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(54) **Title**: DETERMINING VEHICLE LENGTH IN A ROAD TRAIN

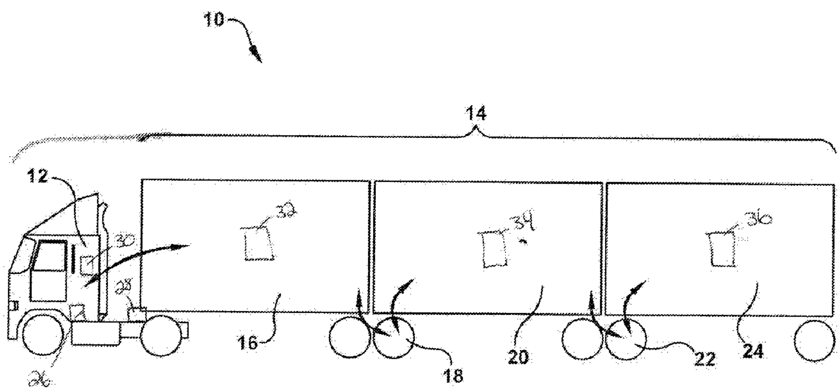

Fig. 1

(57) **Abstract**: A system for determining the length of a road train includes controllers on both towing and towed vehicles. Each controller may transmit a vehicle length and GPS coordinates in a specified wireless message format. The towing vehicle controller receives a first wireless message from the towed vehicle controller. The wireless message includes at least one of a speed of the towed vehicle, a length of the towed vehicle and GPS coordinates of the towed vehicle. The towing vehicle controller determines if the towed vehicle transmitting the message is coupled to the towing vehicle and then adds the length of the towed vehicle to the length of the towing vehicle to attain an overall length of the road train in response to the determination that the towed vehicle transmitting the wireless message is coupled to the towing vehicle. The towing vehicle controller then transmits the overall length of the road train.

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DETERMINING VEHICLE LENGTH IN A ROAD TRAIN

Background

[0001] The present invention relates to embodiments of a controller and a method for determining vehicle length in a road train. Increasingly, vehicles are being equipped with Vehicle to Vehicle (V2V) communication capabilities to improve a driver's awareness of the other vehicles sharing the same roadway. A basic message transmitted by a vehicle using V2V communication may include the type of vehicle, the computed mass of the vehicle and the length of the vehicle. This information can be used for collision mitigation by the vehicle receiving the message. In the instance of a commercial tractor trailer, or "road train," the length of the vehicle can vary as trailers are added or removed. Individual trailer length can vary from about twenty five (25) feet to about sixty (60) feet, while a tractor length can vary from about eight (8) feet to about twenty two (22) feet. Therefore, to establish the overall length of the road train, each tractor must know to what trailers(s) it is connected. Additionally, when a tractor knows the number of trailers attached to it, the tractor safety systems can use the information for features such as stability control, since the parameters can be adjusted to improve performance for the size of the vehicle. Therefore, there is a need for a tractor to be able to accurately determine the entire length and mass of a tractor trailer combination vehicle and transmit this information to other vehicles on the roadway.

Summary

[0002] Various examples of an apparatus for determining the length of a road train comprise a processor having control logic. The control logic is capable of receiving a message at a towing vehicle from at least one towed vehicle transmitter, the message comprising at least one of a GPS coordinate of the towed vehicle, a length of the towed vehicle, a speed of the towed vehicle and a heading of the towed vehicle. The control logic is also capable of determining if the at least one towed vehicle is coupled to a towing vehicle

and determining the overall length of the road train based on adding the length of the towed vehicle to the length of the towing vehicle in response to determining the at least one towed vehicle is coupled to the towing vehicle. The control logic is further capable of transmitting a message comprising the length of the road train and at least one of a GPS coordinate of the towing vehicle and the heading of the road train.

[0003] Various examples of a controller on a host vehicle for determining a length of a road train comprise a wireless port for transmitting and receiving wireless messages; an input for receiving a speed of the host vehicle; a global positioning system (GPS) receiver; and control logic. The control logic has a memory programmed with the length of the host vehicle and is capable of receiving a first wireless message from an other vehicle at the wireless port subsequent to the host vehicle speed being greater than a predetermined speed. The wireless message includes at least a speed of the other vehicle, a length of the other vehicle and GPS coordinates associated with the other vehicle. The control logic is capable of determining if the other vehicle is coupled to the host vehicle; adding the length of the other vehicle to the length of the host vehicle to attain an overall length of the road train in response to the other vehicle being coupled to the host vehicle; and transmitting the overall length of the road train and at least one of the GPS coordinates associated with the host vehicle and the heading of the host vehicle.

[0004] Various examples of a method of determining a length of a road train comprise receiving a host vehicle speed and receiving a first wireless message from a first vehicle subsequent to the host vehicle speed being greater than a predetermined speed. The wireless message includes at least a speed of the first vehicle, a length of the first vehicle, a heading of the first vehicle and GPS coordinates associated with the first vehicle. The method also comprises determining if the first vehicle is coupled to the host vehicle and adding the length of the first vehicle to the length of the host vehicle to attain an overall length of the road train in response to the first trailer being coupled to the tractor.

[0005] Various examples of a system for determining the length of a road train includes a plurality of transmitters for transmitting messages and a tractor controller. The tractor controller has a GPS receiver and capable of receiving the messages from each transmitter. The tractor controller is capable of receiving a tractor speed; receiving a first message from a first transmitter subsequent to the tractor speed being greater than a predetermined speed, the first message including at least a speed of the vehicle on which the first transmitter is located, a length of the vehicle and GPS coordinates associated with the vehicle; and comparing the speed in the first message to the speed of the tractor. The tractor controller is further capable of adding the length of the first vehicle to the length of the tractor to attain an overall length of the road train in response to the speed information in the first message being equivalent to the speed of the tractor; and transmitting the overall length of the road train and GPS coordinates associated with the tractor.

Brief Description of the Drawings

[0006] In the accompanying drawings which are incorporated in and constitute a part of the specification, embodiments of the invention are illustrated, which, together with a general description of the invention given above, and the detailed description given below, serve to exemplify the embodiments of this invention.

[0007] **FIGURE 1** illustrates a road train incorporating a system according to an example of this invention.

[0008] **FIGURE 2** illustrates a tractor controller according to an example of this invention.

[0009] **FIGURE 3** illustrates a flow chart for a method of determining the length of a road train according to an example of this invention.

[0010] **FIGURE 4** illustrates a flow chart for a method of determining the length of a road train according to another example of this invention.

