

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

SIEMENS MOBILITY, INC., GROUND TRANSPORTATION SYSTEMS USA,
INC., HUMATICS CORP., and PIPER NETWORKS, INC.

Petitioners,

v.

METROM RAIL, LLC
Patent Owner.

Case No. IPR2023-00470
Patent No. 8,812,227

DECLARATION OF MR. SCOTT ANDREWS

Siemens Exhibit 1003 Siemens, et al. v. Metrom Rail
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I, Scott Andrews, declare:

1. I have been retained by counsel for Petitioners Siemens Mobility, Inc., Ground Transportation Systems USA, Inc., Humatics Corp., and Piper Networks, Inc., to assess claims 1-28 (the “challenged claims”) of U.S. Patent No. 8,812,227 (“the ’227 patent”). I am being compensated for my time at my standard rate of \$505.00 per hour, plus actual expenses. My compensation is not dependent in any way upon the outcome of the *inter partes* review of the ’227 patent.

I. PERSONAL AND PROFESSIONAL BACKGROUND

2. My complete qualifications and professional experience are described in my curriculum vitae, a copy of which is provided as EX1004. The following is a brief summary of my relevant qualifications and professional experience.

3. I am currently a consultant for Cogenia Partners, LLC, focusing on systems engineering, business development and technical strategy supporting automotive and information technology. I have been in this position since 2001. In one of my active engagements, I serve as a co-principal investigator in a research program funded by the Federal Highway Administration (FHWA), called Integrated Advanced Transportation System. I also serve as a technical consultant in multiple FHWA projects with Rockwell Collins and Booz Allen related to connected vehicle technology research.

4. I have over 30 years of professional experience in the field of automotive technologies and systems, including vehicle information systems and vehicle safety and control systems. Further, I have authored numerous published technical papers and am a named inventor on 11 U.S. and foreign patents.

5. I received a Bachelor of Science degree in Electrical Engineering from University of California, Irvine in 1977 and a Master of Science degree in Electronic Engineering from Stanford University in 1982.

6. From 1977 to 1979, I worked at Ford Aerospace where I designed, tested and delivered microwave radar receiver systems.

7. From 1979 to 1983, I worked at Teledyne Microwave, where I developed high reliability microwave components and developed CAD tools.

8. From 1983 to 1996, I worked at TRW, Inc., having held various positions. From 1983 to 1985 I was a member of the technical staff in the RF Communications Laboratory; from 1985 to 1988 I was a sub-project manager on a communications system; from 1988 to 1991 I was an assistant project manager on the USDOD MIMIC program, leading the development of microwave integrated circuit technology development; from 1991 to 1993, I was a Manager of MMIC (monolithic microwave-integrated-circuit) Products Organization. In this role, I developed business strategy and managed customer and R&D programs. During this time, I also developed the first single chip 94 GHz Radar, used for automotive cruise

control and anti-collision systems. In 1993 I transferred to the TRW Automotive Electronics Group and managed about 30 engineers in the Systems Engineering and Advanced Product Development organization. In this role, I managed advanced development programs such as automotive radar, adaptive cruise control, occupant sensing, automatic crash notification systems, in-vehicle information systems, and other emerging transportation products. As part of this work, I also evaluated various technologies for collision and proximity sensing, including vision-based systems, ultrasonic systems, microwave systems, and ultrawideband systems.

9. From 1996 to 2000, I was a Project General Manager in the R&D Management Division at Toyota Motor Corporation in Japan. In that role, I worked extensively with engineering staff on various collision warning and avoidance systems, including vision and radar based autonomous driving vehicles. I also developed multimedia and new technology products and services for Toyota's future generations of passenger vehicles for the United States and Europe. As part of this work, I established the Automotive Multimedia Interface Collaboration, under the direction of Toyota's board members.

10. In 2000, I founded Cogenia, Inc. to develop enterprise class data management software systems. I served as the company's Chief Executive Officer until 2001, when I created Cogenia Partners, my current consulting firm.

II. MATERIALS REVIEWED AND CONSIDERED

11. My findings, as explained below, are based on my years of education, research, experience, and background in the field of positioning systems and techniques, as well as my investigation and study of relevant materials for this declaration. When developing the opinions set forth in this declaration, I assumed the perspective of a person having ordinary skill in the art, as set forth in Section IV below. In forming my opinions, I have studied and considered the materials identified in the list below.

Exhibit	Description
1001	U.S. Patent No. 8,812,227 (“227 patent”)
1002	Prosecution File History of US Patent No. 8,812,227
1005	European Patent Application No. EP 1 785 744 (“Suzuki”)
1006	U.S. Patent No. 6,759,948 (“Grisham”)
1007	Declaration of Sylvia Hall-Ellis, Ph.D.
1008	An Outdoor UWB Tracking System to Improve Safety of Semi-Autonomous Vehicle Operations (“Richardson”)
1009	[reserved]
1011	U.S. Patent No. 8,874,359 (“Douglas”)
1012	U.S. Patent Publication No. 2009/0255329 (“Connell”)
1013	U.S. Patent No. 6,133,876 (“Richards”)
1014	U.S. Patent No. Publication No. 2010/0052945 (“Breed ’945”)
1015	U.S. Patent Publication No. 2007/0255498 (“McDaniel”)
1016	International Application No. WO 03/009254 (“Nixon”)
1017	[reserved]

1018	U.S. Patent Publication No. 2008/0150786 (“Breed ’786”)
1019	U.S. Patent 2,188,293 (“Williams”)
1020	U.S. Patent No. 3,898,652 (“Rashid”)
1021	“Driving Assistance Provided by Adaptive Cruise Control”
1022	SAE J2735/2009-11
1023	U.S. Patent No. 5,036,478 (“MacDougall”)
1024	“Operation of the Eaton VORAD Collision Warning System and Analysis of the Recorded Data”
1025	US Patent Publication 20070293153 (“Molisch”)
1026	IEEE Std 802.15.4™-2011, IEEE Standard for Local and Metropolitan Area Networks: Part 15.4: Low-Rate Wireless Personal Area Networks
1027	Time Domain’s Ultra Wideband (UWB) Definition and Advantages, Time Domain (March 2011)
1028	U.S. Patent Publication No. 2006/0009240
1029	U.S. Patent No. 7,725,252 (“Heddebaut”)
1030	U.S. Patent No. 2,216,575 (“Seinfeld”)
1031	“Transponder History - RADAR Identification of Aircraft”
1032	“Collision of Metrolink Train 111 With Union Pacific Train LOF65-12”
1033	“Collisions & Casualties by Year”
1034	“Fatal Crashes at Highway Rail Grade Crossings”
1035	“Highway-Rail Grade Crossings Overview”
1036	“Railroad Accident: Common Causes, Statistics and Prevention”
1037	U.S. Patent No. 6,631,322 (“Arthur”)
1038	Positive Train Control (May 2012)
1039	“CCS: A Railway Corridor Control System Utilizing UWB Radio Technology”
1040	Docket Sheet for Case 1:22-cv-00049-RGA

III. MY UNDERSTANDING OF PATENT LAW

12. In developing my opinions, I discussed various relevant legal principles with Petitioner's attorneys. Though I do not purport to have prior knowledge of such principles, I understood them when they were explained to me and have relied upon such legal principles, as explained to me, in the course of forming the opinions set forth in this declaration. My understanding in this respect is as follows:

13. I understand that "*inter partes* review" (IPR) is a proceeding before the United States Patent & Trademark Office for evaluating the patentability of an issued patent's claims based on prior-art patents and printed publications.

14. I understand that, in this proceeding, Petitioner has the burden of proving that the challenged claims of the '227 patent are unpatentable by a preponderance of the evidence. I understand that "preponderance of the evidence" means that a fact or conclusion is more likely true than not true.

15. I understand that, in IPR proceedings, claim terms in a patent are given their ordinary and customary meaning as understood by a person of ordinary skill in the art ("POSITA") in the context of the entire patent and the prosecution history pertaining to the patent. If the specification provides a special definition for a claim term that differs from the meaning the term would otherwise possess, the specification's special definition controls. I have applied these standards in preparing the opinions in this declaration.

16. I understand that determining whether a particular patent or printed publication constitutes prior art to a challenged patent claim can require determining the effective filing date (also known as the priority date) to which the challenged claim is entitled. I have been told to assume that the earliest priority date for the claims of the '227 patent is **May 19, 2011**.

17. I understand that for an invention claimed in a patent to be patentable, it must be, among other things, new (novel—*i.e.*, not anticipated) and not obvious from the prior art. My understanding of the legal standard is set forth below.

18. I understand that a patent claim may be unpatentable if it would have been obvious in view of a single prior-art reference or a combination of prior-art references.

19. I understand that a patent claim is obvious if the differences between the subject matter of the claim and the prior art are such that the subject matter as a whole would have been obvious to a person of ordinary skill in the relevant field at the time the invention was made. Specifically, I understand that the obviousness question involves a consideration of:

- the scope and content of the prior art;
- the differences between the prior art and the claims at issue;
- the knowledge of a person of ordinary skill in the pertinent art; and

- if present, objective factors indicative of non-obviousness, sometimes referred to as “secondary considerations.” To my knowledge, the Patent Owner has not asserted any such secondary considerations with respect to the ’227 patent.

20. I understand that in order for a claimed invention to be considered obvious, a POSITA must have had a reason for combining teachings from multiple prior-art references (or for altering a single prior-art reference, in the case of obviousness in view of a single reference) in the fashion proposed.

21. I further understand that in determining whether a prior-art reference would have been combined with other prior art or with other information within the knowledge of a POSITA, the following are examples of approaches and rationales that may be considered:

- combining prior-art elements according to known methods to yield predictable results;
- simple substitution of one known element for another to obtain predictable results;
- use of a known technique to improve similar devices in the same way;
- applying a known technique to a known device ready for improvement to yield predictable results;

- applying a technique or approach that would have been “obvious to try,” *i.e.*, choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success.
- known work in one field of endeavor may prompt variations of it for use in either the same field or a different one based on design incentives or other market forces if the variations would have been predictable to one of ordinary skill in the art;
- some teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill to modify the prior-art reference or to combine prior-art reference teachings to arrive at the claimed invention. I understand that this teaching, suggestion or motivation may come from a prior-art reference or from the knowledge or common sense of one of ordinary skill in the art.

22. I understand that for a single reference or a combination of references to render the claimed invention obvious, a POSITA must have been able to arrive at the claimed invention by altering or combining the applied references.

IV. PERSON OF ORDINARY SKILL IN THE ART (“POSITA”)

23. I have been informed and understand that for purposes of assessing whether prior-art references disclose every element of a patent claim (thus “anticipating” the claim) and/or would have rendered the claim obvious, the patent and the prior-art references must be assessed from the perspective of a person having ordinary skill in the art (“POSITA”) to which the patent is related, based on the understanding of that person at the time of the patent claim’s priority date. I have been informed and understand that a POSITA is presumed to be aware of all pertinent prior art and the conventional wisdom in the art and is a person of ordinary creativity. I have applied this standard throughout my declaration.

24. At a high-level, the ’227 patent involves wireless communications technologies used in the field of transportation control and collision avoidance systems. More specifically, the patent relates to the use of such wireless technologies to control functions in a railway or train system.

25. I have been asked to provide my opinions as to the state of the art in this field by 2011. I use this timeframe because the face of the ’227 patent indicates an earliest claimed priority date of a May 19, 2011, filing date of a provisional application. EX1001 at (60). While I believe the provisional applications filed in 2011 are missing significant content of the claims, I use that date for my opinions contained herein. Whenever I offer an opinion in this declaration about the

knowledge of a POSITA, the manner in which a POSITA would have understood the claims of the '227 patent or its description, the manner in which a POSITA would have understood the prior art, or what a POSITA would have been led to do based on the prior art, I am referencing the 2011 timeframe, even if I do not say so specifically in each case.

26. I understand that the Patent Owner may attempt to prove that the alleged invention recited in the challenged claims was conceived at some time prior to the earliest claimed priority date on the face of the patent. At the time of this declaration, I am unaware of the Patent Owner having alleged any earlier conception date or produced any evidence to establish any earlier conception date.

27. In my opinion, a person of ordinary skill in the art (POSITA) at the time of the alleged invention would have had a background in wireless electronics, including at least a bachelor's degree in electrical engineering or a related field, and would have at least two years of experience with using such electronics for control systems applications such as collision-avoidance systems or positioning systems. Extensive experience and technical training may substitute for educational requirements, while advanced education such as relevant MS or PhD might substitute for experience. This person would have been capable of understanding and applying the teachings of the '227 patent and the prior-art references discussed in this declaration.

