td>
<td>20</td>
<td>Reduce Restricted Speed to 15 MPH the level at which severity transitions to “Marginal”</td>
<td>22</td>
<td>A design solution that completely avoids the risk of collision caused by inattention of the Engineer is not possible. RESTRICTED SPEED enforcement by CBOSS is expected to marginally reduce this risk by capping travel speed to 20 MPH in manual mode. The reduction of permitted manual operating speed to 15 MPH might be expected to result in lower impact speeds resulting in reduced severity and probability of collision. The assumption that 20 mph is a typical impact speed for such conditions is not supported by available data. It is reasonable to assume that a lower impact speed is more typical. The very small and uncertain safety improvement from a lowering of RESTRICTED SPEED from 20 MPH to 15 MPH is not justifiable. RESTRICTED SPEED will remain at 20 MPH.</td>
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<th>Resolution and Remarks Residual HRI</th>
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| I.1.1 | EMU collides with wayside immovable structure | Post derailment after:  
a) Collision with another EMU or FRA-compliant Vehicle  
b) Track in poor repair  
c) EMU in poor repair  
d) Rail vehicle overspeed | Minor injuries and limited major injuries  
Major Damage to Exterior of EMU, Occupied volume is not compromised | Improbable  
Serious | 20 | Implement more rigorous track preventive maintenance program  
Implement more rigorous EMU preventive maintenance program  
Maintain infrastructure design criteria requiring adjacent fixed object structures be kept to a minimum and placed back away from the operating envelope to the degree possible and particularly away from special trackwork areas  
Continue to apply Caltrain design criteria that requires a check rail to be used when in areas that exhibit this risk. | 20 | A design solution that completely avoids the risk of derailment due to improper operation or vehicle equipment or track failures is not possible. Continue use of existing controlling measures. |
## GENERAL DESCRIPTION

### HAZARD CAUSE/EFFECT

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| J.1.1 | EMU collision with object (derailed train) across the path | a) Track in poor repair  
b) EMU in poor repair  
c) Earthquake  
d) Bridge displacement (due to strike, earthquake)  
e) Adjacent Railroad Derailment  
f) Rail vehicle overspeed | Major Damage to Exterior of EMU, Occupied volume is compromised | Improbable Catastrophic | Implement more rigorous track preventive maintenance program  
Implement more rigorous EMU preventive maintenance program  
Integrate seismic event detection into CBOSS to allow direct and immediate speed reduction when the condition is indicated  
Implement sensors to detect a derailment and require CBOSS to automatically reduce speed (and stop) of approaching trains  
Implement sensors to enable CBOSS to respond to degraded track conditions inconsistent with the allowable speed  
Implement intrusion/derailment detection equipment to interface with CBOSS for automatic intervention  
Implement derailment containment structures  
Temporal separation of freight train operations. | 14 | Collision with a derailed train is a possibility and can be expected to result in casualties, particularly involving persons unable to quickly move to an area of safety from the derailed train cars. Accident consequences are expected to be equivalent for EMU and compliant trains in these scenarios, both being Catastrophic. Reducing the severity of the mishap consequences to Critical is not practicable for either type of vehicle.  
While the severity of the outcome cannot be practically reduced. Probability can be reduced but not eliminated. The benefits of introducing additional mitigation is limited since the mishap probability is already classified as improbable. CBOSS based mitigation might reduce some risks, but would introduce other risks due to false activation.  
Controlling measures involving infrastructure changes are disproportionately costly for benefit.  
Temporal separation segregates and reduces freight operations on adjacent tracks during passenger operating hours and lowers derailment risk though as the risk is already low, the improvement is marginal. |