Detailed Description

[0011] **FIGURE 1** illustrates a system **10** according to one example of the invention. The system **10** comprises a road train **14**. The road train **14** shown in Figure 1 includes a towing vehicle, such as tractor **12**. The tractor **12** is electrically and pneumatically coupled to a towed vehicle, such as a first trailer **16**. A first dolly **18** electronically and pneumatically couples the first trailer **16** to another towed vehicle, such as a second trailer **20**. A second dolly **22** electronically and pneumatically couples the second trailer **20** to another towed vehicle, such as a third trailer **24**. The number of towed vehicles in the road train **14** may change frequently based on the needs of the vehicle operator and local transportation regulations. The tractor **12** may be considered a “host vehicle” for the purposes of this invention. The trailers **16, 20, 24** may be considered “other vehicles” for the purposes of this invention. In addition, a “towing vehicle” may be a passenger car while the “towed vehicle” may be a storage trailer.

[0012] Each vehicle in the road train **14** is equipped with a controller capable of wireless communication. Tractor **12** includes a tractor controller **30**. The tractor **12** also includes a braking controller **26** for controlling anti-lock and stability control functions on the tractor **12.** The braking controller **26** communicates with the tractor controller **30** over a vehicle communications bus (not shown) or wirelessly. The tractor **12** may also include a weight measurement device **28**. The weight measurement device **28** may be a pressure sensor located in the air suspension of the tractor **12** to estimate the combined vehicle weight of the road train **14**. The weight measurement device **28** communicates with the braking controller **26.** The combined vehicle weight may also be determined through the engine torque or other means.

[0013] The first trailer **16** includes a trailer controller **32**, the second trailer **20** includes a trailer controller **34** and the third trailer **24** includes a trailer controller **36**. Each dolly **18, 22** may also be equipped with a dolly controller (not shown). The tractor controller **30** and trailer controllers **32, 34, 36** may be equipped to facilitate Vehicle to Vehicle (V2V) communication among each controller and/or with other vehicles on the same roadway that are also equipped for V2V communication. Alternatively, the tractor controller **30** may communicate with the trailer controllers **32, 34, 36** through a wired communications bus, such as SAE J2497 Power Line Carrier Communications or other protocol.

[0014] For each trailer **16, 20, 24** the trailer controllers **32, 34, 36** may be affixed to any location on the trailer body. When each trailer **16, 20, 24** is a box trailer, the trailer controllers **32, 34, 36** may be affixed to the middle of the trailer body. Locating the trailer controllers **32, 34, 36** in nearly identical locations on each trailer is not required to determine trailer length and overall road train length, as will be explained.

[0015] **FIGURE 2** illustrates the tractor controller **30** according to an example of this invention. Tractor controller **30** comprises a communications port **42** for receiving and transmitting information from the vehicle communications bus on the tractor **12**. The tractor controller **30** comprises an antenna port **40** for receiving and transmitting wireless messages using antenna **41**. The tractor controller **30** comprises a global positioning system (GPS) receiver **44** for receiving position information of the tractor **12** using the GPS protocol.

[0016] The tractor controller **30** includes a processor **45** with control logic **46** for receiving and transmitting the wireless messages at the antenna port **40** and receiving and transmitting communications bus messages at the communications port **42**. The control logic **46** may include a memory **48**, which may be a volatile, non-volatile memory, solid state memory, flash memory, random-access memory (RAM), read-only memory (ROM), electronic erasable programmable read-only memory (EEPROM), variants of the foregoing memory types, combinations thereof, and/or any other type(s) of memory suitable for providing the described functionality and/or storing computer-executable instructions for execution by the control logic **46**. The memory **48** may be preprogrammed with the length of the tractor **12**. The processor **45** may also include a timer.

[0017] Some information received at the communications port **42** includes the host vehicle speed, host vehicle weight and diagnostic messages. Some information transmitted at the communications port **42** includes GPS coordinates and the overall length of the road train **14.** The bus messages may be formatted in the SAE J1939 protocol or another protocol. The GPS receiver **44** receives coordinate information for the tractor **12**. Some information transmitted at the antenna port **40** includes the coordinates as received by the GPS receiver **44**, the length of the road train **14** and the heading of the road train **14**. The wireless messages may be formatted in the SAE J2945 Dedicated Short Range Communications (DSRC) protocol or another protocol, such as Bluetooth, ZigBee or Wi-Fi. DSRC is a two-way short to medium range wireless communications capability that permits high data transmissions in vehicle applications. The transmission rate on the antenna port **40** may be about one hundred (100) milliseconds.

[0018] The trailer controllers **32, 34, 36** may be similar in construction and operation to the tractor controller **30**. The trailer controllers **32, 34, 36** include communications ports and wireless ports. The trailer controllers **32, 34, 36** include processors having control logic with memory and may be preprogrammed with the length of the trailer **16, 20, 24**. However the wireless transmission rate of the trailer controllers **32, 34, 36** may be slower than the transmission rate of the tractor controller **30,** such as about one (1) second. In another example, the wireless transmission of the trailer controllers **32, 34, 36** may occur at the time when the seconds as measured by the GPS change from 59 to 00.

[0019] Therefore, various examples of an apparatus for determining the length of a road train comprise a processor having control logic. The control logic is capable of receiving a message at a towing vehicle from at least one towed vehicle transmitter, the message comprising at least one of a GPS coordinate of the towed vehicle, a length of the towed vehicle, a speed of the towed vehicle and a heading of the towed vehicle. The control logic is also capable of determining if the at least one towed vehicle is coupled to a towing vehicle and determining the overall length of the road train based on adding the length of the towed vehicle to the length of the towing vehicle in response to determining the at least one towed vehicle is coupled to the towing vehicle. The control logic is further capable of transmitting a message comprising the length of the road train and at least one of a GPS coordinate of the towing vehicle and the heading of the road train.

[0020] Furthermore, various examples of a controller on a host vehicle for determining a length of a road train comprise a wireless port for transmitting and receiving wireless messages; an input for receiving a speed of the host vehicle; a global positioning system (GPS) receiver; and control logic. The control logic has a memory programmed with the length of the host vehicle and is capable of receiving a first wireless message from an other vehicle at the wireless port subsequent to the host vehicle speed being greater than a predetermined speed. The wireless message includes at least a speed of the other vehicle, a length of the other vehicle and GPS coordinates associated with the other vehicle. The control logic is capable of determining if the other vehicle is coupled to the host vehicle; adding the length of the other vehicle to the length of the host vehicle to attain an overall length of the road train in response to the other vehicle being coupled to the host vehicle; and transmitting the overall length of the road train and at least one of the GPS coordinates associated with the host vehicle and the heading of the host vehicle.

[0021] Additionally, various examples of a system for determining the length of a road train include a plurality of transmitters for transmitting messages and a tractor controller. The tractor controller has a GPS receiver and capable of receiving the messages from each transmitter. The tractor controller is capable of receiving a tractor speed; receiving a first message from a first transmitter subsequent to the tractor speed being greater than a predetermined speed, the first message including at least a speed of the vehicle on which the first transmitter is located, a length of the vehicle and GPS coordinates associated with the vehicle; and comparing the speed in the first message to the speed of the tractor. The tractor controller is further capable of adding the length of the first vehicle to the length of the tractor to attain an overall length of the road train in response to the speed information in the first message being equivalent to the speed of the tractor; and transmitting the overall length of the road train and GPS coordinates associated with the tractor.