28. By 2011, I held a M.S. in Electrical Engineering, and I had 20+ years of experience with wireless technologies and using those technologies in transportation collision avoidance systems. Therefore, I was a person of more than ordinary skill in the art during the relevant timeframe. However, I have hired and supervised many people who fit the characteristics of the POSITA, and I am familiar with their level of skill. When developing the opinions set forth in this declaration, I assumed the perspective of a person having ordinary skill in the art, as set forth above.

V. TECHNOLOGY BACKGROUND AND OVERVIEW OF THE PATENT

29. In Section V, I provide an overview of the relevant technology to which the '227 patent is directed as well as an overview of the patent itself.

A. Relevant Technology Background

30. As discussed in more detail in Section V.B., the '227 patent relates to collision avoidance systems for rail-line vehicles within a railway network. In Sections V.A.1. to V.A.3., I discuss conventional vehicular collision avoidance systems that were well-known in the art prior to August 2011.

31. As discussed in more detail in Section V.B., the '227 patent also relates to the use of wireless communications to facilitate vehicular collision avoidance systems. The primary wireless communication technology that the patent uses in its exemplary embodiments is ultra-wideband (or UWB for short) radio technology. In

Sections V.A.3. to V.A.6., I discuss UWB technology and how it was known in the prior art that UWB can be used both to communicate data and/or determine a device's position by, for example, determining the distance between two UWB radios.

1. Vehicular Collision Avoidance Systems

32. As of 2011, there were numerous known collision avoidance systems, each with their own unique benefits and drawbacks.

33. While radar has been used for decades to identify potential hazards, for example other ships at sea, the use of radar on wheeled vehicles is somewhat more recent. One of the earliest vehicle collision avoidance radar systems was described in U.S. Patent No. 2,216,575 (“Seinfeld”), issued on October 1, 1940, from an application filed on January 19, 1938. This patent describes a “Vehicle Safety Device” that used a light source focused using a parabolic reflector. The resulting light beam was aimed at a spot on the road some distance in front of the vehicle. A photoelectric cell was mounted near the light transmitter, and this received some portion of the light reflected from the roadway. To prevent accidental triggering of the photo electric cell by other light sources, a rotating disk was used to modulate the light source, creating a series of light pulses, and the output of the photo electric cell was filtered to only received signals with the modulated frequency.

34. If the vehicle encountered an obstacle on the roadway, the obstacle would scatter the light differently from the road, and this would cause the system to stop the vehicle through a governor mechanism connected to the brakes and controlled by the photocell.

The light beam periodically illuminates spot G in the roadway some of the light being reflected to periodically illuminate the photoelectric cell E. The periodic pulsations are close enough to produce in effect a continuous current to normally energize electro magnet P, holding armatures Q and R up. When the illumination of the photoelectric cell is cut off, the armature R drops down and closes the circuit to motor T through one of the three point, contacts 13 and applies the brakes by the rotation of the motor T at a speed partly proportioned. to the speed of the vehicle since the governor is driven by the running gear.

EX1030, p. 3, 1:22-35.

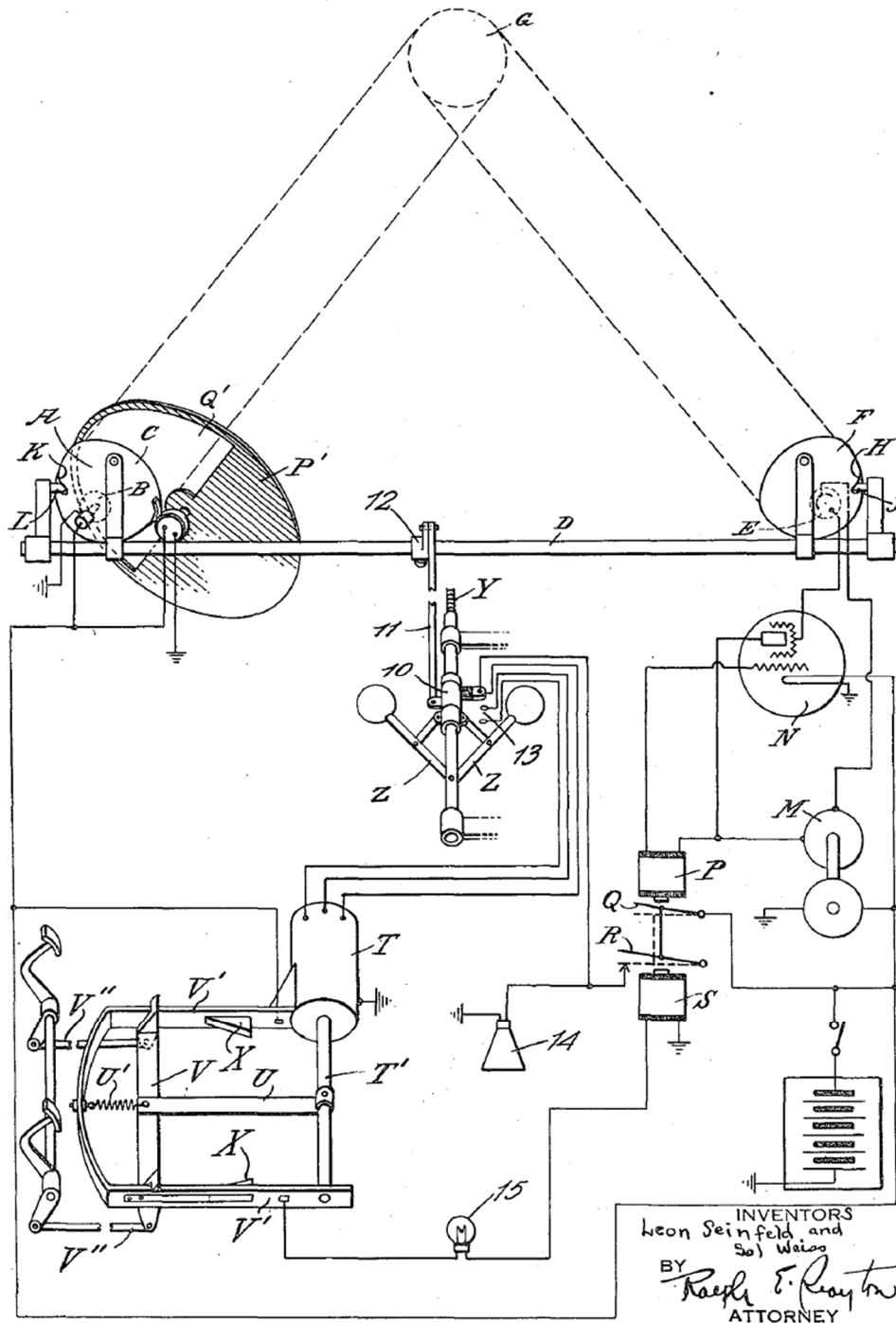
35. In addition to detecting obstacles at some pre-determined distance (i.e., where the light beam is directed in front of the vehicle, the patent also describes moving the light beam farther out in front of the vehicle as the speed increases. This provides for a speed sensitive activation distance.

The object of the invention is to provide mechanism which will operate to change the speed or direction of the vehicle when an object appears within a predetermined distance of the vehicle. Another object is to vary this distance in accordance with the speed of the vehicle.

EX1030, p. 2, 1:34-39.

As the speed of vehicle varies, a shaft Y connected to any suitable part of the running gear, preferably the transmission or tail shaft, rotates the governor arms Z connected by a sliding collar 10 longitudinally along the shaft Y. A link connection 11 rotates the shaft D through crank arm 12 and thereby changes the angular Inclination of the reflectors A and F as will be readily understood.

EX1030, p. 3, 1:8-16.



36. U.S. Patent 2,188,293 describes an “Automatic Vehicle Control System.” This system is described as being applicable to a wide variety of vehicles, including aircraft, automobiles, ships, and rail vehicles.

This invention relates to the art of vehicle control and includes control of all types of vehicles, particularly those which are dirigible such as automobiles, ships, and aircraft. More particularly, the invention concerns the automatic control of vehicles so that their control mechanism is automatically responsive to dangerous conditions without requiring a physical reaction on the part of the vehicle operator.

EX1019, p. 9,1:1-9.

37. Williams particularly describes that the system is applicable to automatic control of braking and headway for rail vehicles, and that it should be adaptable to changing conditions. For example:

In rail vehicles it is desirable to have means carried by the vehicles themselves to prevent rear-end collisions. While it has been proposed in the prior art to cause a brake application on a following train approaching a leading train too closely, it has never, so far as I am aware, been proposed to control, by means independent of the track rails, the interval of separation between two such vehicles in accordance with conditions of rest or motion of one of the vehicles. It has never been proposed to take into account the velocity and the acceleration or deceleration of one vehicle with respect to the other, or to take into account the fact that the safe interval may vary in accordance with varying conditions and to provide automatically for all such variations. It is, therefore, a further object of this invention to provide automatic control means for said vehicles, and to vary the

response or effectiveness of the control means automatically in response to changing conditions.

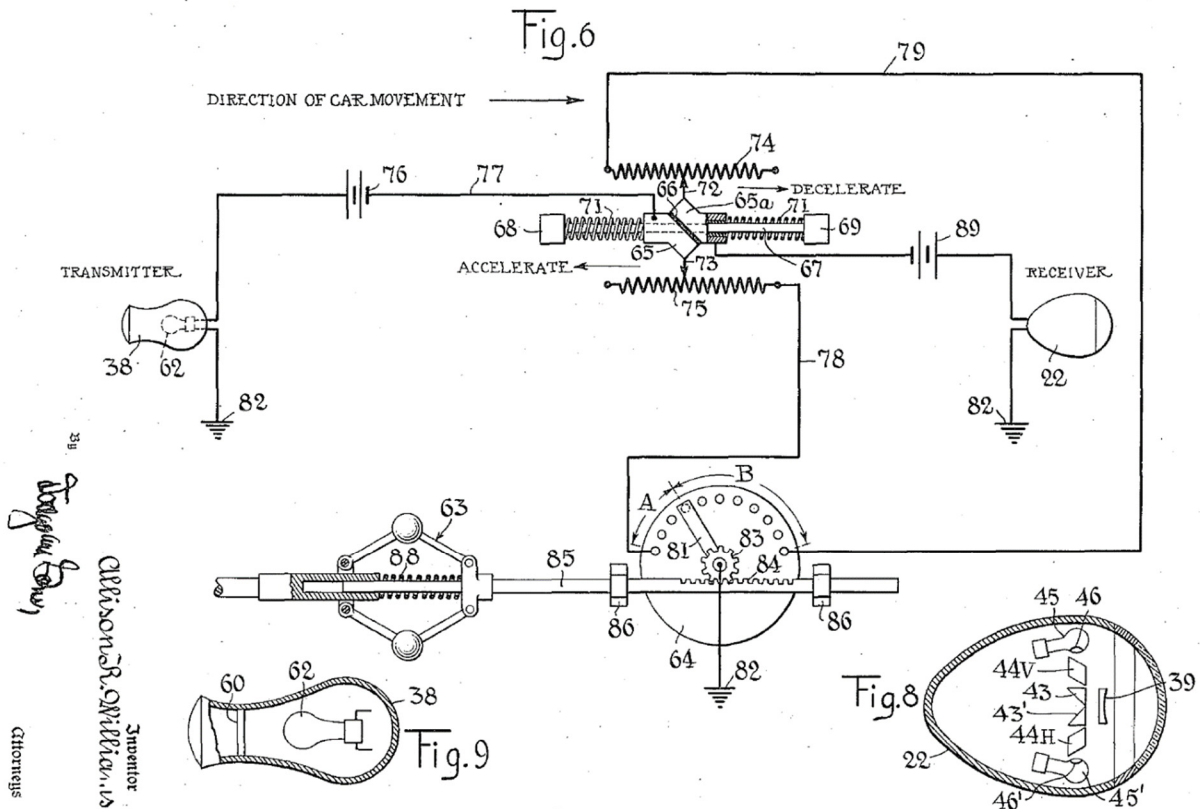
EX1019, p. 10, 1:50-70.

38. As with Seinfeld above, the Williams system uses a focused light beam to detect the distance to the obstacle in front of the host vehicle. To adapt to changing conditions such as vehicle speed, the output of the light transmitter, and the sensitivity of the light receiver are controlled as a function of speed, effectively increasing the range of the obstacle detector as the vehicle speed increases.

