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A Driver Warning System for Railway Level Crossings

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ABSTRACT

Embodiments of the invention provide a system that warns a driver as their vehicle approaches a railway level crossing based on the current location of the vehicle and its proximity to the railway level crossing at that time.

A DRIVER WARNING SYSTEM FOR RAILWAY LEVEL CROSSINGS

TECHNICAL FIELD

[1] The present invention relates to a system and method for driver warnings as a road vehicle approaches a railway level crossing. More specifically, the invention relates to a system for warning a driver of a road vehicle approaching a railway level crossing to reduce and mitigate collisions.

BACKGROUND

[2] Any references to methods, apparatus or documents of the prior art are not to be taken as constituting any evidence or admission that they formed, or form part of the common general knowledge.

[3] Railway level crossings present a persistent challenge due to the risk of collisions between vehicles and trains, leading to significant infrastructure damage, traffic delays, injuries and casualties.

[4] Railway level crossings globally present a significant safety concern, with thousands of incidents reported annually. In Australia, where there are over 23,500 crossings, both active and passive, there were more than 1,000 near-miss incidents annually by 2024. Fatalities and serious injuries were commonplace, with approximately 30 fatalities per year until recently. Despite efforts to improve safety, the issue persists, as evidenced by hundreds of collisions and thousands of near misses reported over the years. Similar challenges exist in the UK, EU, USA, and Canada, where large numbers of level crossings are associated with numerous collisions and fatalities.

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[5] Attempts to remove level crossings entirely are unrealistic due to the sheer volume of crossings and excessive costs for doing so.

[6] Current mitigation measures, whether passive (static signs) or active (flashing lights, boom gates), have inherent limitations such as high implementation costs, maintenance challenges in remote areas, and reliance on human compliance.

[7] Challenges with passive controls include their impracticality in remote areas lacking power infrastructure and the potential for drivers to miss warnings due to distractions or poor visibility.

[8] Active systems face issues such as drivers disregarding warnings, impaired visibility, and in-vehicle noise masking audible signals.

[9] Human error and distraction significantly contribute to the ineffectiveness of both passive and active controls. Factors such as delayed response times, distraction, and complacency increase the risk of incidents. The time taken for drivers to become aware of a situation and initiate corrective action, coupled with braking distances, underscores the need for proactive warning systems.

[10] Attempts at solutions are further hindered by the locations of the crossings spread out across large areas, power availability, maintenance costs, and human error, which can result in failing to provide timely warnings to drivers to enable swift decision-making and action to prevent collisions.

[11] Therefore, there is a pressing need for a more effective and reliable system to alert vehicle drivers to the presence of railway level crossings, irrespective of existing mitigation controls. This system must address challenges such as remote locations, power availability, maintenance costs, and human error, while facilitating timely warnings to drivers to enable swift decision-making and action to prevent collisions.

SUMMARY OF INVENTION

[12] In an aspect, the invention provides a driver warning system for railway level crossings, the system comprising:

a railway level crossing database including a railway crossing location data associated with railway level crossings in a road network;

a road vehicle warning assembly having visual and/or audible outputs;

a road vehicle tracking assembly located in a vehicle and in communication with the railway level crossing database and the road vehicle warning assembly, the road vehicle tracking assembly being arranged to:

repeatedly generate vehicle data including vehicle location data based on a location of the road vehicle as the road vehicle travels;

determine that the vehicle is approaching a railway level crossing from the vehicle location data;

determine warning commands to cause the road vehicle warning assembly to output visual and/or audible warnings within the vehicle; and

transmit the warning commands to the vehicle warning assembly.

[13] Preferably, the vehicle data and/or vehicle location data does not include a planned or pre-planned route of the vehicle. Preferably, the vehicle data and/or vehicle location data is limited to a current location of the road vehicle at a time of sampling.

[14] Preferably, the road vehicle tracking assembly is arranged to determine that the vehicle is approaching a railway level crossing from only the vehicle location data consisting of a current location or position of the vehicle.

[15] Preferably, the road vehicle tracking assembly is further configured to:

receive railway vehicle data including railway vehicle location data associated with each of one or more railway vehicles;

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determine the road vehicle and a railway vehicle of the one or more railway vehicles are approaching a railway level crossing;

determine further warning commands to cause the road vehicle warning assembly to output visual and/or audible warnings within the vehicle; and

transmit the further warning commands to the vehicle warning assembly.

[16] Preferably, the driver warning system further comprises a road vehicle control assembly configured to control the road vehicle in response to a control command from the road vehicle tracking assembly. Preferably, the road vehicle tracking assembly is further configured to:

repeatedly generate the vehicle data further including vehicle speed data associated with a speed of the road vehicle at each sampling of the vehicle location data;

determine that the vehicle approaching the railway level crossing will not stop before reaching the railway level crossing based on the vehicle data;

determine control commands to cause the road vehicle control assembly to control the vehicle; and

transmit the control commands to the road vehicle control assembly.

[17] Preferably, the control commands comprise braking, acceleration and/or deceleration commands.

