Hy-Rail Limits Compliance

Functional Description

And

Human / Machine Interface

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1 DESCRIPTION

The Hy-Rail Limits Compliance System (HLCS) project is in Phase II implementation. The project adds an additional layer of safety to the operation of Hy-Rail vehicles on active mainline tracks. It does so by using Global Positioning Satellites (GPS) to monitor the locations of “on-rail” Hy-Rail vehicles and comparing locations against respective track authorization limits issued to the vehicle.

1.1 How Authority Compliance Works

Fig. 1 displays how a vehicle approaching the limits of its authority will be alerted. A vehicle exceeding the limits of its authority will receive a continual alarm until the vehicle returns to the authorized limits. Authority limit exceedance is alerted to the dispatcher.

![How Authority Limits Compliance Works](image)

1.2 How Proximity Alerts Work

Fig. 2 displays how Proximity alerts are provided when a vehicle is nearby other on-track vehicles that are equipped. A “Geo-Fence” (bubble of protection) is established around an equipped vehicle. When the bubbles touch each vehicle is alerted to the presence of the other equipped vehicle.
1.3 Additional Functionality

The system also uses a Packet Data radio. This radio, when interfaced to the vehicles display unit, provides additional functionality.

1.3.1 The system provides a means for Hy-Rail operators to declare emergencies to their dispatchers. A pushbutton on the vehicle display unit allows the operator to notify the dispatcher of an emergency. When the button is pressed, a position report with the emergency message is sent to the dispatcher. To prevent accidentally sending this message, the button must be pressed for a minimum time that is configured via the dispatcher system software. A chirp acknowledges each push over the speaker.

1.3.2 The vehicle operator can report an emergency to the dispatcher when the operator is away from the vehicle by using a Remote Emergency Device. Pressing the remote device “panic” button
sends a position report. The device is a wireless unit that is similar to a pager and is worn on the operators’ belt. It has a range of approximately 1500 feet from the vehicle.

1.3.3 The system allows the Hy-Rail operator to “mark” a location by reporting the marked position to the system software. This is accomplished by pressing the “mark” button on the display unit in the vehicle. The functionality is provided to enable the user to mark specific points to latitude / longitude and the distance from a specified mile post marker. The integration of a laptop would enable the operator to “tag” and identify these marks as railroad identifiable points (markers, crossing devices, frost heaves, etc.).

1.3.4 The system provides a data port for the use of a laptop computer. This could be used for the documentation of the dropped “marks”, data delivery of authorities, or for corporate uses.

2 GLOBAL POSITIONING SYSTEM (GPS) OVERVIEW

The Hy-Rail Limits Compliance program uses the Global Positioning system (GPS) to:

- Accurately map the subdivision main line territory. This must be accomplished to establish the baseline for the correlation with authority limits and the accurate determination of vehicle location for the proximity warning. The mapping of the right of way is done to sub-meter accuracy. This data is entered into the train control database and is provided to the BNSF Railway Information System (RIS) to update and correct corporate track data. Dispatchable point location changes (i.e., restricted limits, yard limits) in the field must be entered into the train control database in near real time to insure the features provided by the project function correctly.
- Provide “real-time” vehicle location:
  - To dispatchers. Because GPS location information is centrally processed, dispatchers have a means of knowing the on-track locations of all HLCS equipped vehicles.
  - To the system for use by the authority limits module, and the proximity warning module.
  - To the system to support the Emergency Notification module.
  - Provide a “marker” feature capability to locate physical features in the field.

Operator input is used to identify track location in the event that the system is unable to determine the specific track that the vehicle is on. The input device is a thumbwheel located on the Vehicle Display Unit (VDU). The thumbwheel is shown in figure 3.

3 VEHICLE DISPLAY UNIT (VDU) FUNCTIONALITY

The Vehicle Display Unit (VDU) is a vehicle dashboard display and control unit that is installed in HY-Rail vehicles for the specific purpose of:

1. Warning and/or preventing a vehicle from exceeding its limits of authority.

2. To prevent collisions between two or more vehicles operating within the same authorized compliance limits.
3. For emergency notification

4. To “mark” a location for future reference

5. To provide a data port for connecting a data terminal such as a laptop computer.

The VDU is interfaced to a Packet Data Radio that automatically transmits the vehicle’s position to the dispatcher system interface and provides a real-time communication link between the driver and his Dispatcher. The vehicle position update rate is a function of time and distance traveled by the vehicle, and proximity to other vehicles.

The VDU is normally located on the dashboard, or mounted to a flexible conduit attached to the floor of a Hi-Rail. The VDU measures 4.0" X 7.0" X 1.5" and weighs less than 2 pounds.

A pictorial sketch of the VDU is shown in Figure 3
VEHICLE DISPLAY

TRACK TYPE

M1

BNSF

EMERGENCY TEST MARKER DATA PORT

NET GPS OFFICE RAIL TKY TYPE

TRACKING PROXIMITY WARNING

DATA PORT

L = 20 FEET

TO S45C

S45 FO CABLE
THE VEHICLE DISPLAY UNIT DESCRIPTION

The Vehicle Display Unit (VDU) is an essential element of this warning system and provides the interface to the Hy-Rail operator in the vehicle. A brief functional description of the VDU is given below.