The operation of the circuits of Fig. 6 is as follows: When the vehicle suddenly starts from rest with the transmitter 38 at maximum intensity and receiver 22 at minimum sensitivity, the device 63 acts to rotate rheostat arm 81 to the right to increase A and decrease B. The inertia mass moves to the left at once before device 63 is effective, hence resistance 16 increases to dim lamp 62. Resistance 14 decreases to increase sensitivity of 22 before arm 81 moves to right to decrease B for the same purpose. When acceleration ceases, the mass assumes fixed position shown and centrifugal device 63 acts to control simultaneously both 22 and 38 through A and B. As vehicle speed increases, B decreases to increase sensitivity of 22, and A increases to decrease effectiveness of 38. Decrease in vehicle speed reduces A and increases B. When the vehicle decelerates the inertia mass moves to the right to increase 14 to decrease sensitivity of 22 while action of 63 tends to increase B for the same purpose. Movement

of contact 13 to the right decreases 15 to brighten 62 as action of 63 tends to decrease A for the same purpose. When the vehicle stops, 22 assumes normal value for which it is set and 62 assumes highest effectiveness with A at lowest value.

EX1019, p. 13,1:4-30.

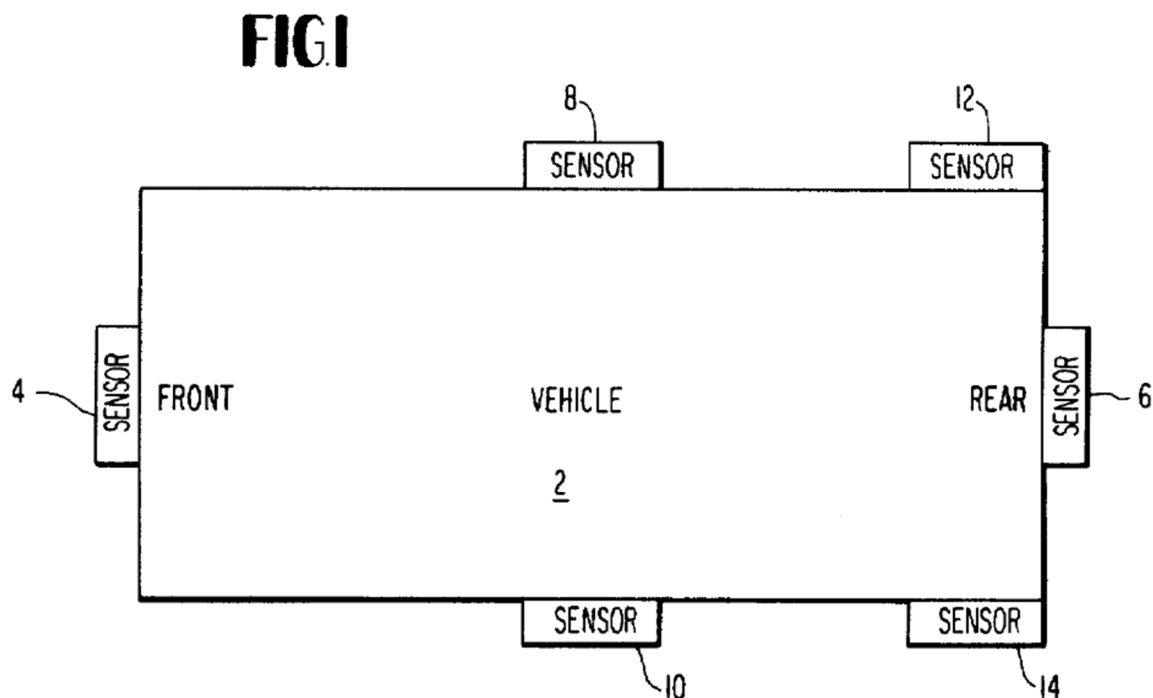


39. Numerous later systems replaced the light beams described above with radio signals using conventional radar techniques. For example, U.S. Patent No. 3,898,652 issued on August 5, 1975, from an application filed on December 26, 1973 ("Rashid"). The patent is titled "Vehicle Safety and Protection System". It describes a system for a vehicle that uses front, rear and side mounted radars to detect the presence and distance of obstacles. The system can either warn the driver, or slow

and stop the vehicle to avoid a collision. This system is described in connection with Figure 1, reproduced below.

FIG. 1 shows a vehicle 2 and the location of the sensors for detecting objects around the vehicle. Sensor 4 is the front sensor and is located in the front of the vehicle for detecting objects in front of the vehicle. Rear sensor 6 is positioned to detect objects to the rear of the vehicle. Side sensors 8 and 10 are positioned at approximately the middle of the sides of the vehicle to detect objects in a blind spot occurring to the side of the vehicle, while sensors 12 and 14 are located at the side rear of the vehicle to detect blind spots to the side of the vehicle near its rear.

EX1020, 2:66-3:8.



40. Rashid describes that the front and rear radar sensor outputs are fed to a processor that, using vehicle speed determines the distance required to stop based on current road conditions. For example:

Front sensor 4 and rear sensor 6 are each connected to Doppler radar unit 20 which is part of the signal processing control assembly 22. A vehicle velocity transducer 24 generates a signal which is indicative of the velocity of the vehicle. This signal is applied to vehicle velocity computer 26 which computes the velocity of the vehicle based upon the output of the vehicle velocity transducer 24. One output from the vehicle velocity computer is applied to the operator control and display console 18 which produces an indication of the vehicle velocity. Another output from vehicle velocity computer 26 is applied to control system computer 28. The 25 control system computer computes the distance required for the vehicle to stop based on existing road conditions and the velocity of the vehicle and compares this to the range of an object in front of the vehicle. This range is computed by the Doppler radar. Based upon the comparison, the control system computer produces an output which is indicative of the vehicle's ability to stop prior to colliding with the object in front of the vehicle.

EX1020, 3:14-34.

41. The stopping distance is determined based on a combination of factors that include the length of the vehicle, the speed of the vehicle and the reaction time

of the driver, the relative speed of the vehicle in front, and the weather conditions.

The weather conditions are input by the driver using selector switches.

The gain factors for various weather conditions have been developed by using computer simulations and actual road tests.

Typical gain factors are shown in the following chart:

Condition	G_a	G_b	G_r
Normal	1	1	2.5
Wet	2	2	4
Ice	4	4	6

The selection of normal, wet or ice conditions is made, by the driver, with switch 106 located on the operator control and display console 18. As can be seen, the different weather conditions will effect the distance that the vehicle must maintain from an object in front of it. The worse the road condition, the greater the distance must be in order to allow the vehicle to stop.

EX1020, 6:21-38.

42. A great deal of development work was focused on automotive collision avoidance systems, specifically using various types of radar systems between the early 1970's and the late 1990's. For example, starting in 1972, Eaton corporation developed a system known as Vehicle Onboard RADar (VORAD). This system was eventually sold commercially to the trucking industry in 1982. *See* EX1024. As noted in my Professional Background, I was responsible for the development of a 94 GHz radar system used for automotive collision warning and adaptive cruise

control (ACC) between 1990 and 1996. I am also aware that Delphi Corporation and Lucas both developed similar systems around the same time frame. Numerous other examples of collision avoidance radars have been published, and by the filing date of the '227 patent collision avoidance radar was a common feature on many vehicles including automobiles, rail vehicles, boats and ships, and aircraft.

2. Collision Avoidance Systems on Trains

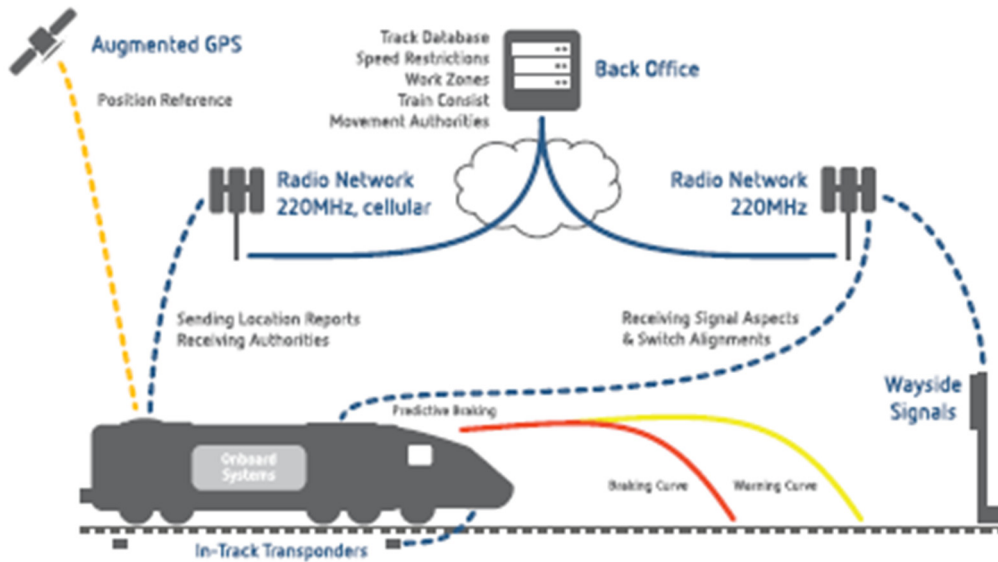
43. Train operations began in the United States in the early 1800s, and trains grew in size, speed, and weight-carrying capacity through the 1900s into the system we have today. Throughout the development of the rail industry, there has been the need for trains to have a method of operation that allows for exclusive occupancy of a track, allowing for collision avoidance and higher operating speeds. These methods of operation evolved from early timetable and train order systems to various paper-based mandatory directives, to signal overlay systems, to Traffic Control signals, and in parts of the U.S., cab signal systems that supplement wayside signals. Most of these methods of operation rely on the train crew to comply with their authority limits and maximum operating speeds. Railroading history is replete with instances where the crew members failed to do so.

44. For example, on September 12, 2008, Metrolink Train 111 departed westbound from the Chatsworth station in Chatsworth, California. The engineer on Train 111 was likely distracted by a personal electronic device and failed to stop

short of the subsequent Stop signal west of Chatsworth at CP Topanga. The Metrolink train subsequently collided with eastbound Union Pacific train LOF65-12, resulting in 25 fatalities and numerous injuries plus more than \$12 million in damages to the equipment and railroad infrastructure. In addition to the engineer's failure to comply with the wayside signal, the National Transportation Safety Board (NTSB) said in its report that "[c]ontributing to the accident was the lack of a positive train control system that would have stopped the Metrolink train short of the red signal and thus prevented the collision." EX1032, p. 66.

45. The Railway Safety Improvement Act (RSIA) of 2008 was signed into law by President G.W. Bush, roughly one month after the Chatsworth accident, on October 16, 2008. The requirement for railroads to implement Positive Train Control ("PTC") was a main provision of the 2008 RSIA and driven largely by the Chatsworth collision.

46. PTC is a processor-based/communication-based train control system designed to prevent train accidents. PTC may be implemented by a railroad following the requirements of 49 CFR Part 236, Subpart I – Positive Train Control Systems. The below diagram shows a general overview of PTC operation, including the main components of the "Onboard Systems" (on the train) the "Wayside Signals," the "Back Office," and the communications segment ("Radio Network"):



EX1037, 8.

47. PTC interfaces with a railroad's computer-aided dispatching systems and may additionally interface with existing wayside and/or cab signal systems. When all "goes well" and the train is operated in accordance with existing paper and dispatch/signal systems, PTC does not take any action to enforce train speed control or stop the train. It is thus critical that PTC function in compliance with the existing systems.

48. PTC technology is designed to be capable of automatically controlling train speeds and enforcing movement authority should the train operator fail to take appropriate action for the conditions present. As mandated by the RSIA and the associated regulations, PTC is intended to prevent:

- Train vs. train collisions;

- Unauthorized incursions by trains onto sections of track where maintenance activities are taking place;
- Derailments caused by excessive speed; and
- Movement of a train through a track switch left in the wrong position.

3. Collision Avoidance and Headway Time

49. A key aspect of collision warning and avoidance systems is the control of vehicle headway, that is, the separation distance between the host vehicle and any obstacle (for example another vehicle moving at the same speed) in front of the host vehicle. A common rule of thumb used for determining automotive headway is that the separation distance should be one vehicle length for every 10 mph of vehicle speed. This is the factor, for example, described in the Rashid patent discussed above (*See e.g.*, EEX1020, 5:38-45). A more systematic measure of headway is to maintain a fixed time interval between the host vehicle and the obstacle. This approach results in the same speed dependent separation, since at higher speeds the vehicle will cover more distance in a given time interval than at lower speeds, but it is intended to more readily allow for variations in reaction time and stopping time. For example, a paper titled *Driving Assistance Provided by Adaptive Cruise Control*¹ describes that under steady following (where the lead vehicle is moving at the same speed as the host

¹ EX1021.

vehicle, the desired headway is between 1.1 and 2.1 seconds, with a middle range of 1.5 seconds. With these headway times an alert driver (or an automated control system) can maintain a safe following distance to the vehicle ahead such that it is able to react and stop before colliding with the vehicle ahead.