[0022] **FIGURE 3** illustrates a method **50** of determining the length of a road train according to an example of this invention. In step **52**, the tractor controller **30** is powered up. In step **54**, the speed of the tractor **12** is compared to a threshold speed. In one example, the threshold speed is between about five (5) miles per hour and about fifteen (15) miles per hour. The threshold speed is set at a point where the speed of the tractor **12** can be reliably attained by the components on the tractor **12**, such as wheel speed sensors. In addition, the tractor **12** and any trailers that may be coupled to the tractor **12** would more likely be spaced longitudinally from each other when above the threshold speed. If the speed is equal to or less than a threshold speed, the method **50** remains at step **54**. If the speed is greater than the threshold speed, the method **50** continues to step **56**.

[0023] In step **56**, a timer in the processor **45** is started. In one example, the timer can be synchronized with ignition power on or with the receipt of the first wireless message by the control logic **46**.

[0024] In step **58**, the control logic **46** listens for wireless messages on port **40**. In step **60**, the timer value is compared to a predetermined time value. In one example, the predetermined time value is about ten (10) seconds. The predetermined time value is set to a value equivalent to the time necessary for about ten (10) wireless messages to be sent from each trailer. The predetermined time value is set to allow multiple wireless messages to be broadcast, thereby accounting for signal interference or other interruptions. If the timer value equals or exceeds the predetermined time value, the method **50** proceeds to step **68**. If the timer value is less than the predetermined time value, the method proceeds to step **62.**

[0025] In step **62**, a wireless message is received. The message may include information indicating the type of vehicle transmitting the message. If the wireless message is from a trailer, as identified in the message, the control logic **46** retains the message for use in determining the length of the road train **14**. If the wireless message is from a different vehicle, such as a passenger car near the tractor **12**, the wireless message is not used for determining the length of the road train. The identification of vehicle type as in the received message is used because the range of the wireless transmission protocol is up to about five hundred (500) feet.

[0026] In step **64**, the control logic **46** determines if the vehicle that transmitted the wireless message is coupled to the tractor **12**. For purposes of DSRC, the transmitted location of the vehicle is the geographical center of the vehicle's latitude and longitude. The altitude is defaulted to the ground. The control logic **46** can determine whether the vehicle is physically coupled to the tractor **12** in at least three different manners.

[0027] In a first example, the control logic **46** determines if the vehicle that transmitted the message is coupled to the tractor **12** by comparing the speed of the tractor **12** and the speed as in the received message. If the speed of the tractor **12** is within a predetermined speed of the speed as in the received message, for example about 0.5 miles per hour, then the control logic **46** adds the vehicle length as in the received message to the length of the tractor **12** to determine the overall length of the road train **14** in step **66**.

[0028] In a second example, the control logic **46** compares the GPS coordinates of the tractor **12** with the GPS coordinates of received message. The control logic **46** determines that the vehicle which transmitted the message is coupled to the tractor **12** when the GPS coordinates of the tractor **12** place the tractor **12** within a predetermined proximity of the vehicle that transmitted the message. The predetermined proximity may be set as between about eighteen (18) feet and ninety (90) feet of the tractor **12** GPS coordinates to the rear of the tractor **12.** If the proximity of the tractor **12** is within the predetermined proximity to the vehicle transmitting the message and the location is to the rear of the tractor **12**, then the control logic **46** adds the vehicle length as in the received message to the length of the tractor **12** to determine the overall length of the road train **14** in step **66**. Any messages with a GPS location placing the vehicle transmitting the message to the side of the tractor **12** would be rejected as the vehicle could not logically be coupled to the tractor **12**. In this example, the GPS coordinates can also be used in place of adding together a preprogrammed trailer length with a preprogrammed tractor length. When the trailer controllers **32, 34, 36**

are consistently placed in the same location on the trailer body, the GPS coordinates as in the received message can be used to determine the length of trailer and subsequently, the road train **14**. The control logic **46**, knowing the GPS coordinates of the tractor controller **30**, can add the information regarding the GPS coordinates of the trailer controllers **32, 34, 36** to achieve the overall length of the road train **14**. For example, if the GPS coordinates of the tractor **12** are N 41° 22' 44.932" and W 82° 4' 17.749" and the GPS coordinates of the received message are N 41° 22' 45.088" and W 82° 4' 17.257" then the control logic **46** adds the values between the GPS coordinates to determine the length of the vehicle transmitting the message. This length is added to the length of the tractor **12** in step **66.**

[0029] In a third example, the control logic **46** compares the heading of the tractor **12** with the heading of the vehicle transmitting the message. If the heading of the tractor **12** is less than a predetermined angle threshold of the heading of the vehicle as in the received message, for example within two (2) degrees, then the control logic **46** determines that the tractor **12** is coupled to the vehicle transmitting the message and adds the length as in the received message to the length of the tractor **12** to determine the overall length of the road train **14** in step **66**.

[0030] For additional accuracy in determining whether the vehicle transmitting the message is coupled to the tractor **12,** any of the above examples can be combined. For example, the speed and the heading may be compared before determining the vehicle transmitting the message is coupled to the tractor **12.** Alternatively, the GPS coordinates and the speed may be compared. In yet another example, the type of vehicle and the heading may be compared. In yet another example, the tractor **12** can compare when the tractor **12** is powered on with when the vehicle transmitting the message was powered on. If the tractor **12** power on time is equal to the power on time in the received message, then the determination can be made that the tractor **12** is coupled to the vehicle transmitting the wireless message. The vehicle transmitting the message may also transmit a message indicating a brake activation, which can be compared with a brake activation on the tractor **12.**

[0031] In step **66,** the received length or measured length of the vehicle transmitting the message is added to the tractor length programmed in the memory **48**. For example, if the known tractor length is eighteen (18) feet and two trailers of twenty-five (25) feet each are determined to be attached to the tractor, then the overall road train length would be sixty-eight (68) feet. However, an additional six (6) feet may be added to account for a dolly, if the dolly was not equipped to be transmitting its own wireless message. The six feet between the two trailers also accounts for the standard gap allowed between trailers for maneuverability. Therefore, the overall length of the road train **14** would more accurately be seventy-four (74) feet.