At times, VDU functionality is described relative to “dispatch software” and/or the “Dispatcher”. This is not intended to specify the functionality of the dispatch software but only to aid in understanding the VDU role within the system. “Dispatcher” is used when human intervention or attention is required. “Dispatch software” is used when human intervention or attention may not be required.

4.1 Tracking LED

(see figure 4)

The “tracking LED” provides immediate confirmation to the vehicle operator that the system is functioning and the vehicle is being tracked. When the Hi-Rail operator desires access to a particular section of track, the operator calls the Dispatcher and requests a Track Authorization. Following authorization, the operator places the vehicle on the track. The wheel locking mechanism automatically closes a relay that signals the VDU to turn on the RAIL LED. This also causes the data radio to send a position report indicating ON RAIL. This report informs the Dispatcher that the unit is on the rail at the location indicated by GPS coordinates.

Once on the track the Hy-Rail Operator sets the track number thumbwheel switch on the VDU to match the track that the Hi-Rail vehicle is on. When the dispatch software at the NOC receives a message with the ON RAIL, it checks the vehicle position and track number. If the position is within the authorized Track Warrant, a tracking message is sent to the vehicle. Upon receipt of the message the VDU TRACKING LED is turned on for a period of (TBD) minutes, where TBD is the time duration that an authorization is granted. This is
normally 5 minutes. To keep the TRACKING LED on, additional authorization messages are automatically sent by the dispatch software with a period of TBD minutes until the authorization runs out. In this manner, the operator knows that the dispatch software is tracking him.

The TRACKING LED is logically correlated with the five status LEDs directly below it on the VDU face plate. If one or more of the status LEDs are OFF, then the TRACKING LED will also be turned OFF. When the TRACKING LED goes from ON to OFF, a pulsating audible alarm is sounded. The status LEDs are described below.

4.1.1 NET Status

(see figure 4)

The NET status LED indicates the status of the radio communications link between the base station tower and the vehicle. This LED is ON when the vehicle is able to send and receive messages to and from a base station. If the NET LED turns OFF, indicating the vehicle is not within range of any base station tower, the TRACKING LED also turns OFF.

4.1.2 GPS Status

(see figure 4)

The GPS status LED indicates the status of the GPS receiver located inside of the data radio. The GPS LED is ON when the GPS is outputting a valid position when the vehicle wheels are locked, a vehicle off (wheels unlocked) state turns the LED OFF. If the GPS LED turns OFF, indicating an invalid position, the TRACKING LED also turns OFF.
4.1.3 OFFICE Status

(see figure 4)

The OFFICE status LED indicates the status of the office-to-vehicle communications link. This status indicator operates as a watchdog timer. It is turned ON when the data radio receives a track authorization message. This confirms to the operator that the office is actively tracking the Hi-Rail vehicle. It turns OFF after a preset time (usually 5 minutes, selected by the track authorization message parameter) if another track authorization message is not received before the watchdog timer expires. When the OFFICE LED turns OFF, the TRACKING LED also turns OFF.

4.1.4 Rail Status

(see figure 4)

The RAIL status LED indicates the status of the Hi-Rail vehicle. It automatically turns ON when the vehicle is on the track, which is indicated to the VDU via a relay contact closure in the steering wheel lock mechanism. When the RAIL LED turns OFF, indicating the vehicle has been taken off the track, the TRACKING LED also turns OFF.

4.1.5 TRK TYPE Status

(see figure 4)

The TRK TYPE status LED indicates that the TRACK TYPE thumbwheel switch is set to any position except NA. When the TRACK TYPE thumbwheel switch is set to NA, the TRACKING LED also turns OFF. If the office determines that NA is an incorrect setting, it sends a verify track command. The verify track command
flashes the TRK TYPE LED and turns on an audible alarm for the number of seconds specified by the office in the verify track command. During this time, the TRACKING LED is also turned OFF.

4.2 PROXIMITY LED
(see figure 4)

The data radio has the ability to send its position data to a base station and at the same time to hear other vehicles transmitting their position reports to a base station. This gives the data radio / VDU the ability to warn the operator whenever another unit is operating within a preset PROXIMITY radius. Two proximity radii are preset in the data radio by the dispatch software. One radius is for other Hi-Rail vehicles, the other is for locomotives (future functionality).

The PROXIMITY LED turns AMBER whenever another unit is operating within its respective PROXIMITY radius. An audible alarm is also sounded.

4.3 WARNING LED
(see figure 4)

The WARNING LED serves two purposes:

1. WARNING – AMBER

   The WARNING LED turns AMBER whenever the vehicle is within $N$ miles of its track limits. $N$ is a programmable value set by the dispatch software. This gives the operator a heads up that he is approaching his authorized limits. A pulsating audible alarm is also sounded when this condition occurs.
2. WARNING – RED

The WARNING LED turns RED whenever the vehicle exceeds its authorized limits. A continuous audible alarm is also sounded when this condition occurs.