[18] Preferably, the driver warning system further comprises trackside signal activated transmitter assemblies and/or trackside sensor assemblies arranged to generate the railway vehicle location data.

[19] Preferably, the trackside sensor assemblies are arranged to generate crossing control commands to cause visual and/or audio outputs at one or more warning devices located along a road approaching the railway level crossing.

[20] Preferably, the road vehicle is configured to respond to the braking, acceleration and/or deceleration commands through operation of propulsion systems and braking systems thereof.

[21] Preferably, the system further comprises one or more roadside signal assemblies (RSAs) positioned along a roadway approaching a railway level crossing, the RSAs configured to:

transmit a warning signal to the approaching road vehicle; and

the road vehicle tracking assembly of the road vehicle further configured to:

receive the warning signal from the RSA and determine, in combination with the vehicle location data and geofence, that the vehicle is approaching the railway level crossing, and

generate visual and/or audible warnings within the vehicle to alert the driver.

[22] Preferably, the RSA is configured to receive a wireless signal from the road vehicle tracking assembly indicating the vehicle's approach and, in response, activate visual roadside warning devices. The visual roadside warning devices comprise one or more of flashing lights and message displays.

[23] In another aspect, the invention provides a method for warning drivers approaching a railway level crossing in a road vehicle, the method comprising:

monitoring a location of a road vehicle as it travels along a road network;

determining that the vehicle is approaching a railway level crossing from the location of the road vehicle;

determining warning commands to cause visual and/or audible warnings within the vehicle; and

causing visual and/or audible warnings to be output within the vehicle.

[24] In an aspect, the invention provides a driver warning system for railway level crossings, the system comprising:

one or more roadside signal assemblies (RSAs) positioned along a roadway approaching a railway level crossing, the RSAs configured to transmit a warning signal to an approaching road vehicle;

a railway level crossing database including a railway crossing location data associated with railway level crossings in a road network;

a road vehicle comprising:

a road vehicle warning assembly having visual and/or audible outputs;

a road vehicle tracking assembly located in a vehicle and in communication with the railway level crossing database and the road vehicle warning assembly, the road vehicle tracking assembly being arranged to:

receive the warning signal from the RSA and determine that the vehicle is approaching the railway level crossing in response to receiving the warning signal;

determine warning commands to cause the road vehicle warning assembly to output visual and/or audible warnings within the vehicle; and

transmit the warning commands to the vehicle warning assembly.

BRIEF DESCRIPTION OF THE DRAWINGS

[25] Preferred features, embodiments and variations of the invention may be discerned from the following Detailed Description which provides sufficient information for those skilled in the art to perform the invention. The Detailed Description is not to

be regarded as limiting the scope of the preceding Summary of the Invention in any way. The Detailed Description will make reference to a number of drawings as follows:

Figure 1 depicts an embodiment of the driver warning system according to the present invention in use on a road network;

Figure 2 illustrates a block diagram of the driver warning system; and

Figure 3 illustrates the driver warning system shown in Figure 1 including geofences.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[26] Figures 1 to 3 illustrate a driver warning system 1 for railway level crossings. Embodiments of the invention provide a system that warns a driver as their vehicle approaches a railway level crossing based on the current location of the vehicle and its proximity to the railway level crossing at that time.

[27] Figure 1 depicts a portion of a road network 2 in the form of a public road network in which systems, methods and apparatus according to embodiments of the invention can be implemented.

[28] Road vehicles 4, such as cars, motorbikes and trucks, traverse the road network 2 and may encounter railway level crossings 6 at various points in their travels.

[29] Figure 2 depicts a driver warning system 1 according to an embodiment of the present invention that can detect a vehicle approaching a railway level crossing, irrespective of whether the crossing is “active” (i.e., rail vehicle on track approaching the crossing) or not, and alert the driver of the vehicle to the presence of the approaching railway level crossing.

[30] The system 1 may include a railway level crossing database 8, a road vehicle warning assembly 10 and a road vehicle tracking assembly 12.

[31] The railway level crossing database 8 may include railway crossing location data 14 associated with railway level crossings 6 in the road network 2. As such, the railway level crossing database 8 may store the locations of multiple railway level crossings 6 in the road network 2 in the form of GPS coordinates.

[32] The railway level crossing database 8 may be either located in the vehicle 4 (as shown in Figure 2) or located remotely (as shown in Figure 1) and is wirelessly accessible through a cloud interface via GSM or other communication protocol.

[33] The railway level crossing database 8 is an electronic database configured to interface with the road vehicle tracking assembly12 to allow the road vehicle tracking assembly 12 to obtain coordinates of railway level crossings 6.

[34] The road vehicle warning assembly 10 is located within the vehicle 4 and is arranged to output visual and/or audible outputs in response to receiving warning commands 16 from the road vehicle tracking assembly 12, which will be described in greater detail below.

[35] The road vehicle warning assembly 10 may include a dedicated display 18 and/or speaker 20 for providing the outputs. Alternatively, the road vehicle warning assembly 10 may be integrated with the vehicle 4 and vehicle instruments 22 to allow the road vehicle warning assembly 10 to control displays and/our speakers pre-installed (e.g., OEM) in the vehicle 4 to enable the warning outputs to be provided. For example, the road vehicle warning assembly 10 may be connected to an OBD-II (On-Board Diagnostics II) connector of the vehicle or to an onboard vehicle computer 21.