[0032] If the control logic **46** determines the vehicle transmitting the message is not coupled to the tractor **12** in step **64,** the method **50** proceeds to step **68.**

[0033] After step **66** is completed, the method returns to step **58** to continue to listen for additional wireless messages. The method **50** continues until the timer value is equal to or greater than the predetermined time value in step **60**. When the timer value is equal to or greater than the predetermined time, the method **50** proceeds to step **68.** In step **68,** the control logic **46** transmits the overall length of the road train **14** using the wireless port **40**. The control logic **46** may also transmit the overall length via the communications port **42** for use by other safety systems on the tractor **12.**

[0034] **FIGURE 4** illustrates a method **80** of determining the length of a road train **14** and transmitting the information in situations where the length of the road train has already been calculated, but must be determined again because a trailer might have been removed while the tractor controller **30** was still in the powered on state.

[0035] The method **80** begins at step **82** where the tractor speed is compared to the threshold speed, similar to step **54** in method **50**. In one example, the threshold speed is between about five (5) miles per hour and about fifteen (15) miles per hour. If the speed is equal to or less than the threshold speed, the method **80** proceeds to step **100** and the previously calculated length of the road train **14** is transmitted as no updates to the vehicle length can be made while the vehicle is stopped or at a very low traveling speed. If the speed of the tractor **12** equals or exceeds the threshold speed, the method **80** continues to step **84**.

[0036] In step **84** the timer in the processor **45** is started. In step **86**, the control logic **46** listens for wireless messages on port **40**. In step **88**, the timer value is compared to a predetermined time value, similar to step **60** in method **50**. In one example, the predetermined time value is about ten (10) seconds. If the timer value is less than the predetermined time value, the method **80** proceeds to step **90.** If the timer value is greater than or equal to the predetermined time value, the method **80** proceeds to step **100** to transmit the overall length of the road train **14.**

[0037] In step **90**, the control logic **46** determines if a wireless message is received. If a wireless message is received, the method **80** continues to step **92.** If no wireless message is received, the method **80** continues to step **96.**

[0038] In step **92**, the control logic **46** determines if the vehicle that transmitted the message is coupled to the tractor **12**, similar to step **64** in method **50.** In a first example, the control logic **46** determines if the vehicle that transmitted the message is coupled to the tractor **12** by comparing the speed of the tractor **12** and the speed as in the received message. If the speed of the tractor **12** is within a predetermined speed of the speed in the received message, for example about 0.5 miles per hour, then the control logic **46** adds the vehicle length as in the received message to the length of the tractor **12** to determine the overall length of the road train **14** in step **94**.

[0039] In a second example, the control logic **46** compares the GPS coordinates of the tractor **12** with the GPS coordinates of received message. The control logic **46** determines that the vehicle which transmitted the message is coupled to the tractor **12** when the GPS coordinates of the tractor **12** place the tractor **12** within a predetermined proximity of the vehicle that transmitted the message. The predetermined proximity may be set as between about eighteen (18) feet and ninety (90) feet of the tractor **12** GPS coordinates to the rear of the tractor **12.** If the proximity of the tractor **12** is within the predetermined proximity to the vehicle transmitting the message and the location is to the rear of the tractor **12**, then the control logic **46** adds the vehicle length as in the received message to the length of the tractor **12** to determine the overall length of the road train **14** in step **94**. Any messages with GPS coordinates placing the vehicle transmitting the message to the side of the tractor **12** would be rejected as the vehicle could not logically be coupled to the tractor **12**. In this example, the GPS coordinates can also be used in place of adding together a preprogrammed tractor length and a preprogrammed trailer length. As stated previously, when the trailer controllers **32, 34, 36** are consistently placed in the same location, the GPS coordinates as in the received message can be used to determine the length of the road train **14**. The control logic **46**, knowing the GPS coordinates of the tractor controller **30**, can add the information regarding the GPS coordinates of the trailer controllers **32, 34, 36** to achieve the overall length of the road train **14**. For example, if the GPS coordinates of the tractor **12** are N 41° 22' 44.932" and W 82° 4' 17.749" and the GPS coordinates of the received message are N 41° 22' 45.088" and W 82° 4' 17.257" then the control logic **46** adds the values between the GPS coordinates to determine the length of the vehicle transmitting the message. This length is added to the length of the tractor **12** in step **94.**

[0040] In a third example, the control logic **46** compares the heading of the tractor **12** with the heading of the vehicle transmitting the message. If the heading of the tractor **12** is less than a predetermined angle threshold of the heading of the vehicle as in the received message, for example within two (2) degrees, then the control logic **46** determines that the tractor **12** is coupled to the vehicle transmitting the message and adds the length as in the received message to the length of the tractor **12** to determine the overall length of the road train **14** in step **94**.

[0041] If, however, the control logic **46** determines that the vehicle transmitting the wireless message is not coupled to the tractor in step **92**, the method **80** continues to step **100.**

[0042] After adding to or maintaining the length of the vehicle transmitting the message to the overall length of the road train **14** in step **94,** the method **80** returns to step **86** to continue to listen for additional wireless messages. If the timer value is equal to or exceeds the predetermined time, the method **80** continues to step **100** and transmits the calculated overall length of the road train **14.**

[0043] If no wireless message was received in step **90**, the method **80** proceeds to step **96.** The control logic **46** determines if the vehicle that had previously been part of the road train **14** did not send a message N consecutive times**.** N may set to an integer, such as three (3), to allow for missed wireless messages or delays in transmission of the message. If the number of times the expected wireless message is less than N, the method **80** increments N by one and returns to step **86** to continue to listen for wireless messages. If the number of times the expected wireless message was not received is equal to N, then the method **80** continues to step **98.** In step **98,** the length of the vehicle that had previously been part of the road train **14** is removed and a new length of the road train **14** is calculated. Using a prior example, the length of the road train **14** was determined to be seventy-four (74) feet. If a message from one trailer is no longer being received using method **80**, the new calculated length of the trailer would be forty-three (43) feet. The method **80** continues to step **100** where the control logic **46** transmits the wireless message containing the calculated length of the road train **14** on the wireless port **40.**

[0044] In yet another method, if no wireless messages are received**,** the tractor controller **30** may still make assumptions about the road train length based on the combined vehicle weight measured at the tractor. The combined vehicle weight may be measured at the air suspension of the tractor using weight measurement device **28**, for example. If there are no wireless messages received by the tractor control logic **46** during the predetermined time and the weight measured at the tractor is only the estimated weight equivalent to the tractor itself, then the control logic **46** can assume that no towed vehicles are coupled to the tractor **12** and transmit only the length of the tractor**.** If the weight measured at the tractor is greater than the estimated weight equivalent to the tractor by itself, then the tractor control logic **46** can assume the longest available single trailer type, a sixty (60) foot trailer, is coupled to the tractor **12.** The control logic **46** will then transmit the length of the tractor plus the trailer for an overall length of the road train **14** of seventy-eight (78) feet. From a safety standpoint, the control logic **46** assumes a longer length road train so that the vehicles sharing the roadway will keep a farther distance away from the road train **14**.