4. Radar Sensing Generally

50. Radar (RADio Detection And Ranging) is a technique for detecting objects at a distance using radio waves. Conceptually a radar uses a transmitter and a receiver. The transmitter transmits a radio signal, in a given direction using a narrow beam antenna. The signal reflects off any objects in the path of the radio signal, and the reflected waves are received by the co-located receiver. Different radars use different types of radio signals, but conceptually all of them measure the time of flight of the signal to measure the range. Because radio signals travel at the speed of light it is a simple matter to calculate the range from the time of flight. Specifically:

$$R=c(T_F/2)$$

where c is the speed of light, and T_F is the round-trip time of flight, that is the time interval between when the radar signal was sent, and when the reflected signal is received.

51. In practice, different types of radars are used for different purposes. Two common types of radar are the frequency modulated continuous wave (FMCW)

radar and the Pulse Doppler radar. The FMCW radar uses a linear frequency modulation on an otherwise fixed amplitude radio signal, this signal is often referred to as a “chirp.” Since the frequency changes over time, the frequency difference between the transmitted signal and the received signal represents the round-trip time of flight. These radars generally use a mixer to combine the transmitted and reflected signals. The mixer then outputs a signal whose frequency is the difference between the transmitted and received signals. Depending on the range of the detected object, and the chirp rate, the resulting signal is generally low frequency, and this can be analyzed to measure the frequency, and thus the time difference between the transmitted and received signals. A minor drawback of this sort of system is that if the object is moving at a high-speed relative to the radar, the reflected signal will be doppler shifted, and thus the measured frequency difference, and the time of flight and resultant range will be slightly off. Measurement of relative speed requires measuring the range at multiple time intervals. From this the rate of change of the range can be determined, and this represents the relative speed of the object. For this reason, this measured speed is also known as range rate (i.e., the rate of change of range).

52. Pulse Doppler radar uses a short radio pulse of a known fixed frequency. The return signal is received and the time between the transmitted pulse and the received pulse is measured to determine the time of flight, and thus the range.

In addition, since the signal is at a fixed frequency, any difference between the frequency of the transmitted signal and the received signal represents the doppler shift created by the moving object, and from this the relative speed of the object can be calculated. A drawback of this type of radar is that if the object to be detected is located at a relatively close range the pulses are separated by a very short time interval, and in any case, there is a finite resolution for the time measurement, so there is a finite limit to the range resolution for this type of radar. The direction of the object can be determined either by using a narrow radio beam that is swept in azimuth, or by using a specialized pair of antennas. The signals from the two antennas are applied to sum and difference networks. The Sum output thus represents an antenna pattern that has a peak at boresight (the main axis of the radar). The output of the difference port exhibits a null at boresight, and signals from the right side of the antenna have opposite phases from signals from the left side. Using this scheme, when an object is located on the boresight of the antenna the output of the sum port is at a peak, and the output of the difference port is at a minimum. Similarly, as the object moves right or left the amplitude of the sum signal decreases, and the difference signal increases. Thus, it is possible to determine the azimuth direction of the object relative to the boresight of the radar without scanning the radar beam. This type of radar is also known as a “monopulse” radar, since it is possible to determine the range, the speed and the boresight angle relative to the

radar using only a single radio pulse. Radars may be implemented using a variety of frequencies, antenna types and signal modulations, depending on the desired application.

5. Vehicle to Vehicle Communications

53. Communication between vehicles is also well-known. For example, since the 1950's aircraft have used what is known as secondary surveillance radar (SSR)² to provide both position information as well as identification. This system uses a transponder on the aircraft that responds to a radar inquiry from an air traffic control system. Essentially the transponder receives a radar signal from the ATC center, adds its own information (for example identifying information and altitude information) to the radar signal and re-transmits it. The ATC radar then receives this response signal and, using conventional radar techniques, determines the position and speed of the aircraft, and, using communications techniques, extracts identification and other information added to the signal by the aircraft. Thus, SSR is both a radar system and a communication system.

54. Such vehicle-to-vehicle communication is not limited to aircraft. For example, drivers of automobiles frequently communicate with one another in order to convey their intentions. Anyone with even modest driving experience has

² See EX1031.

observed other drivers gesturing to one another to inform another driver that they may proceed ahead of them, or that they are turning, etc.

55. In 1997, the industry group Intelligent Transportation Systems, America (ITSA) petitioned the U.S. Federal Communications Commission (FCC) to allocate 75 MHz of spectrum in the 5.9 GHz band (5.85-5.925 GHz) for use in advanced transportation related applications (Intelligent Transportation Systems). This allocation (in 2002) led to the development of several standards to implement communication systems to use this spectrum. These standards defined the physical layer (originally specified in the IEEE 802.11p standard), the Medium Access Control (MAC), networking, security, and application layers (multiple standards under IEEE 1609.x), and a detailed message set defined in the SAE J2735 standard. *See generally* EX1022. Collectively these standards defined a short-range communication system known as Dedicated Short Range Communications (DSRC).

56. DSRC was intended to support a variety of transportation related applications including automobiles, commercial vehicles, off road equipment, and rail vehicles.

57. The SAE J2735 standard defines, among other things, a basic safety message (BSM) that provides a set of core operational data for a vehicle. The BSM is broadcast by all vehicles equipped with DSRC transceivers so that any other vehicles (or any type) in range can obtain this operational information. For example:

The basic safety message (BSM) is used in a variety of applications to exchange safety data regarding vehicle state. This message is broadcast frequently to surrounding vehicles with a variety of data content as required by safety and other applications. Transmission rates are beyond the scope of this standard, but a rate 10 times per second is typical. Part I data shall be included in every BSM.

EX1022, p. 26.

58. The BSM specification includes a variety of vehicle parameters. Specifically, it includes a data frame called “VehicleSize”, as shown below. The VehicleSize data frame comprises VehicleWidth and the VehicleLength data elements. As shown below, the VehicleLength data element provides the length of the vehicle in centimeters. Thus, the DSRC Message set contemplated sending the vehicle length as part of a general vehicle information message.

5.2 Message: MSG_BasicSafetyMessage (BSM)

Use: The basic safety message (BSM) is used in a variety of applications to exchange safety data regarding vehicle state. This message is broadcast frequently to surrounding vehicles with a variety of data content as required by safety and other applications. Transmission rates are beyond the scope of this standard, but a rate 10 times per second is typical. Part I data shall be included in every BSM. Part II data are optional for a given BSM and are included as needed according to policies that are beyond the scope of this standard. A BSM without Part II content is also a valid message. Refer to the Annex "Operation with the Basic Safety Message in Vehicles" for examples of how the Basic Safety Message can be used.

ASN.1 Representation:

```
BasicSafetyMessage ::= SEQUENCE {  
  -- Part I  
  msgID          DSRCmsgID,          -- 1 byte  
  
  -- Sent as a single octet blob  
  blob1          BSMblob,  
  
  --  
  -- The blob consists of the following 38 packed bytes:
```

- 26 -

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SAE J2735 Revised NOV2009

```
--  
-- msgCnt      MsgCount,          -x- 1 byte  
-- id          TemporaryID,       -x- 4 bytes  
-- secMark     DSecond,           -x- 2 bytes  
  
-- pos         PositionLocal3D,  
-- lat         Latitude,          -x- 4 bytes  
-- long        Longitude,         -x- 4 bytes  
-- elev        Elevation,         -x- 2 bytes  
-- accuracy    PositionalAccuracy, -x- 4 bytes  
  
-- motion      Motion,  
-- speed       TransmissionAndSpeed, -x- 2 bytes  
-- heading     Heading,           -x- 2 byte  
-- angle       SteeringWheelAngle -x- 1 bytes  
-- accelSet    AccelerationSet4Way, -x- 7 bytes  
  
-- control     Control,  
-- brakes      BrakeSystemStatus, -x- 2 bytes  
  
-- basic       VehicleBasic,  
-- size        VehicleSize,       -x- 3 bytes  
  
-- Part II, sent as required  
-- Part II,  
safetyExt     VehicleSafetyExtension OPTIONAL,  
status        VehicleStatus       OPTIONAL,  
  
... -- # LOCAL_CONTENT  
}
```

6.70 Data Frame: DF_VehicleSize

Use: The VehicleSize is a data frame representing the vehicle length and vehicle width in a three byte value.

ASN.1 Representation:

```
VehicleSize ::= SEQUENCE {  
    width      VehicleWidth,  
    length     VehicleLength  
} -- 3 bytes in length
```

7.136 Data Element: DE_VehicleLength

Use: The length of the vehicle measured from the edge of the front bumper to the edge of rear bumper expressed in centimeters, unsigned. Note that this is a 14 bit value and it is combined with a 10 bit value (DE_VehicleWidth) to form a 3 byte data frame. When sent alone it shall occupy 2 bytes. The value zero shall be sent when data is unavailable.

ASN.1 Representation:

```
VehicleLength ::= INTEGER (0..16383) -- LSB units are 1 cm
```

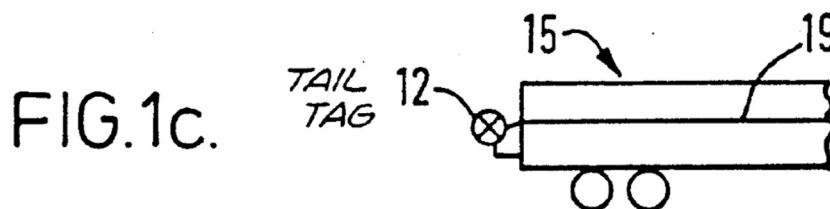
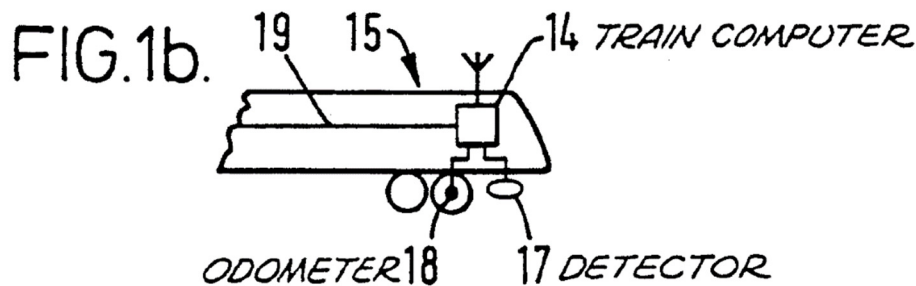
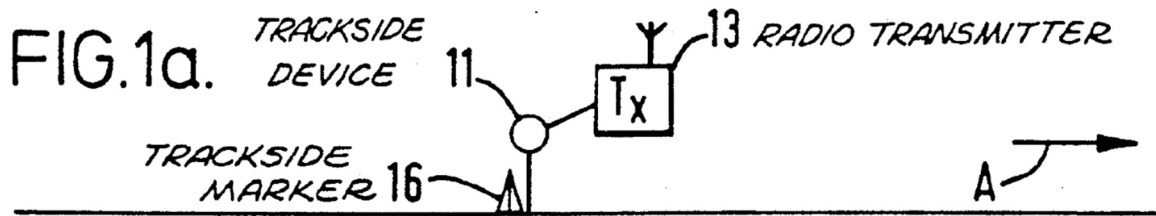
59. Communicating the length of a rail vehicle, or a train of such vehicle was also the topic of U.S. Patent No. 5,036,478 (“MacDougall”), which issued on July 30, 1991, from an application filed on April 13, 1989. In this patent the length of the rail vehicle or train is measured by determining the time interval between the passage of the front of the rail vehicle or train past a track-side device, and the passage of the rear of the rail vehicle or train past the track-side device. This length or the location of the rear of the train is then communicated to various elements that can use this information. For example:

The present invention enables a system whereby a railway vehicle or train of such vehicles can measure its own length and use this information to deduce and report to a following vehicle or train, or to an interlocking or control computer, or both, the

location or clearance of its tail in relation to fixed points along the track or to pass a positive report of vehicle or train length to an interlocking or control computer to enable the inter locking or control computer to effect subsequent route release and give proceed authorities to following vehicles or trains based on reports from the vehicle or train of the location of its front only.

EX1023, 2:3-14.