[36] The road vehicle tracking assembly 12 is located in a vehicle 4 and is in communication with the railway level crossing database 8 and the road vehicle

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warning assembly 10. The communication between the road vehicle tracking assembly 12 and the railway level crossing database 8 and road vehicle warning assembly 10 is such that data and commands can be received and transmitted between the assemblies.

[37] The road vehicle tracking assembly 12 repeatedly generates vehicle data 24 including vehicle location data 26 based on a location of the road vehicle 4 as the road vehicle 4 travels along the road network 2.

[38] The vehicle data 24 may be generated or retrieved from a number of sources and devices. For example, the vehicle location data 26 is generated from a location tracking system, such as a Global Positioning System (GPS) receiver which communicates with a GPS satellite network 28 and is configured to generate information about the time varying position, orientation and speed of the vehicle 4.

[39] The location tracking system may also, either additionally or alternatively, triangulate a location estimate from terrestrial transmitters such as wireless transceivers. The location tracking system may also include gyroscopes or other inertial navigation apparatus that can also be used to generate signals indicating the location of the vehicle within the road network and to ascertain the vehicles orientation, velocity and acceleration.

[40] The vehicle 4 may also include a sensor assembly 39 which may include sensors for gauging the weight of a load being hauled, brake condition, steering angle, wheel rotation speed, fuel level, engine temperature, tyre pressure, driver fatigue and radar and/or LiDAR sensors for estimating obstacle proximity.

[41] The vehicle data 24 may also include a vehicle identification number or other identification.

[42] The road vehicle tracking assembly 12 may also determine that the vehicle 4 is approaching a railway level crossing 6 from the vehicle location data 26. In an embodiment where the railway level crossing database 8 is remotely located from the vehicle 4, the road vehicle tracking assembly 12 will wirelessly access and retrieve the railway crossing location data 14 from the railway level crossing database 8.

[43] In determining whether the road vehicle 4 is approaching a railway level crossing 6, the vehicle data 24 and/or vehicle location data 26 may not include a planned or pre-planned route of the vehicle. That is, the vehicle data 24 and/or vehicle location data 26 may be limited to a current location of the road vehicle at a time of sampling (i.e., at each time the current location of the road vehicle is determined). In other words, the vehicle data 24 and/or vehicle location data 26 may be timestamped.

[44] In some embodiments, the road vehicle tracking assembly 12 may be arranged to determine that the vehicle 4 is approaching a railway level crossing 6 from only the vehicle location data 26 consisting of a current location or position of the vehicle. The current location or position of the vehicle takes the form of GPS coordinate data as described above.

[45] In some embodiments, determining whether the road vehicle 4 is approaching a railway level crossing 6 may be provided by one or more geofences associated with each railway level crossing 6. An example of this is shown in Figure 3. A first geofence is indicated by dashed box 29. A first geofence is indicated by dashed box 30. Each time the road vehicle 4 enters the area of one of the geofences, a warning command is provided to the vehicle warning assembly 12 by the vehicle tracking assembly 10. As an example, when the road vehicle 4 crossing the boundary of the first geofence 29, a warning is generated in the road vehicle 4 in accordance with procedures set out herein. In this example, the driver may not react to the warning and continues travelling

toward the railway level crossing 6 and crosses the boundary of the second geofence 30 a short time later. When the road vehicle 4 crossing the boundary of the second geofence 30, a warning is generated in the road vehicle 4 in accordance with procedures set out herein.

[46] In some embodiments, determining whether the road vehicle 4 is approaching a railway level crossing 6 may be achieved by calculating a distance between the vehicle 4 and the railway level crossing 6 and comparing the distance to a threshold value. If the distance is less than the threshold value, it may be determined that the vehicle 4 is approaching the railway level crossing 6.

[47] Other methods for determining the vehicle 4 approaching a railway level crossing 6 will be readily determined by a person skilled in the art.

[48] The road vehicle tracking assembly 12 may also determine warning commands 16 to cause the road vehicle warning assembly 10 to output visual and/or audible warnings within the vehicle 4. The warning commands 16 may be generated in response to a determination of the road vehicle 4 approaching a railway level crossing 6.

[49] The road vehicle tracking assembly 12 may then transmit the warning commands 16 to the road vehicle warning assembly 10.

[50] The warning commands 16 may be timestamped. Furthermore, a timestamp may be generated at a time the warning command 16 is received at the road vehicle warning assembly 10. In some embodiments, a location (e.g., GPS coordinates) of the road vehicle 4 may be recorded at the time the warning commands 16 are received at the road vehicle warning assembly 10.

[51] In response to receiving the warning commands 16, the road vehicle warning assembly 10 may then cause one or more audible and/or visual outputs to be provided

within the vehicle 4 to gain the attention of the driver and alert said driver to their approach to a railway level crossing.