[0045] If there are multiple trailers attached to the tractor **12** but fewer than all the trailers have a controller as described in this invention, the tractor control logic **46** can still make assumptions about the length of the overall road train **14** by using the GPS coordinates to establish approximately where in the road train **14** the vehicle transmitting the message is located**.**

[0046] Therefore, various examples of a method of determining a length of a road train comprise receiving a host vehicle speed and receiving a first wireless message from a first vehicle subsequent to the host vehicle speed being greater than a predetermined speed. The wireless message includes at least a speed of the first vehicle, a length of the first vehicle, a heading of the first vehicle and GPS coordinates associated with the first vehicle. The method also comprises determining if the first vehicle is coupled to the host vehicle and adding the length of the first vehicle to the length of the host vehicle to attain an overall length of the road train in response to the first trailer being coupled to the tractor.

[0047] While the present invention has been illustrated by the description of embodiments thereof, and while the embodiments have been described in considerable detail, it is not the intention of the applicants to restrict or in any way limit the scope of the appended claims to such detail. Additional advantages and modifications will readily appear to those skilled in the art. Therefore, the invention, in its broader aspects, is not limited to the specific details, the representative apparatus, and illustrative examples shown and described. Accordingly, departures may be made from such details without departing from the spirit or scope of the applicant's general inventive concept.

We claim:

1. An apparatus for determining the length of a road train comprising:

a processor having control logic, the control logic capable of:

receiving a message at a towing vehicle from at least one towed vehicle transmitter, the message comprising at least one of a GPS coordinate of the towed vehicle, a length of the towed vehicle, a speed of the towed vehicle and a heading of the towed vehicle;

determining if the at least one towed vehicle is coupled to a towing vehicle in response to the message;

determining the overall length of the road train based on adding the length of the towed vehicle to the length of the towing vehicle in response to determining the at least one towed vehicle is coupled to the towing vehicle; and

transmitting a message comprising the overall length of the road train and at least one of a GPS coordinate of the towing vehicle and the heading of the road train.

2. The apparatus as in claim 1, wherein determining if the at least one towed vehicle is coupled to a towing vehicle comprises comparing the speed of the towed vehicle and the speed of the towing vehicle and determining the speed of the towed vehicle is within a predetermined speed of the speed of the towing vehicle.

3. The apparatus as in claim 1, wherein determining if the at least one towed vehicle is coupled to a towing vehicle comprises comparing the GPS coordinates of the towed vehicle with the GPS coordinates of the towing vehicle and determining that the GPS coordinates of the towed vehicle places the towed vehicle within a predetermined proximity of the towing vehicle.

4. The apparatus as in claim 1, wherein determining if the at least one towed vehicle is coupled to a towing vehicle comprises comparing the heading of the towed vehicle with the heading of the towing vehicle and determining that the heading of the towed vehicle is less than a predetermined angle threshold with the heading of the towing vehicle.

5. The apparatus as in claim 1, the control logic further capable of:

receiving a message at the towing vehicle from a second towed vehicle transmitter, the message comprising at least one of a GPS coordinate of the second towed vehicle, a length of the second towed vehicle, a speed of the second towed vehicle and a heading of the second towed vehicle;

determining if the second towed vehicle is coupled to a towing vehicle in response to the message; and

determining the overall length of the road train based on adding the length of the second towed vehicle to the length of the road train.

6. The apparatus as in claim 1, wherein the control logic is further capable of:

initiating a timer upon the at least one towing vehicle reaching a minimum speed; and

determining if the at least one towed vehicle is coupled to the towing vehicle in response to a timer value being less than a predetermined time value.

7. A host vehicle controller for determining a length of a road train comprising:

a wireless port for transmitting and receiving wireless messages;

an input for receiving a speed of the host vehicle;

a global positioning system (GPS) receiver; and

control logic, the control logic having a memory programmed with the length of the host vehicle and capable of:

receiving a first wireless message from an other vehicle at the wireless port subsequent to the host vehicle speed being greater than a predetermined speed; the wireless message including at least a speed of the other vehicle, a length of the other vehicle and GPS coordinates of the other vehicle;

determining if the other vehicle is coupled to the host vehicle;

adding the length of the other vehicle to the length of the host vehicle to attain an overall length of the road train in response to the other vehicle being coupled to the host vehicle; and

transmitting the overall length of the road train and at least one of the GPS coordinates associated with the host vehicle and the heading of the host vehicle.

8. The controller as in claim 7, wherein the length of the road train is recalculated each time the controller is powered up.

9. The controller as in claim 7, the control logic further capable of receiving additional wireless messages until a timer exceeds a predetermined time period prior to adding the length of the other vehicle to the length of the host vehicle.

10. The controller as in claim 9, wherein the predetermined time period is about ten seconds.

11. The controller as in claim 7, wherein determining if the other vehicle is coupled to the host vehicle comprises comparing the speed of the other vehicle and the speed of the host vehicle and determining that the speed of the other vehicle is less than a predetermined speed of the speed of the towing vehicle.

12. The controller as in claim 7, wherein determining if the other vehicle is coupled to the host vehicle comprises comparing the GPS coordinates of the other vehicle with the GPS coordinates of the host vehicle and determining that the GPS coordinates of the other vehicle places the other vehicle within a predetermined proximity of the host vehicle.

13. The controller as in claim 7, wherein determining if the other vehicle is coupled to the host vehicle comprises comparing the heading of the other vehicle with the heading of the host vehicle and determining that the heading of the other vehicle is less than a predetermined angle threshold with the heading of the host vehicle.

14. The controller as in claim 7, the control logic further capable of:

receiving a second wireless message from a second other vehicle at the wireless port subsequent to the host vehicle speed being greater than a predetermined speed;

determining the second other vehicle is coupled to the host vehicle;

adding the length of the second other vehicle to the length of the other vehicle and the host vehicle to attain an overall length of the road train in response to the second other vehicle being coupled to the host vehicle; and

transmitting the overall length of the road train and GPS coordinates associated with the host vehicle.

15. The controller as in claim 7, wherein the wireless port is configure for wireless communication using at least one of a Dedicated Short Range Communications (DSRC), Bluetooth, ZigBee and Wi-Fi protocol.

16. A controller on a tractor for determining a length of a road train comprising:

a wireless port for transmitting and receiving wireless messages;

an input for receiving a speed of the tractor;

a global positioning system (GPS) receiver; and

control logic, the control logic having a memory programmed with the length of the tractor and capable of:

receiving a first wireless message from a first trailer at the wireless port subsequent to the tractor speed being greater than a predetermined speed; the wireless message including at least a speed of the first trailer and GPS coordinates associated with the physical location of a transmitter on the first trailer;

comparing the speed in the first wireless message to the speed of the tractor;

determining a length of the first trailer based on the GPS coordinates;

adding the length of the first trailer to the length of the tractor to attain an overall length of the road train in response to the speed information in the first wireless message being equivalent to the speed of the tractor; and

transmitting the overall length of the road train and GPS coordinates associated with the tractor.