60. MacDougall describes the operation of this system in connection with Figure 1 of the patent, reproduced below.



Referring first to FIGS. 1a), 1b) and 1c), a trackside device 11 such as a transponder reader or magnet detector detects a corresponding tail tag 12 mounted on the tail of a train 15 moving in the direction of arrow A and generates a train tail detection message which is transmitted by a radio transmitter 13 to a train computer 14 at the front of the train 15. The location of the trackside device 11 is first recorded by the train computer as the front of the train passes and detects either a related trackside marker 16 (such as a transponder) or the active trackside device 11 itself by means of a detector 17, which may be a transponder reader of known type also used for other signalling purposes. The train computer 14 tracks distance travelled as in known systems, for example by an odometer 18, and is therefore able to measure the distance travelled between detection of the trackside device 11 or its associated marker 16 and receipt of the train tail detection message from the trackside device 11. This distance corresponds to the train length.

EX1023, 2:34-54.

6. Ultra-Wideband Positioning and Sensor Technology, Including Its Use for Ranging

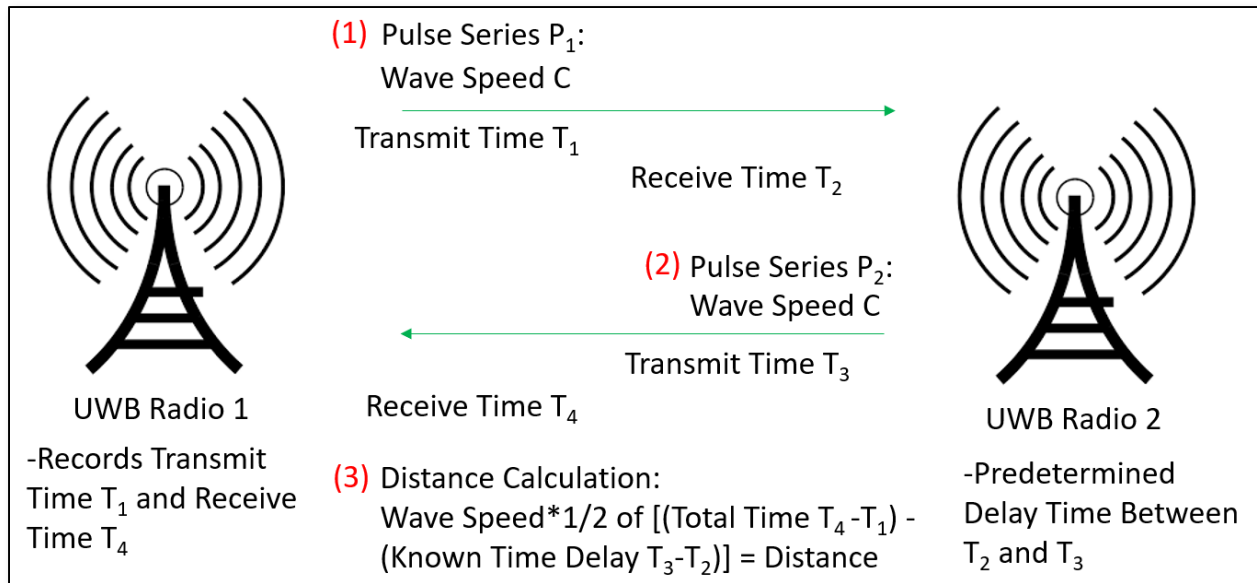
61. Ultra-Wideband (UWB) technology “is a wireless technology for transmitting large amounts of data over a wide spectrum of frequency bands with very low power and for a short distance.” EX1025, [0003]. UWB signals also “have the ability to carry signals through doors and other obstacles that tend to reflect signals having more limited bandwidths and a higher power.” *Id.* “UWB

communication has three main types of application:” “radar applications,” “data transmission applications,” and “location awareness applications” (i.e., ranging). *Id.*, at [0005]. One way UWB systems can achieve high-bandwidth is by transmitting impulse-like waveforms, which have a short time profile and wide frequency profile, as opposed to traditional RF modulated sine waves, which have a long time profile and narrow frequency profile. EX1027, at p. 3. By 2007, IEEE had established a UWB standard 802.15.4a which includes use of UWB in precision-ranging applications. *See generally* EX1026; EX1025, [0009] (noting as background information that the “IEEE 802.15.4.a Task Group (TG) has been established to develop a UWB-based physical (PHY) layer standard with a precision ranging capability.”).

62. UWB-based ranging techniques are used to measure the distance between two UWB radio units. Additionally, UWB devices can determine range with a single device by measuring round trip time from a reflected pulse. EX1005, FIG. 1A, [0009] One known way to perform ranging in UWB (and most radar technologies) is based on the time it takes for a wireless signal to travel from one radio unit to the other. *See, e.g.*, EX1028, [0004] (“Several methods are known in the art for wirelessly determining the location of roaming devices.”), [0006] (“Another sub-method measures the Time of Arrival (TOA) of a signal emitted by the roaming wireless device, received at least at three of the networks antennas.

Knowing the location of these antennas and the TOA of the received signal, the location of the roaming wireless device can be derived.”). For example, a first UWB radio unit may be on a fixed station on the wayside of a train track and a second UWB radio unit may be onboard a train traveling on the train track. The distance between the fixed station and the train can be measured based on the time it takes for UWB signals to be exchanged between the two UWB radio units. EX1029, FIG. 1, 6:3-9 (disclosing “[m]easuring the distance relative to a fixed reference upstream and/or downstream as *based on the flight time of signals* derived from pieces of geolocalised equipment and situated in upstream/downstream stations *determines, with high degree of certainty and accuracy, the absolute position of the guided mobile*”) (emphasis added); EX1025, [0010] (incorporating by reference a 2002 IEEE-published document that disclosed “a time-of-arrival (TOA)-based ranging scheme using an ultra-wideband (UWB) radio link”).

63. An example of how UWB-based ranging may be performed using two-way time-of-flight (TW-TOF) techniques according is illustrated below:



First, UWB Radio 1 transmits a first UWB signal that is received by UWB Radio

2. Then, UWB Radio 1 transmits a first UWB signal received by UWB Radio 2.

64. UWB Radio 2 transmits a second UWB signal that is received by UWB Radio 1. Finally, the time elapsed between UWB Radio 1 transmitting the first UWB signal and receiving the second UWB signal from UWB Radio 2 is used as the basis for calculating the distance between the two radios. EX1027, p. 11; EX1025, [0007]. For example, the distance calculation can be determined dividing the elapsed time in half (to get a one-way time-of-flight), subtracting the processing delay (i.e., the time between UWB Radio 2 receiving and responding to UWB Radio 1's signal), and multiplying the result by the velocity of the UWB signals (i.e., the speed of light in air). EX1025, [0008].

65. It was also known in the prior art that UWB (and other wireless technology) ranging measurements can also be used to determine the speed and

direction of movement of an object. For example, the distance between two units can be measured at regular intervals in the manner I described above. By measuring the distance between the transceivers at regular intervals, it is possible to calculate the speed and direction of movement of the object by comparing the distances between the transceivers at different points in time.

66. For example, if the distance between the transceivers increases over time, it can be inferred that the object is moving away from the receiver in a particular direction. Similarly, if the distance between the transceivers decreases over time, it can be inferred that the object is moving towards the receiver in a particular direction. The change in distance over an interval of time (typically a very short period of time such that straight line motion can be assumed) can be used to estimate the velocity over that interval (by dividing the change distance by the interval of time). *See, e.g.,* EX1039, 1 (“By co-locating such a chain of nodes along a railroad right-of-way, precise information on the location and velocity of trains could be distributed throughout the corridor.”).

67. UWB-based technology has several benefits over other common wireless technology. First, because of the wide-bandwidth / short-pulse duration of UWB signals, UWB-based signals are naturally resistant to multipath effects, improving operation in cluttered or non-line-of-sight (NLOS) environments without the need for additional techniques to overcome multipath effects. *See, e.g.,* EX1027,

p. 5 ; [0064]; EX1025, [0010]. By way of example, a UWB signal transmitted in many directions may take a direct path from a first UWB radio to a second UWB radio, and the same UWB signal may also take an indirect path from the first UWB radio to the second UWB radio by reflecting off of a wall. EX1027 at p.6. A narrowband (*i.e.*, long pulse) system may be unable to distinguish the direct path UWB signal from the indirect path UWB signal since they may overlap in time, resulting in multipath error. *Id.* In contrast, a UWB-based system uses short pulses that are more easily distinguishable in time because they are unlikely to overlap with their multipath reflections, allowing ranging to be performed using the first arriving UWB signal even if subsequent reflected versions of the same UWB signal arrive afterwards. EX1027 at pp. 6-7, 10.

68. As another advantage, UWB-based ranging provides high resolution for precise distance measurements. EX1027, p. 4. As I explained above, distance measurement is calculated based on the amount of time elapsed between transmission of a signal and its subsequent reception. *Id.*, p. 7. Since UWB signals are short and thus easily distinguishable in time, the arrival time of a UWB signal is easy to identify precisely. *Id.* Ambiguity in the exact arrival time can be reduced algorithmically to provide distance measurements with precision of less than a few inches, and theoretically less than 2 mm. *Id.*

69. Another advantage, UWB-based ranging may be combined with UWB-based data communications functionality to use the same UWB signals for both ranging and (non-ranging) data communications. EX1027, p. 13. That is, whereas previous systems used different technologies for ranging and data communications, needing multiple antennas, RF sections, and processors, a single UWB signal is simultaneously capable of transmitting data and used for ranging measurements. EX1027 at pp. 8-9, 13.

70. Another benefit of UWB-based technology is that it requires low operating power, making UWB efficient, unlikely to interfere with coexisting RF systems, and resistant to interception. EX1027 at p. 5; EX1025, [0003]-[0005]. For example, a typical UWB system transmits at power levels of only 50 μ W, and a high power UWB unit is around 10 mW. EX1027, p. 5; EX1028, [0015] (noting that Bluetooth's power ranges from 1mW to 100mW).

B. An Overview of the '227 Patent

71. The '227 patent discloses a system for “collision avoidance system (CAS) that includes one or more sensor technologies, including for example Ultra Wideband (UWB) sensing technology.” EX1001, Abstract.

72. The patent recognizes that prior art collision avoidance systems for rail-line vehicles existed employing various types of wireless sensors. “Previous systems for preventing collisions of rail-line vehicles have typically utilized a single sensor,

for example a GPS or radar-based sensor, to monitor the approximate location of rail mounted vehicles.” EX1001, 2:57-60.

73. The '227 patent asserts that these single sensor systems have various shortcomings depending on the type of sensors employed. “A shortcoming of single sensor systems, such as ones that depend on GPS sensors, is that the rail vehicles being monitored often enter into “blackout” areas (for example, around buildings, in the mountains, canyons, around sharp curves or in tunnels) where the single sensor may be unable to accurately determine the vehicle's location.” EX1001, 2:60-66; *see also* EX1001, 3:13-19 (“A limitation of radar-based sensors in particular is that they may initiate numerous false positives (warning alarms that are not warranted). With the normal clutter of maintenance operations (people, equipment, trains on adjacent tracks, trackside structures, trestle sides, tunnel walls), radar-based sensors can become confused as to when vehicles are actually in danger of colliding.”).

74. The '227 patent asserts that many of these limitations can be overcome by the use of a combination of known technologies, including UWB. “The present disclosure describes a collision avoidance system (CAS) for rail-line vehicles that may utilize a combination of sensor technologies, including an Ultra Wideband (UWB) sensing technology, to counter the limitations of previous systems, and to significantly reduce the potential for vehicle collisions and to enhance the safe operation of a variety of railway vehicles.” EX1001, 3:28 – 34.