[52] In some embodiments, the road vehicle tracking assembly 12 may be arranged to detect and record driver action that results in changes to the vehicle 4 (e.g., braking to slow the vehicle down).

[53] The road vehicle tracking assembly 12 and road vehicle warning assembly 10 may each take the form of a computer system that may include a processor for executing the functions of devices and actions described herein, which may be provided by hardware or by software. The software may be stored in a memory component and instructions may be provided to the processor to carry out the functionality of the assembly. In some cases, for example in a cloud computing implementation, software arranged to manage and/or process data on behalf of the assembly may be provided remotely.

[54] In some embodiments, the driver warning system 1 may further comprise trackside signal activated transmitter assemblies 32 and/or trackside sensor assemblies 34 arranged to generate railway vehicle data including railway vehicle location data 36. The trackside sensor assemblies 34 include trackside signal switches and sensors that become active when a railway vehicle 38, such as a train, for example, passes over a certain section of the rail network 40 connected to or being monitored by the trackside sensor assembly 34. That is, the trackside sensor assembly 34 is arranged to generate an active signal in response to detection of a railway vehicle 38 on the track. More specifically, the trackside sensor assembly 34 may be arranged to generate an active signal in response to detection of a railway vehicle on the track approaching the railway level crossing.

[55] The trackside sensor assemblies 34 may be existing sensors or switches connected to the rail network 40 used to traditionally activate boomgates, sirens and lights, for example.

[56] The trackside sensor assemblies 34 may also be in communication with lights 42 and/or gates 44 (such as boom gates, for example) located at the railway level crossing 6 that are arranged to activate in response to the detection of the railway vehicle 38 on the track as the railway vehicle 38 approaches the railway level crossing 6.

[57] The trackside signal activated transmitter assemblies 32 are in electronic communication with the trackside sensor assembly 34 and arranged to receive the active signal from the trackside sensor assembly 34 and transmit the active signal or an indication/notification of the active signal to the road vehicle tracking assembly 12.

[58] The active signal may be timestamped.

[59] In some embodiments, the road vehicle tracking assembly 12 may be further configured to receive railway vehicle data including railway vehicle location data 36 associated with each of one or more railway vehicles. The railway vehicle location data 36 may be based on or determined from a location of the trackside sensor assembly 34 activated by the railway vehicle.

[60] The railway vehicle data may be timestamped. The railway vehicle data may also include an identification number or other form of identification associated with the railway vehicle.

[61] In some embodiments, a location (e.g., GPS coordinates) of the road vehicle may be recorded at the time the railway vehicle data is received at the road vehicle tracking assembly.

[62] In response to receiving the railway vehicle data 36 and/or the active signal, the road vehicle tracking assembly 12 may be arranged to determine the road vehicle 4 and a railway vehicle of the one or more railway vehicles 38 are approaching a railway level crossing 6. In particular, the road vehicle 4 and the railway vehicle of the one or more railway vehicles 38 may be approaching the same railway level crossing 6. This determination may be achieved in a number of ways, including by comparing the vehicle location data to the railway vehicle location, for example.

[63] The road vehicle tracking assembly 12 may then determine further warning commands to cause the road vehicle warning assembly 10 to output visual and/or audible warnings within the vehicle. These outputs may be in addition to any outputs already provided or that may be provided in response to the warning commands generated in response to approaching the railway level crossing.

[64] The road vehicle tracking assembly 12 may then transmit the further warning commands to the vehicle warning assembly 10 to cause the vehicle warning assembly 10 to output visual and/or audible outputs within the vehicle 4 to alert the driver.

[65] In some embodiments, the driver warning system may further comprise a road vehicle control assembly 46 configured to the control the road vehicle 4 in response to a control command 48 from the road vehicle tracking assembly 12.

[66] The road vehicle control assembly 46 may be integrated with or connected to the vehicle and vehicle instruments to allow the road vehicle warning assembly to control the vehicle. For example, the road vehicle control assembly 46 may be connected to the onboard vehicle computer 22.

[67] Although described separately, the road vehicle control assembly 46 and road vehicle warning assembly 10 could be combined into a single assembly arranged to process the commands received from the road vehicle tracking assembly 12.

[68] The road vehicle control assembly 46 may be arranged to control the vehicle 4 in response to control commands 48 received from the road vehicle tracking assembly 12.

[69] In order to generate the control commands 48, the road vehicle tracking assembly 12 may be further configured to repeatedly generate the vehicle data 24 further including vehicle speed data associated with a speed of the road vehicle 4 at each sampling/time of the vehicle location data.

[70] The road vehicle tracking assembly 12 may then be configured to determine that the vehicle 4 approaching the railway level crossing 6 will not stop, or is unlikely to stop, before reaching the railway level crossing 6 based on the vehicle data 24. For example, based on the speed of the road vehicle 4, the road vehicle tracking assembly 12 may determine that the road vehicle 4 is unlikely or unable to stop before crossing the railway level crossing 6.

[71] In response to the above determination, the road vehicle tracking assembly 12 may determine control commands 48 to cause the road vehicle control assembly 46 to control the vehicle 4, and transmit the control commands 48 to the road vehicle control assembly 12 to cause the road vehicle 4 to be controlled.