The WARNING LED can only be cleared by the System sending a warning clear message to the vehicle.

4.4 Speaker/Audible Alarm

The audible alarm has three states:

<table>
<thead>
<tr>
<th>State</th>
<th>Sound</th>
<th>Duration</th>
<th>Condition(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>OFF</td>
<td>No sound</td>
<td>Default</td>
<td>No alert or warning condition exists</td>
</tr>
<tr>
<td>ALERT</td>
<td>Pulsed tone</td>
<td>Timed</td>
<td>Approaching authorized limit</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Proximity</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>TRACKING LED turns off</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Test</td>
</tr>
<tr>
<td>WARNING</td>
<td>Constant tone</td>
<td>Persistent</td>
<td>Out of authorized limit</td>
</tr>
</tbody>
</table>

In some cases, the “Timed” duration is set via command from the dispatch software. In all other cases, it is 10 seconds. The WARNING condition persists until the Hy-Rail vehicle is again compliant with its track authorization, which is controlled by the dispatch software and/or Dispatcher.

The speaker is also used to give feedback to the Hy-Rail operator when VDU buttons are pushed. Each button push results in a click or chirp to let the operator know that the button push is recognized and that the action invoked by the button push has been initiated.
4.5 Relay Power Control

Battery power to the data radio is routed through a control relay (external to the VDU) that is activated when the vehicle’s ignition switch is turned on. This powers up data radio and the VDU. To keep the data radio and VDU operating for a preset period of time after the ignition switch is turned off, a relay control signal is provided by the VDU to keep the power on for TBD seconds.

4.6 Hi-Rail Operator Inputs

4.6.1 EMERGENCY Push Button

(see figure 4)

The EMERGENCY push button switch allows the operator to notify the Dispatcher of an emergency at the vehicle. When the EMERGENCY button is pressed, a position report with the EMERGENCY message is sent to the Dispatcher. To prevent accidentally sending this message, the button must be pressed for a minimum of TBD seconds where the dispatch software sets TBD. Each push of the button is acknowledged by the VDU with a click or chirp over the VDU speaker.

A Remote Emergency Device (RED) can also be used by the Hy-Rail vehicle operator to report an emergency to the Dispatcher when the Hy-Rail operator is away from the Hy-Rail vehicle. Pressing the RED’s “panic” button sends a position report. The RED is a wireless unit similar to a pager and is typically worn on the driver’s belt. It has a range of about 1500 feet from the Hy-Rail vehicle.
4.6.2 TEST Push Button

(see figure 4)

The TEST push button allows the operator to verify operation of the WARNING LED. Whenever the TEST push button is pressed, a position report is sent to the dispatch software, which causes the software to automatically send a test message back. This message causes the VDU to go through three test states:

During the first test state, the WARNING LED turns RED, a continuous audible alarm sounds from the speaker and all other LEDs are illuminated. During the second test state, the WARNING LED turns AMBER, a pulsating audible alarm sounds from the speaker and all other LEDs are turned OFF. At the completion of the second test state, all LEDs and the audible alarm are returned to their respective states prior when to the TEST button was pushed.

Each push of the button is acknowledged by the VDU with a click or chirp over the VDU speaker.

4.6.3 MARKER Push Button

(see figure 4)

The MARKER push button switch allows the Hy-Rail operator to “mark” a location by reporting the marked position to the dispatch software. When the MARKER button is pressed, a position report sent to the dispatch software. This is called “dropping a marker.” It is up to the Hy-Rail operator to manually record or remember the meaning of each marker dropped. Future links to a laptop computer will allow the operator to document these markers for future recall. The data radio limits the number of markers to one per minute; i.e., no marker can be dropped within a minute of any other marker. To prevent accidental marker drops, the MARKER button
must be held depressed for 0.25 seconds to drop a marker. Each push of the button is acknowledged by the VDU with a click or chirp over the VDU speaker.

4.6.4 TRACK TYPE Thumbwheel Switch

(see figure 4)

The TRACK TYPE selection switch provides the means by which the Hy-Rail operator tells the office of the current track on which the vehicle is running. A TBD seconds after the Hy-Rail Operator finishes setting the thumbwheel, the thumbwheel setting is transmitted in a position report to the Dispatcher. If the On-rail switch is off or the thumbwheel does not remain unchanged for TBD seconds (i.e., the thumbwheel is still being changed by the operator), the track type is not available.

The use of the thumbwheel is required due to the inability to obtain real time, accurate location data sufficient to differentiate between 2 adjacent tracks. The operator uses the thumbwheel to positively identify to the system the track the vehicle is positioned on. The availability of differential GPS does not completely eliminate the requirement of the thumbwheel. The temporary lack of full satellite coverage (blocked by topography or structures) or the unavailability of full coverage during brief periods of the day requires the use of the thumbwheel.