75. Figure 3 depicts an exemplary collision avoidance system that includes Vehicle Mounted Modules (VMM) in communication with each other. In this exemplary system the VMMs are comprised of a number of components. “For example purposes only, FIG. 3 depicts a work gang including only two vehicles 302, 304. In this embodiment, the CAS 300 includes four main types of components—transponder sensor modules (TSMs) (for example, TSMs 306, 308), control electronics modules (CEMs) (for example, CEMs 310, 312), user interface modules (UIMs) (for example, UIMs 314, 316) and a central tracking unit (CTU) (for example, CTU 318). Referring to a single vehicle (vehicle 302 for example), modules that are located in or on the vehicle (for example, TSM 306, CEM 310 and UIM 314) may collectively be referred to as the vehicle mounted module (VMM), even though the individual modules and related components may or may not be housed within a unitary package/enclosure.” EX1001 5:64-6:13

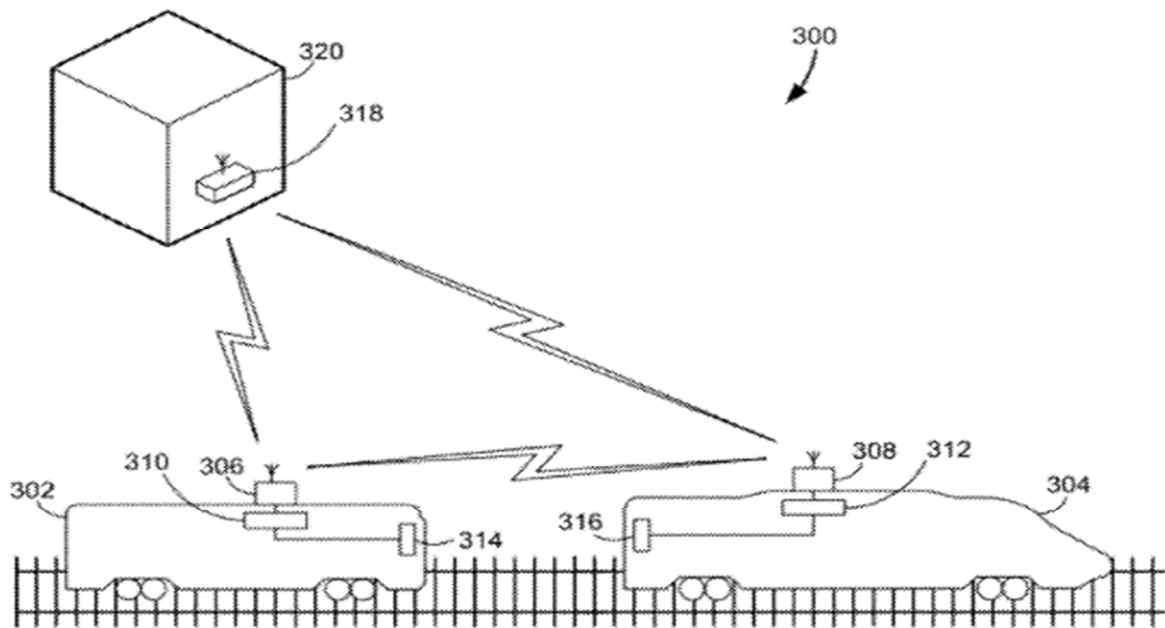


Fig. 3

EX1001, FIG. 3.

76. Figure 6 (below) illustrates an exemplary Vehicle Mounted Module (VMM) that is capable of communicating with an external Central Tracking Unit (CTU).

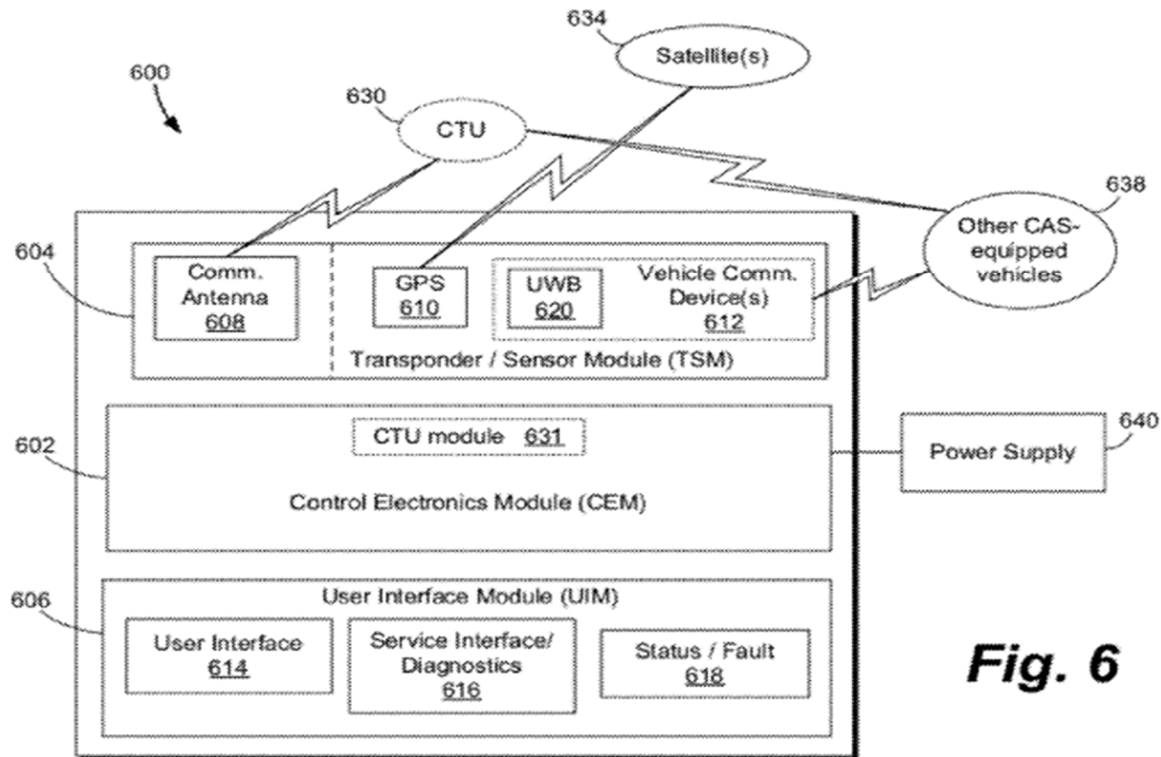
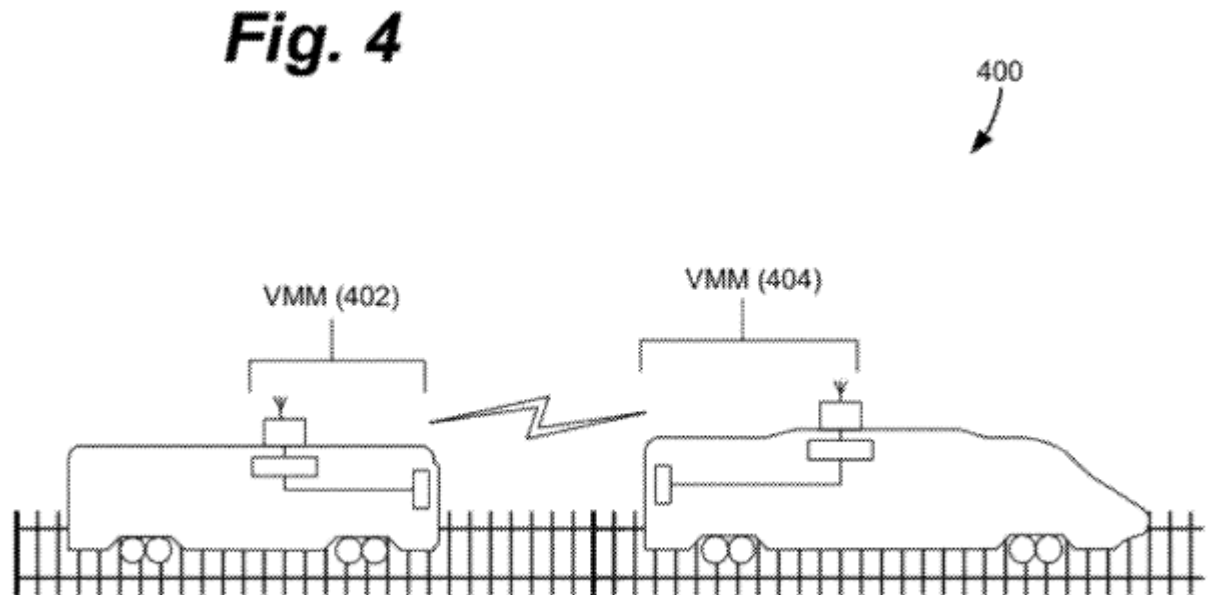


Fig. 6

EX1001, FIG. 6.

77. In other embodiments discussed in the '227 patent the functionality of the Central Tracking Unit is distributed among various VMMs. “In this embodiment, the functionality and intelligence of the CTU is dispersed and/or distributed among the VMMs (for example VMMs 402, 404) in the vehicles within a work gang. With this dispersed design (also referred to as “dispersed thinking”), each VMM includes its own CTU module/component that tracks the location of other vehicles in the work gang, like a CTU disposed in discrete housing would do. It should also be understood that although this embodiment describes a central tracking unit component, the central tracking unit circuitry and technology may be incorporated into other

components/subcomponents of the VMM, such as the CEM.” EX1001, 6:54-7:3. *See also* EX1001, FIG. 4 illustrating a communication between Vehicle Mounted Modules 402 and 404.



78. The ‘227 patent is directed to avoiding collisions between rail-line vehicles by tracking location, speed, and distance between them. “The collision avoidance system is designed to reliably track the location and speed of vehicles and the distance between the vehicles over a wide variety of track and terrain.” EX1001, Abstract. An exemplary method is illustrated in FIG. 14.

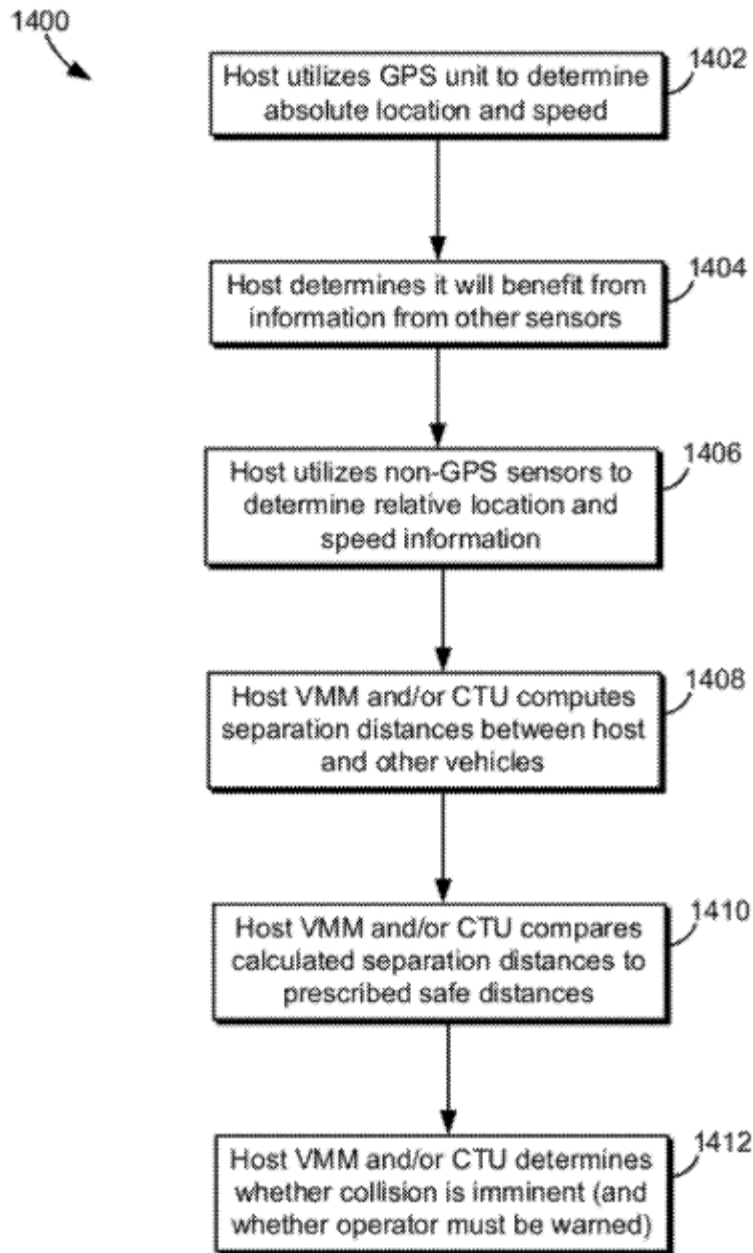


Fig. 14

79. This method is discussed in the '227 patent specification from 22:44 – 23:45. When determining the separation distance and closing speed UWB may be used instead of GPS. “The host may utilize one or more vehicle communication

devices. For example, the UWB unit may determine separation distance and closing speed.” EX1001, 23:1-3.

80. If the system detects that a collision may be imminent, it is configured to warn an operator. “The CAS may consider a variety of types of data and scenarios to determine if a collision is imminent. For example, a separation distance of 40 feet may be acceptable when vehicles are traveling at 5 miles per hour, but if the vehicles are traveling at 20 miles per hour, an unsafe condition may exist and the operator will be notified with an audible and visual alert. In another example, a vehicle that is far ahead may not pose a hazard, but one that is directly ahead, and moving slower than the host vehicle may be a potential collision hazard. In another example, two vehicles may have been creeping along the tracks at a separation distance of 100 feet, and then the vehicles speed up to reach another worksite. If the separation distance does not increase with the increase in speed, the CAS may sound a warning or alarm.” EX1001, 23:31-45.