[72] The control commands 48 may include acceleration, deceleration and/or braking commands the cause the road vehicle control assembly 46 to control the vehicle 4 to accelerate, decelerate and/or brake. That is, the road vehicle 4 is configured to respond to the control commands 48 through operation of propulsion systems and braking systems thereof.

[73] The road vehicle control assembly 12 may take the form of a computer system that may include a processor for executing the functions of devices and actions described herein, which may be provided by hardware or by software. The software

may be stored in a memory component and instructions may be provided to the processor to carry out the functionality of the assembly. In some cases, for example in a cloud computing implementation, software arranged to manage and/or process data on behalf of the assembly may be provided remotely.

[74] In some embodiments, a method for warning drivers approaching a railway level crossing in a road vehicle is provided.

[75] The method may include monitoring a location of a road vehicle as it travels along a road network. The method may further include determining that the vehicle is approaching a railway level crossing from the location of the road vehicle and determining warning commands to cause visual and/or audible warnings within the vehicle. The method may also include causing visual and/or audible warnings to be output within the vehicle.

[76] In some embodiments, the trackside signal activated transmitter assemblies 32 are arranged to generate crossing control commands to cause visual and/or audio outputs at one or more roadside warning devices (or warning devices) located along a road approaching the railway level crossing. An example can be seen in Figure 1 showing flashing lights 50 positioned alongside a portion of the road network 2 approaching the railway level crossing 6.

[77] In some embodiments, the driver warning system may further comprise a roadside signal assembly (RSA) configured to communicate with a vehicle-mounted warning assembly. The RSA may be positioned along a roadway leading to a railway level crossing and may include a transmission assembly arranged to send warning signals to approaching vehicles. The RSA may also be in communication with trackside sensors or railway network systems to detect an approaching train and activate visual or audible warnings accordingly. The warning signals may be received

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by the road vehicle tracking assembly and processed to generate in-cabin alerts, ensuring that the driver is aware of an active railway level crossing ahead.

[78] In some embodiments, the RSA may be configured to receive a signal from the road vehicle tracking assembly, wherein the vehicle transmits its approach to the railway level crossing, thereby triggering activation of roadside warning devices, such as flashing lights, message displays, or sirens. In some embodiments, the RSA may be powered by solar energy or a dedicated power supply to ensure continuous operation in remote locations.

[79] In one embodiment, the invention provides a driver warning system for railway level crossings, comprising one or more roadside signal assemblies (RSAs) positioned along a roadway approaching a railway level crossing, the RSAs being configured to transmit a warning signal to an approaching road vehicle. The system further includes a railway level crossing database storing railway crossing location data associated with railway level crossings in a road network. A road vehicle within the system comprises a road vehicle warning assembly having visual and/or audible outputs and a road vehicle tracking assembly located in the vehicle. The road vehicle tracking assembly is in communication with both the railway level crossing database and the road vehicle warning assembly and is arranged to receive the warning signal from the RSA and, in response, determine that the vehicle is approaching the railway level crossing. Upon making this determination, the road vehicle tracking assembly generates warning commands to activate the road vehicle warning assembly, causing it to output visual and/or audible warnings within the vehicle to alert the driver. The road vehicle tracking assembly then transmits the warning commands to the road vehicle warning assembly to execute the warning output.

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[80] One technical problem addressed by some embodiments of the disclosure is to provide a proactive, reliable, and cost-effective solution to mitigate collisions at railway level crossings. Embodiments of the system aim to enhance situational awareness for drivers by delivering audible and visual alerts as the vehicle approaches railway crossings, regardless of whether passive or active warning systems are in place. By leveraging GPS technology and comparison algorithms, embodiments of the disclosure can provide real-time warnings without requiring pre-route planning or human intervention. Additionally, the system can potentially integrate with telematics for remote monitoring and data transmission, and even trigger vehicle deceleration or emergency braking if warnings are ignored.

[81] Furthermore, embodiments of the disclosure seek to address the shortcomings of existing mitigation systems by offering a standalone device with minimal ongoing costs, reliable GPS coverage, and the potential for integration with other safety technologies. The Inventor envisions that embodiments of the disclosure may significantly reduce the occurrence of railway level crossing incidents, thereby saving lives, reducing infrastructure damage, and minimizing traffic disruptions.

[82] In compliance with the statute, the invention has been described in language more or less specific to structural or methodical features. The term “comprises” and its variations, such as “comprising” and “comprised of” is used throughout in an inclusive sense and not to the exclusion of any additional features.

[83] It is to be understood that the invention is not limited to specific features shown or described since the means herein described comprises preferred forms of putting the invention into effect.

[84] The invention is, therefore, claimed in any of its forms or modifications within the proper scope of the appended claims appropriately interpreted by those skilled in the art.