17. The controller as in claim 16, the control logic further capable of:

receiving a second wireless message from a second trailer at the wireless port subsequent to the tractor speed being greater than a predetermined speed;

comparing the speed information in the second wireless message to the speed of the tractor;

adding the length of the second trailer to the length of the first trailer and the tractor to attain an overall length of the road train in response to the speed information in the second wireless message being equivalent to the speed of the tractor; and

transmitting the overall length of the road train and GPS coordinates associated with the tractor.

18. The controller as in claim 16, the control logic further capable of: determining the position of the first trailer and the second trailer in the road train based on the GPS coordinates of the first trailer, the second trailer and the tractor.

19. The controller as in claim 16, the control logic further capable of: transmitting the overall length of the road train to at least one of an anti-lock brake controller, stability controller and an automatic cruise with braking controller.

20. A method of determining a length of a road train comprising:

receiving a host vehicle speed;

receiving a first wireless message from a first vehicle subsequent to the host vehicle speed being greater than a predetermined speed, the wireless message including at least a speed of the first vehicle, a length of the first vehicle, a heading of the first vehicle and GPS coordinates associated with the first vehicle;

determining if the first vehicle is coupled to the host vehicle; and

adding the length of the vehicle to the length of the host vehicle to attain an overall length of the road train in response to the first vehicle being coupled to the tractor.

21. The method as in claim 20, further comprising:

transmitting the overall length of the road train and at least one of the GPS coordinates associated with the host vehicle and the heading of the host vehicle.

22. The method as in claim 20, wherein determining if the first vehicle is coupled to the host vehicle comprises comparing the speed of the first vehicle and the speed of the host vehicle and determining that the speed of the first vehicle is less than a predetermined speed of the speed of the host vehicle.

23. The method as in claim 20, wherein determining if the first trailer is coupled to the tractor comprises comparing the GPS coordinates of the first trailer with the GPS coordinates of the tractor and determining that the GPS coordinates of the first trailer places the first trailer within a predetermined proximity of the tractor.

24. The method as in claim 20, wherein determining if the first trailer is coupled to the tractor comprises comparing the heading of the first trailer with the heading of the tractor and

determining that the heading of the first trailer is less than a predetermined angle threshold with the heading of the tractor.

25. The method as in claim 20, wherein the first wireless message includes a vehicle type and determining if the first vehicle is coupled to the tractor comprises determining the type of the first vehicle is a commercial vehicle trailer.

26. The method as in claim 20, further comprising:

receiving a second wireless message from a second trailer at the wireless port subsequent to the tractor speed being greater than a predetermined speed;

comparing the speed information in the second wireless message to the speed of the tractor;

adding the length of the second trailer to the length of the first trailer and the tractor to attain an overall length of the road train in response to the speed information in the second wireless message being equivalent to the speed of the tractor; and

transmitting the overall length of the road train and GPS coordinates associated with the tractor.

27. A method for determining the length of a road train comprising:

receiving a host vehicle speed;

receiving a road train weight value;

preparing to receive wireless messages subsequent to the host vehicle speed being greater than a predetermined speed; and

determining an overall length of the road train as a predetermined minimum length in response to receiving no wireless messages at the host vehicle and the road train weight value exceeding the weight of the host vehicle.

28. A system for determining the length of a road train comprising

a plurality of transmitters for transmitting messages; and

a tractor controller, having a GPS receiver and capable of receiving the messages from each transmitter, the tractor controller capable of:

receiving a tractor speed;

receiving a first message from a first transmitter subsequent to the tractor speed being greater than a predetermined speed, the first message including at least a speed of the vehicle on which the first transmitter is located, a length of the vehicle and GPS coordinates associated with the vehicle;

comparing the speed in the first message to the speed of the tractor;

adding the length of the first vehicle to the length of the tractor to attain an overall length of the road train in response to the speed information in the first message being equivalent to the speed of the tractor; and

transmitting the overall length of the road train and GPS coordinates associated with the tractor.