81. In some examples discussed in the ‘227 patent, the notification of the operators can be through a series of progressive alarms. “Instead of sounding a “hard” alarm through visual and audible alarms when a separation distance is violated, the CAS may utilize a “progressive” warning approach. In general, as the relative spacing between potential alarm events decreases, the collision avoidance system may increase the severity of the warning indication. For example, if a vehicle

is on a collision course but has not yet reached a hard threshold, the collision avoidance system may initiate a “soft” alarm/notification initially, such as a short, quiet, visible-only or subdued alarm. The rate, frequency, prominence and/or severity of the alarm may then increase as the vehicles get closer to the hard alarm threshold (indicating a more critical threat condition).” EX1001, 23:57-24:3

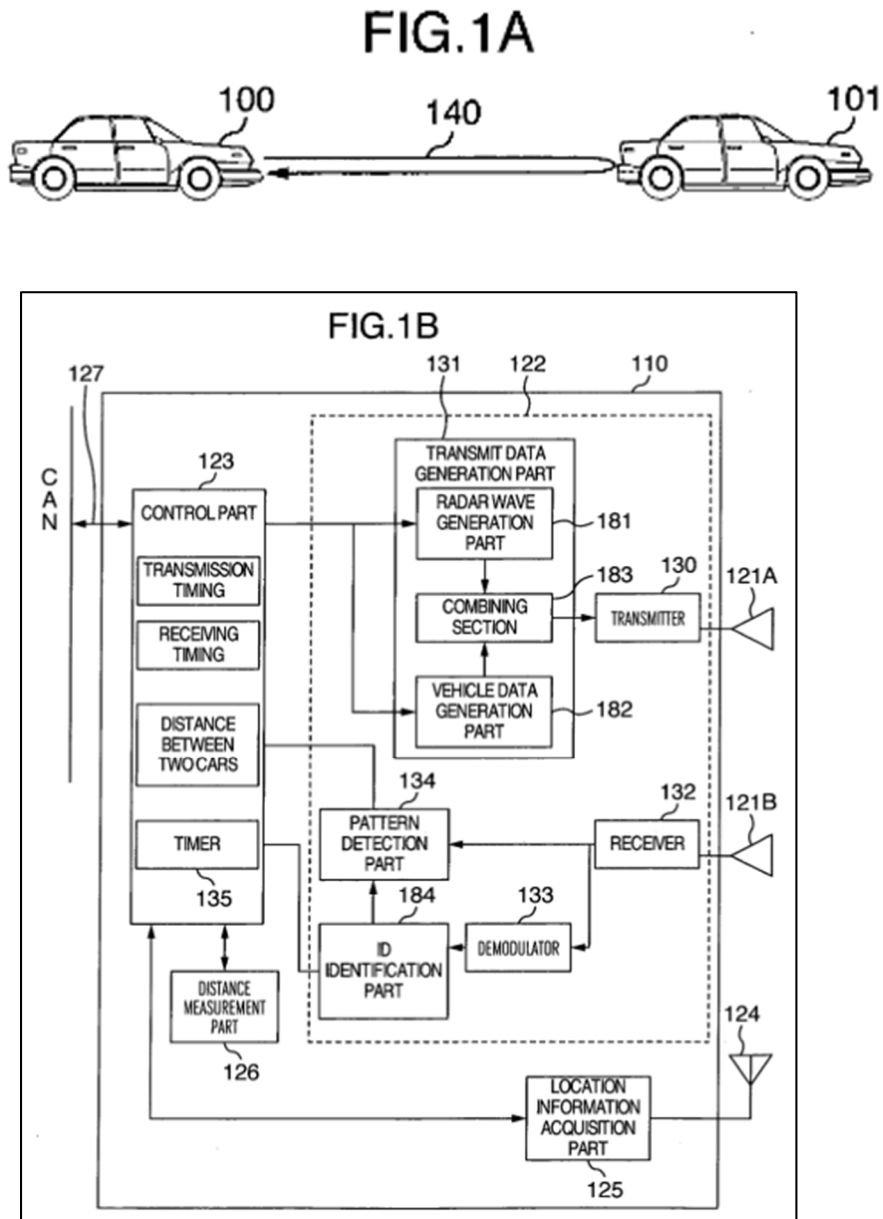
VI. OVERVIEW OF THE PRIOR ART

A. European Patent Application No. EP 1 785 744 (“Suzuki”) (EX1005)

82. Suzuki is entitled “In-Vehicle Radar Device and Communication Device” and was published May 16, 2007. I was told to assume Suzuki qualifies as prior art. It was not cited or considered during prosecution. *See* EX1001, 1.

83. Suzuki describes a method for preventing collisions between vehicles that uses UWB devices having both communication and radar/ranging functions. EX1005, (57). The distance between two vehicles is measured using the UWB-radar function. *Id.* Based on the result, a hazard warning may be issued to the vehicle driver, or a pre-crash operation may be carried out. *Id.* Each vehicle also measures its own position using GPS and transmits such location information to the other vehicle; the separation distance between the vehicles may be measured based on this location information and a hazard warning issued or a pre-crash operation carried out. EX1005, (57), [0013], FIG. 7. The operating frequency and transmission power of the radar are changed based on the vehicle’s own location information, thereby

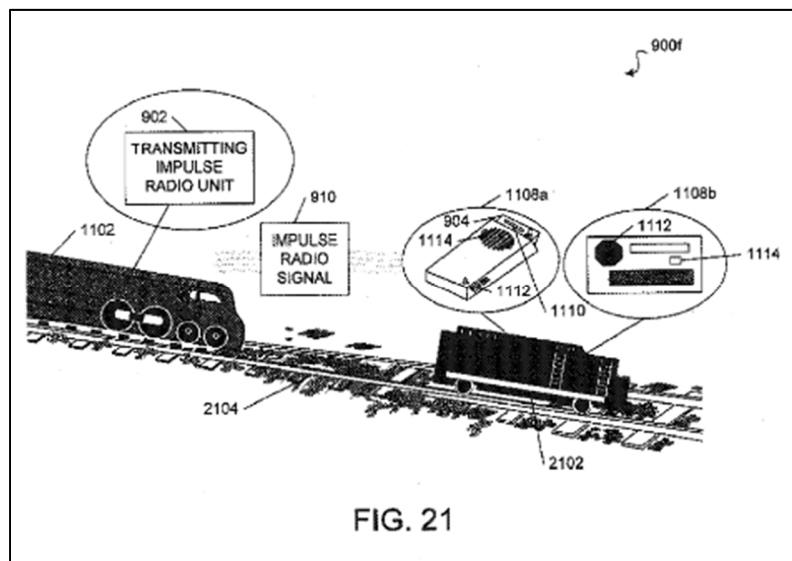
reducing interference from other wireless systems. EX1005, (57). Figures 1A and 1B of Suzuki illustrate an exemplary embodiment of the system and certain of its components:



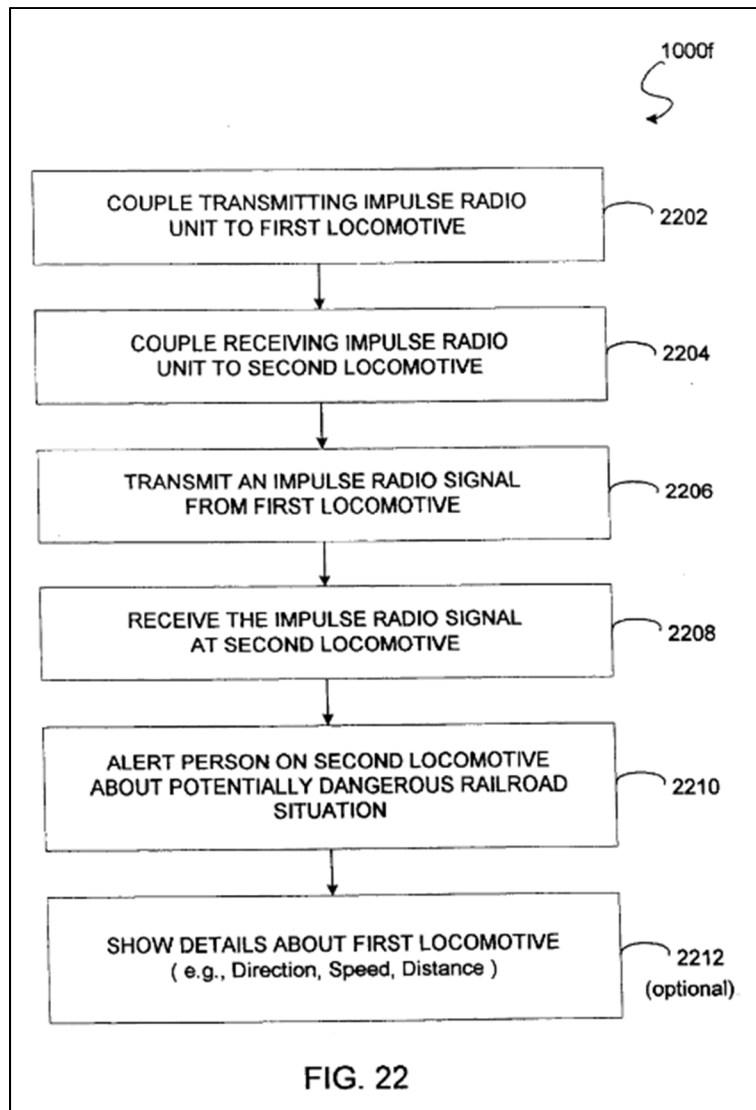
B. U.S. Patent No. 6,759,948 (“Grisham”) (EX1006)

84. Grisham is entitled “Railroad Collision Avoidance System and Method for Preventing Train Accidents” and issued July 6, 2004. I was told to assume Grisham qualifies as prior art. It was not cited or considered during prosecution.³

85. Grisham describes a collision avoidance system for vehicles such as automobiles, rail work vehicles, and locomotives using UWB technology (impulse radios). *See, e.g.*, EX1006, Abstract. Figures 21 and 22 illustrate an embodiment using UWB units on first and second locomotives to avoid collisions. *Id.*, FIGs. 21-22.



³ I understand that a different Grisham reference was of record.

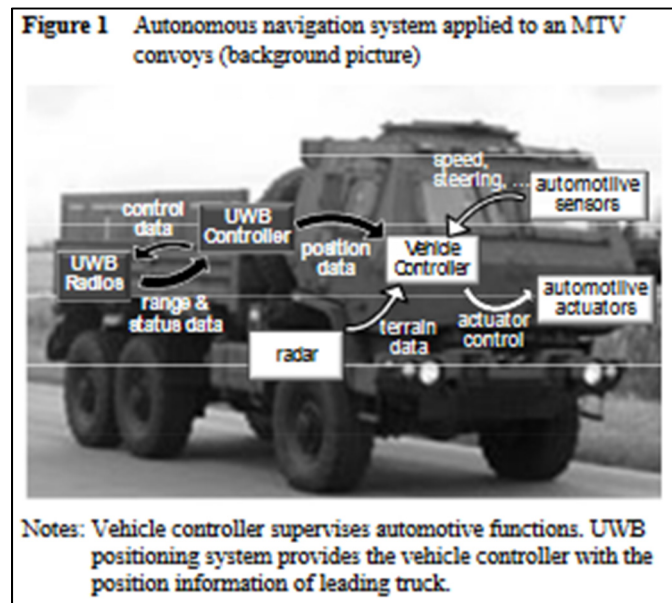


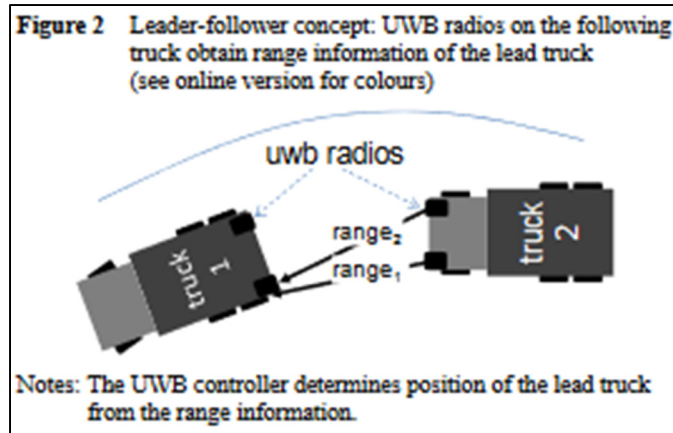
86. Grisham teaches using UWB units on a locomotive and a rail work vehicle to prevent collisions between two rail vehicles. *Id.*, FIGs. 19-20. Grisham also includes embodiments in which UWB units are mounted on an automobile and on a locomotive to prevent collisions between the automobile and locomotive. *Id.*, FIGs. 11-12.