CLAIMS

1. A driver warning system for railway level crossings, the system comprising:

a railway level crossing database including a railway crossing location data associated with railway level crossings in a road network;

a road vehicle warning assembly having visual and/or audible outputs;

a road vehicle tracking assembly located in a vehicle and in communication with the railway level crossing database and the road vehicle warning assembly, the road vehicle tracking assembly being arranged to:

repeatedly generate vehicle data including vehicle location data based on a location of the road vehicle as the road vehicle travels;

determine that the vehicle is approaching a railway level crossing from the vehicle location data and a geofence associated with the railway level crossing, wherein the vehicle data and/or vehicle location data does not include a planned or pre-planned route of the vehicle and the vehicle data and/or vehicle location data consists of a current location of the road vehicle at a time of sampling;

determine warning commands to cause the road vehicle warning assembly to output visual and/or audible warnings within the vehicle; and

transmit the warning commands to the vehicle warning assembly; and

a road vehicle control assembly configured to control the road vehicle in response to a control command from the road vehicle tracking assembly, wherein

the road vehicle tracking assembly is further configured to:

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repeatedly generate the vehicle data further including vehicle speed data associated with a speed of the road vehicle at each sampling of the vehicle location data;

determine that the vehicle approaching the railway level crossing will not stop before reaching the railway level crossing based on the vehicle data;

determine control commands to cause the road vehicle control assembly to control the vehicle;

transmit the control commands to the road vehicle control assembly, wherein the control commands comprise braking, acceleration and/or deceleration commands and road vehicle is configured to respond to the braking, acceleration and/or deceleration commands through operation of propulsion systems and braking systems thereof; and

transmit a signal to activate one or more warning devices located along a road approaching the railway level crossing in response to the road vehicle approaching the railway level crossing.

2. The driver warning system of claim 1, wherein the road vehicle tracking assembly is further configured to:

receive railway vehicle data including railway vehicle location data associated with each of one or more railway vehicles;

determine the road vehicle and a railway vehicle of the one or more railway vehicles are approaching a railway level crossing;

determine further warning commands to cause the road vehicle warning assembly to output visual and/or audible warnings within the vehicle; and

transmit the further warning commands to the vehicle warning assembly.

3. The driver warning system of claim 1 or claim 2, wherein the driver warning system further comprises trackside signal activated transmitter assemblies and/or trackside sensor assemblies arranged to generate the railway vehicle location data.

4. The driver warning system of claim 3, wherein the trackside sensor assemblies are arranged to generate crossing control commands to cause visual and/or audio outputs at one or more warning devices located along a road approaching the railway level crossing.

5. A method for warning drivers approaching a railway level crossing in a road vehicle, the method comprising:

monitoring a location of a road vehicle as it travels along a road network;

determining that the vehicle is approaching a railway level crossing from the location of the road vehicle and a geofence associated with the railway level crossing, wherein the vehicle data and/or vehicle location data does not include a planned or pre-planned route of the vehicle and the vehicle data and/or vehicle location data consists of a current location of the road vehicle at a time of sampling;

determining warning commands to cause visual and/or audible warnings within the vehicle;

causing visual and/or audible warnings to be output within the vehicle;

continuously monitoring a speed of the road vehicle at each sampling of the location of the road vehicle;

determining that the vehicle approaching the railway level crossing will not stop before reaching the railway level crossing based on the speed and location of the road vehicle;

determining control commands to control the road vehicle;

controlling the road vehicle based on the control commands; and

controlling one or more warning devices located along a road approaching the railway level crossing in response to the road vehicle approaching the railway level crossing.

6. The method of claim 5, including generating crossing control commands to cause visual and/or audio outputs at the one or more warning devices located along the road approaching the railway level crossing.