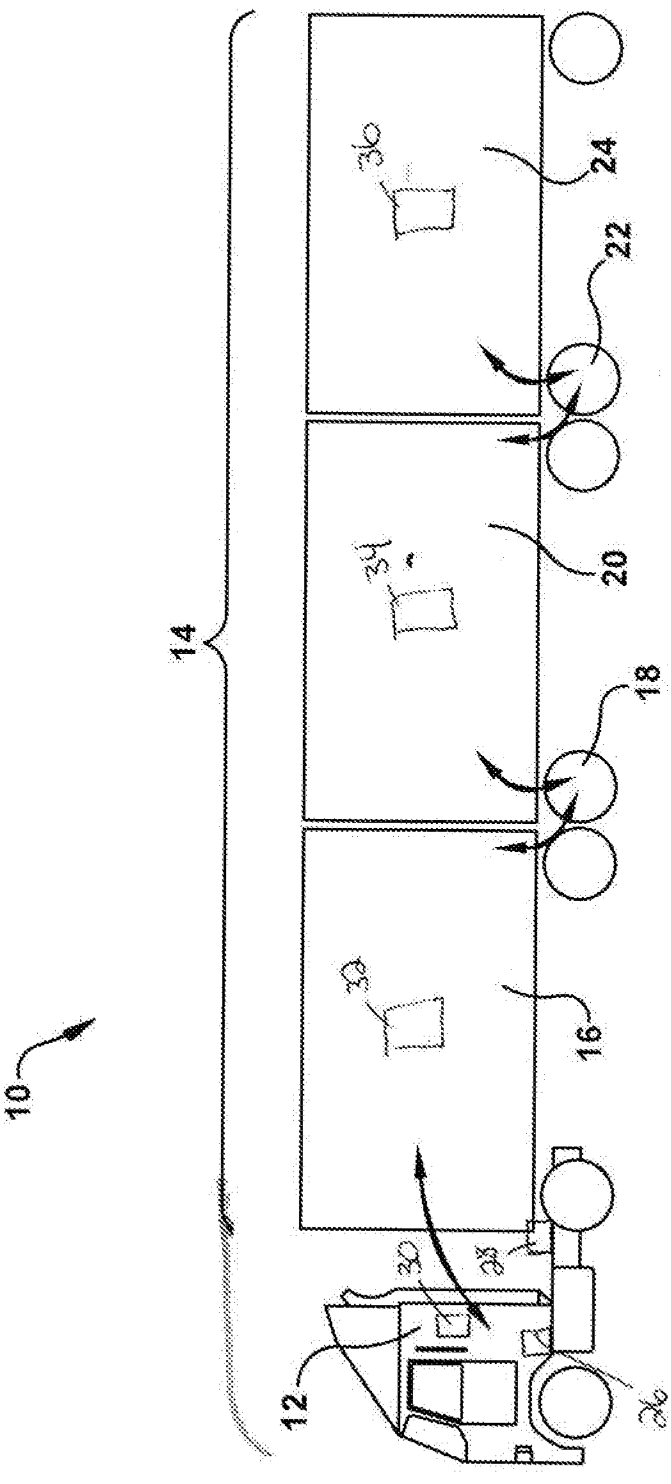

Fig. 1

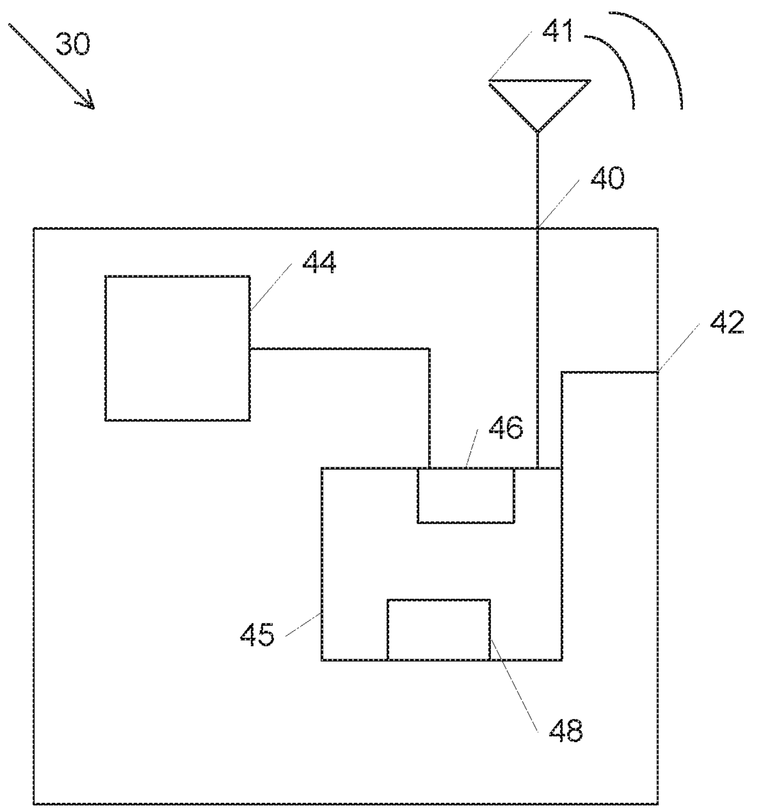

Figure 2

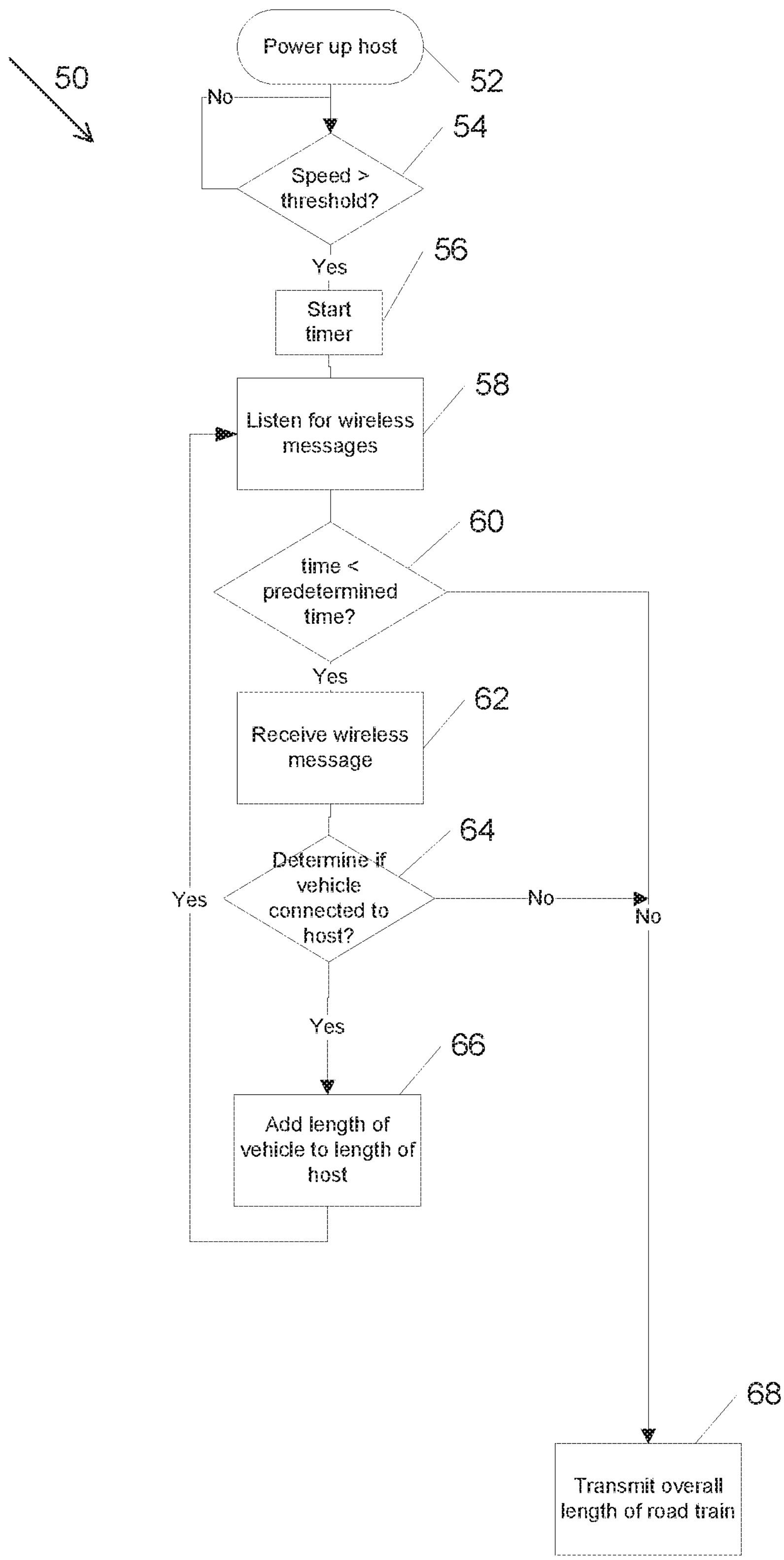
50
Power up host
52
No
Speed > threshold?
54
Yes
Start timer
56
Listen for wireless messages
58
time < predetermined time?
60
Yes
Receive wireless message
62
Determine if vehicle connected to host?
64
No
No
Yes
Yes
Add length of vehicle to length of host
66
Transmit overall length of road train
68