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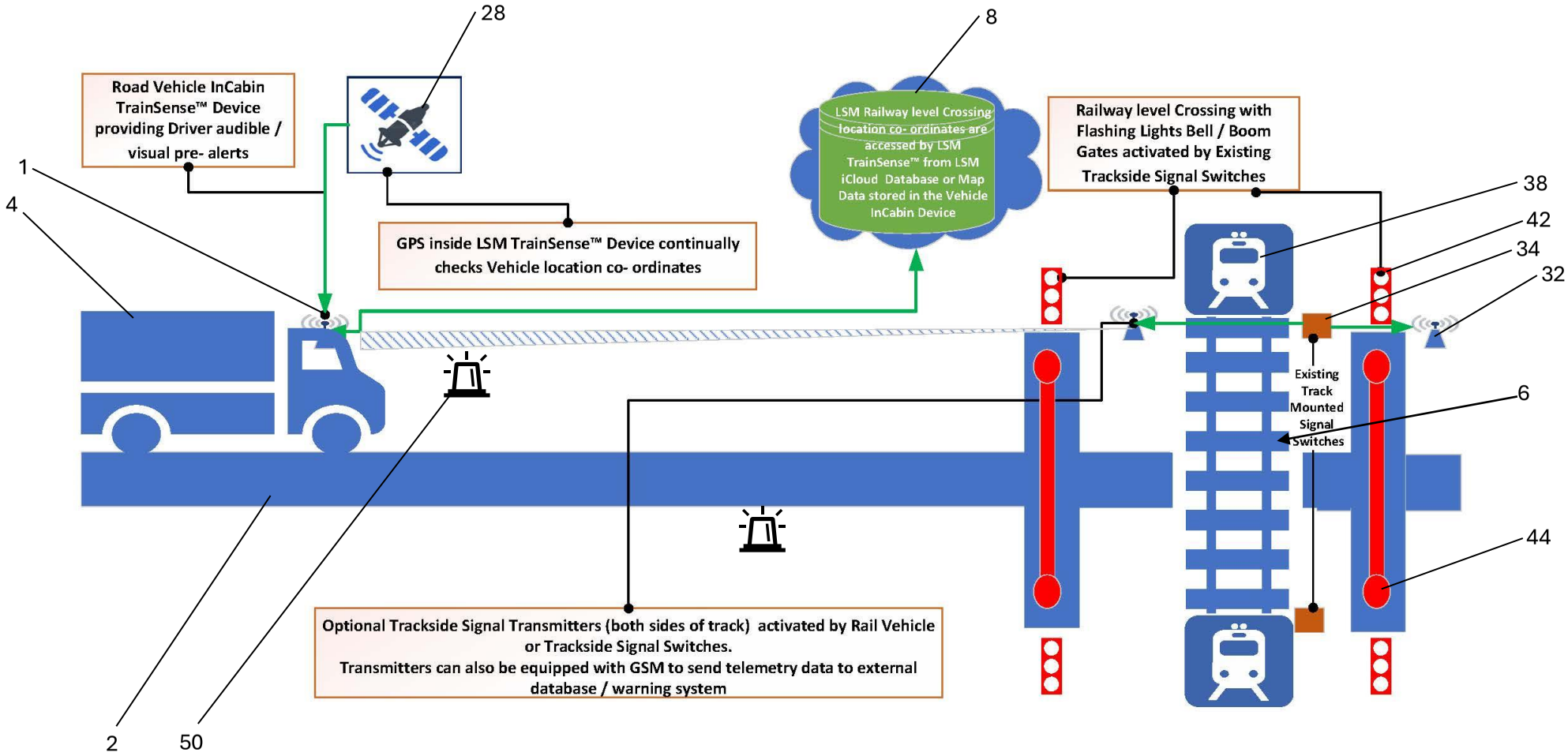

FIGURE 1

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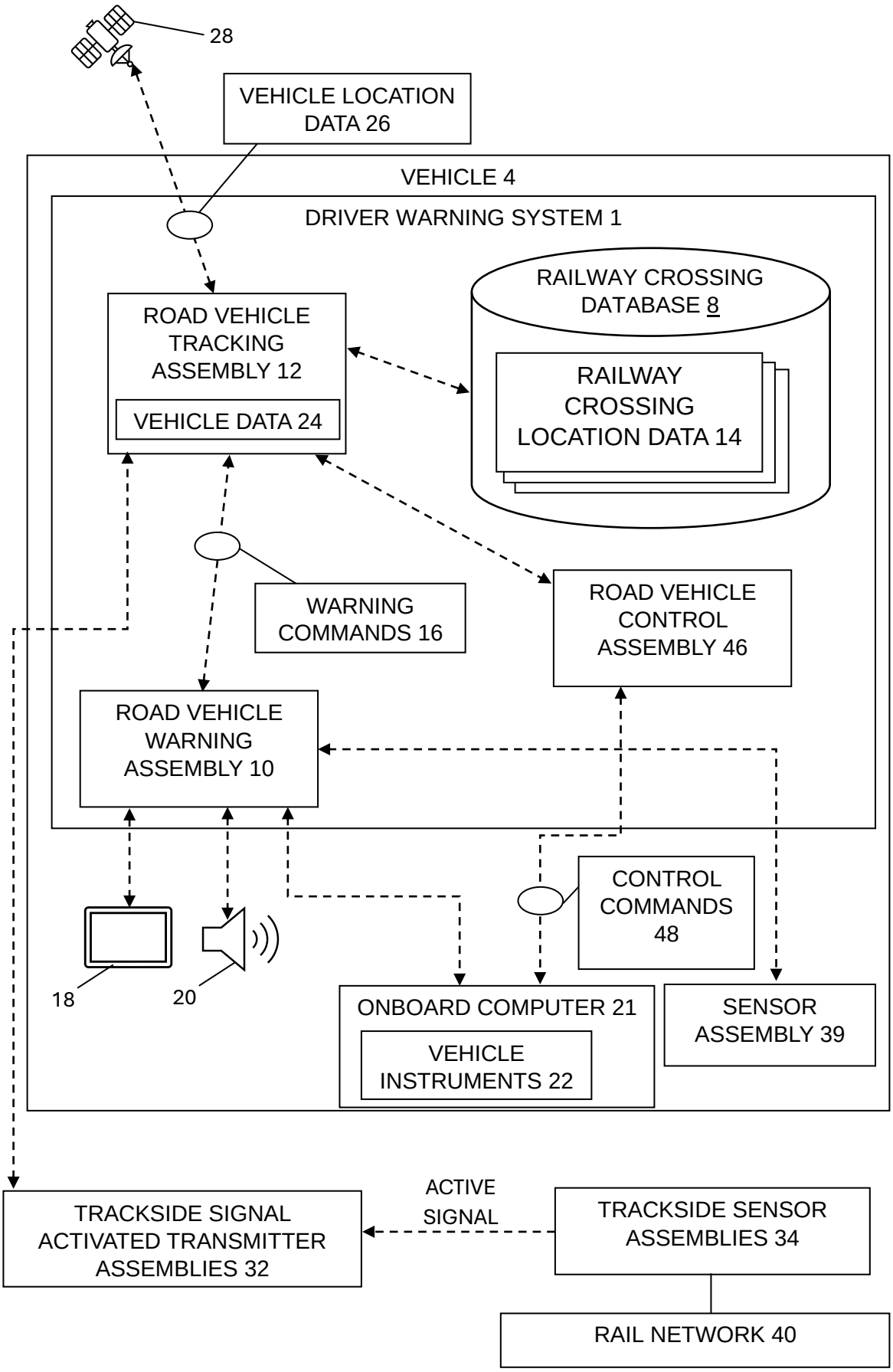

FIGURE 2

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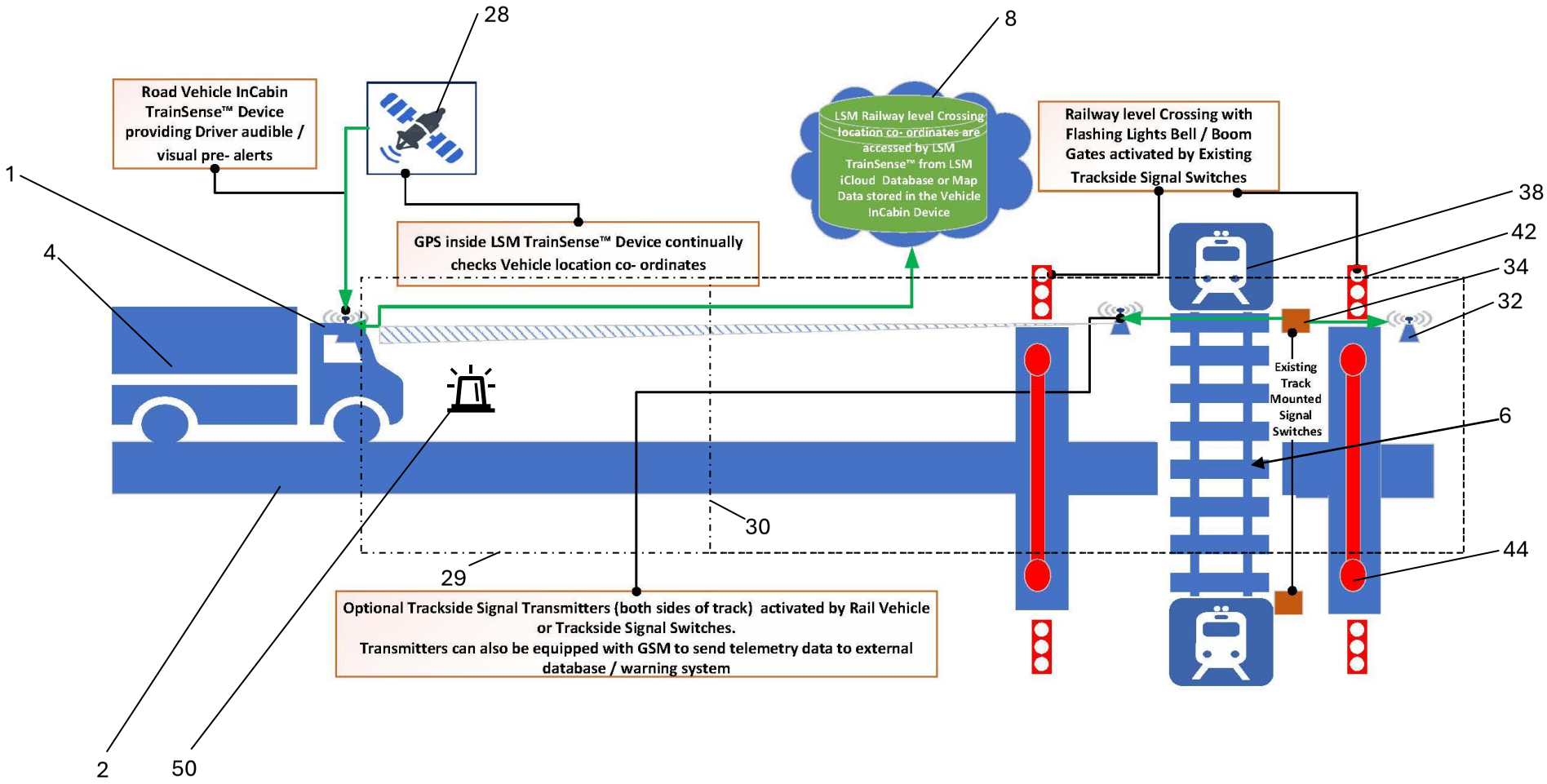

FIGURE 3