Figure 3

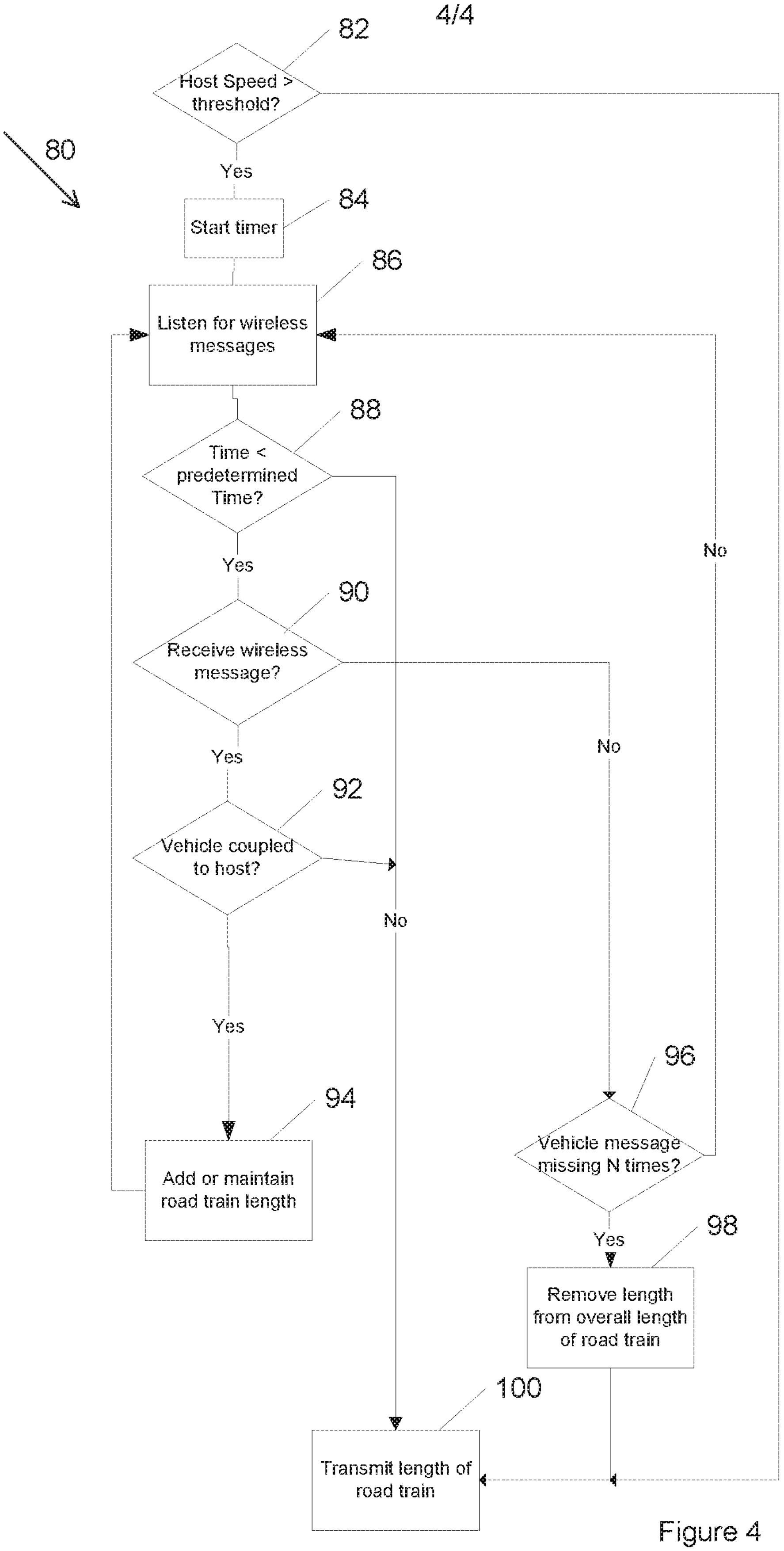
80
82
Host Speed > threshold?
Yes
84
Start timer
86
Listen for wireless messages
88
Time < predetermined Time?
Yes
90
Receive wireless message?
Yes
92
Vehicle coupled to host?
Yes
94
Add or maintain road train length
No
No
No
96
Vehicle message missing N times?
Yes
98
Remove length from overall length of road train
100
Transmit length of road train

Figure 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2017/012816

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-26, 28

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2017/012816

A. CLASSIFICATION OF SUBJECT MATTER
INV. G01B21/02 B60D1/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G01B B60D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2008/243320 A1 (OTSUBO TOM [US] ET AL) 2 October 2008 (2008-10-02) paragraph [0011] - paragraph [0023]; figures 1-3	1-26,28
A	US 9 227 607 B1 (RIPLEY JOHN V [US] ET AL) 5 January 2016 (2016-01-05) column 1, line 8 - column 1, line 31 column 3, line 17 - column 12, line 63; figures 1-8	1-26,28
A	DE 101 07 571 A1 (ALCATEL SA [FR]) 23 May 2002 (2002-05-23) paragraph [0001] paragraph [0013] - paragraph [0014]; figures 1-3	1-26,28
	-/--	

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 April 2017	03/07/2017

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Beyfuß, Martin

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2013/206487 A1 (BODE CHRISTIAN [DE] ET AL) 15 August 2013 (2013-08-15) paragraph [0011] - paragraph [0025]; figure 1 -----	1-26,28

5

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2008243320 A1	02-10-2008	BR PI0801092 A2	18-11-2008
		CA 2627117 A1	30-09-2008
		CN 101327805 A	24-12-2008
		US 2008243320 A1	02-10-2008
		ZA 200802785 B	28-01-2009
US 9227607 B1	05-01-2016	US 9227607 B1	05-01-2016
		WO 2016033255 A1	03-03-2016
DE 10107571 A1	23-05-2002	NONE	
US 2013206487 A1	15-08-2013	CN 102939233 A	20-02-2013
		DE 102010014333 A1	13-10-2011
		DK 2555959 T3	06-10-2014
		EP 2555959 A1	13-02-2013
		ES 2497840 T3	23-09-2014
		US 2013206487 A1	15-08-2013
		WO 2011124519 A1	13-10-2011

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-26, 28

Apparatus and method for determining the length of a road train, the train comprising at least two vehicles ("towing vehicle and towed vehicle"; "host vehicle and other vehicle"; "tractor and first trailer"; "host vehicle and first vehicle"; "tractor and vehicle"), the apparatus/method comprising means/steps for receiving a message from the respective "second" vehicle and for determining the length of said road train by adding the lengths of said vehicles.

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2. claim: 27

Method for determining the length of a road train comprising receiving a host vehicle speed, receiving a road train weight value, preparing to receive wireless messages subsequent to the host vehicle speed being greater than a predetermined speed, and determining an overall length of the road train as a predetermined minimum length in response to receiving no wireless messages at the host vehicle and the road train weight value exceeding the weight of the host vehicle.