C. An Outdoor UWB Tracking System to Improve Safety of Semi Autonomous Vehicle (“Richardson”) (EX1008)

87. Richardson is entitled “An Outdoor UWB Tracking System to Improve Safety of Semi Autonomous Vehicle” and was published online on February 25, 2010. EX1007, ¶¶43-52. I was told to assume Richardson qualifies as prior art. It was not cited or considered during prosecution.

88. Richardson teaches a UWB positioning system integrated into the control system of semi-autonomous vehicles to improve navigation capability and safety by providing operators with positional information about nearby objects and vehicles. EX1008, Abstract and pp. 209-210. Figures 1 and 2 illustrate a “leader-follower” application, where multiple UWB units on each vehicle provide positioning information of a lead vehicle to a following vehicle:





D. U.S. Patent Publication No. 2010/0052945 (“Breed ‘945”) (EX1014)

89. Breed ‘945 is titled “Vehicular Communication Arrangement and Method,” published March 4, 2010. I was told to assume Breed ‘945 qualifies as prior art. It was not cited during prosecution.⁴

90. Breed ‘945 is directed to a vehicle-to-vehicle communication system to avoid collisions, including among trains. EX1014, [0011], [0088], [0109]. Breed ‘945 teaches the use of an “[i]nertial measurement unit (IMU), inertial navigation system (INS) [or] inertial reference unit (IRU).” *Id.*, [0093], [0205]. The information collected from the IMU can be used to “substantially improve the crash sensing algorithms.” *Id.*, [0206]. Breed ‘945 explains the IMUs “contain 3 accelerometers and 3 gyroscopes.” *Id.*, [0093].

⁴ A different Breed reference (Breed ‘786) was of record as noted above. Breed ‘283 is from a different patent family than Breed ‘786

E. U.S. Patent Publication No. 2007/0255498 (“McDaniel”) (EX1015)

91. McDaniel is entitled “Systems and Method for Determining Threshold Warning Distances for Collision Avoidance” and published November 1, 2007. I was told to assume McDaniel qualifies as prior art. It was not cited or considered during prosecution.

92. McDaniel teaches a threshold warning distance, which is the “minimum distance that may be required by the host machine 110 to avoid a collision.” EX1015 [0039]. McDaniel also teaches measuring stopping distances to avoid collision. *Id.* at [0039-0045]. McDaniel defines “stopping distance” as “the minimum distance that may be required for a particular moving object, under certain operating circumstances, to decelerate to a complete stop.” *Id.* at ¶0042.

F. International Application No. WO 03/009254 (“Nixon”) (EX1016)

93. Nixon is entitled “Method and Apparatus for Avoiding Collisions” and published January 30, 2003. I was told to assume Nixon qualifies as prior. It was not cited or considered during prosecution.

94. Nixon teaches using GPS as a way of determining the position of moving vehicles, such as trains. *Id.* at 6-7. Nixon discloses mounting collision avoidance equipment to a vehicle, such as a train. *See id.* at 6. Nixon discloses an alarm system that produces an alert signal based on the proximity of the trains to

each other. *See id.* at 5-6. For example, if the control processor “determines that the target is closer, beeping is faster.” *Id.*

G. U.S. Patent Publication No. 2009/0255329 (“Connell”) (EX1012)

95. Connell is titled “Method and System for Determining Brake Shoe Effectiveness,” published October 15, 2009. I was told to assume Connell qualifies as prior art. It was not cited during prosecution.

96. Connell teaches a control system that dynamically determines the effectiveness of a train’s brake shoes during travel based on braking data (braking arrangement, brake application level, etc.) and train data (train speed, track profile, etc.). EX1012, [0025]-[0026]. Connell also teaches, “[o]nce the selected or desired brake shoe effectiveness data 22 is determined, a variety of control and operational parameters of the train TR can be determined or set” *Id.*, [0028].

H. U.S. Patent No. 8,874,359 (“Douglas”) (EX1011)

97. Douglas is titled “Collision Avoidance Method, System and Apparatus,” and was published October 21, 2010. I have been told to assume it qualifies as prior art. It was not cited during prosecution.

98. Douglas teaches “equipping a plurality of trains each with a transceiver and broadcasting a signal periodically from the transceiver of each train. The signal contains a unique identification of a respective train and a unique identification of a

track the respective train is moving on.” EX1011, Abstract. Douglas also teaches similarly equipping train stations with transceivers. *Id.*, 4:32-49, 7:10-12.

VII. CLAIM INTERPRETATION

99. I understand that determining whether a claimed invention is non-obvious requires comparing the prior art to the claim. I discuss in the sections below the interpretations I have applied to certain claim terms, in accordance with the standards set forth in Section III above.

100. For the reasons I discuss in Sections VIII.A. to VIII.Q., it is my opinion that the prior art I consider in those sections plainly disclose the claim limitations without having to determine the exact outer boundary of the claim terms’ scope and meaning.

VIII. THE CHALLENGED CLAIMS ARE UNPATENTABLE IN LIGHT OF THE PRIOR ART IDENTIFIED IN THE PETITION

101. I have been asked to provide my opinion concerning whether claims 1-28 of the ’227 patent would have been obvious to a POSITA in light of the prior-art. For the reasons explained below, it is my opinion that each of claims 1-28 would have been obvious to a POSITA over the prior art discussed below.

A. Ground 1A: Claims 1, 11, and 14 are obvious over Grisham in view of the knowledge of a POSITA

102. It is my opinion that Grisham in view of the knowledge of a POSITA renders claims 1, 11, and 14 obvious.

1. Claim 1

103. It is my opinion that Grisham in view of the knowledge of a POSITA renders claim 1 obvious.

104. Claim element 1-Pre recites **“A collision avoidance system comprising.”** I understand that whether a claim’s preamble is treated as a limitation on the scope of the claim is a legal question. For the purposes of my analysis this determination is not important because should the preamble be found limiting, it is taught by Grisham

105. Grisham teaches a “Railroad Collision Avoidance System and Method for Preventing Train Accidents.” *See* EX1006, title. Additionally, Grisham teaches “The present invention includes a railroad collision avoidance system and method that utilize impulse radio technology to effectively warn a person when there is a locomotive in their vicinity. In one embodiment, the railroad collision avoidance system includes a transmitting impulse radio unit coupled to a locomotive and a receiving impulse radio unit coupled to a vehicle. The transmitting impulse radio unit operates to transmit an impulse radio signal towards the vehicle when the locomotive is a predetermined distance from a railroad crossing. Upon receiving the impulse radio signal, the receiving impulse radio unit makes sure the person operating the vehicle is informed about the potentially dangerous situation. Several different embodiments of the railroad collision avoidance system and method all of which operate to warn a person when there is a locomotive in their vicinity are described below.”

EX1006, 2:16-31. *See also* “1. A railroad collision avoidance system comprising:” EX1006, claim 1 preamble.

106. Claim element 1a recites “**one or more vehicle mounted modules, each vehicle mounted module mountable on a rail vehicle, each vehicle mounted module comprising:**” It is my opinion that Grisham teaches a system having one or more vehicular mounted modules and, thus, renders this claim element obvious. Grisham teaches first and second radio units (e.g., 902 and 904) coupled to rail vehicles.

107. For example, Grisham states “Referring to FIGS. 21 and 22, there are diagrams illustrating in greater detail the components and steps of a sixth embodiment of the railroad collision avoidance system 900f and method 1000f. In this embodiment, the railroad collision avoidance system 900f includes a transmitting impulse radio unit 902 coupled (step 2202) to a first locomotive 1102 and a receiving impulse radio unit 904 coupled (step 2204) to a second locomotive 2102.” EX1006, 23:33-40. *See also* FIGs 21 and 22.

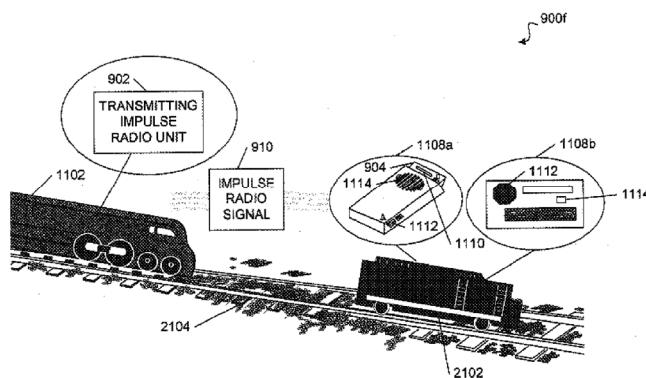


FIG. 21

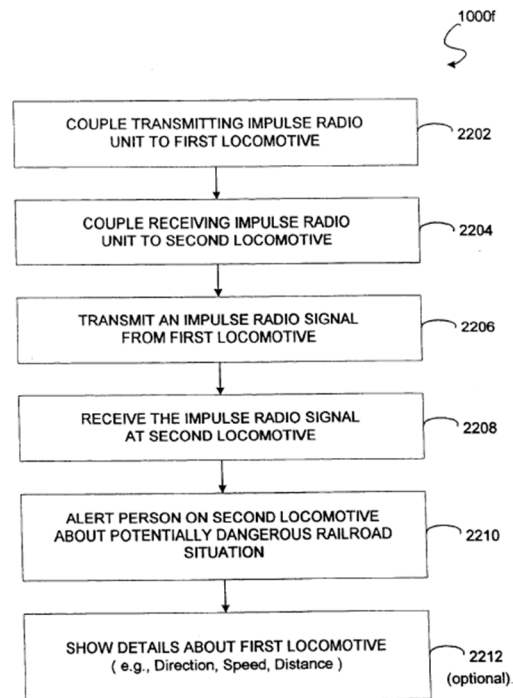


FIG. 22

108. Claim element 1b recites **“a transponder sensor module operable to send and receive data wirelessly, the transponder module comprising a first ultra wideband unit and a first antenna.”** It is my opinion that Grisham teaches this claimed transponder sensor module.

109. For example, as discussed above Grisham teaches radio communication units that include transmitting impulse radio unit 902 and receiving impulse radio unit 904. *See* 1a above. Grisham further explains that in some embodiments these units both transmit and receive and are known as “transceivers.” Grisham states “In a transceiver embodiment, substantial economy can be achieved by sharing part or all of several of the functions of the transmitter

602 and receiver 702. Some of these include the time base 718, precision timing generator 714, code source 722, antenna 704, and the like.” EX1006, 17:44-46. A POSITA would understand that these transceiver units are capable of both transmission and reception of data.

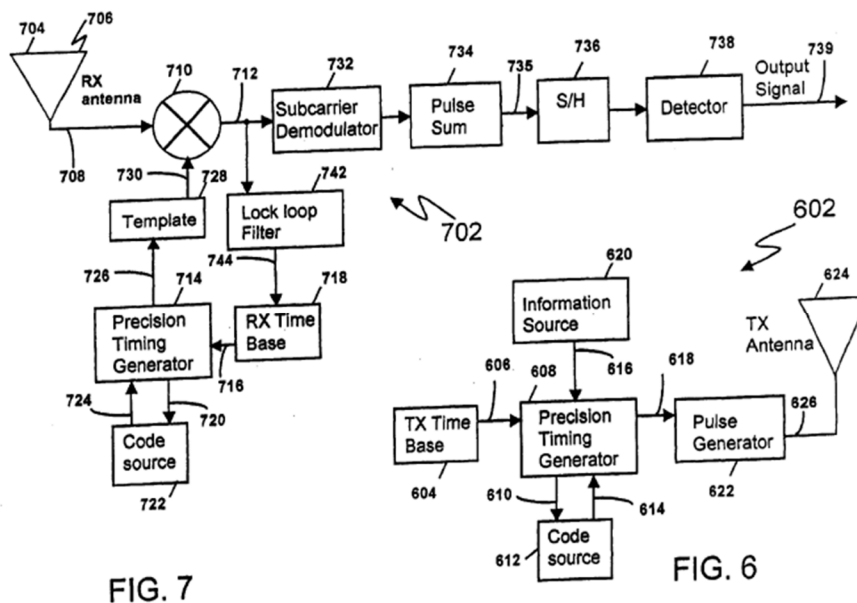
110. Further, Grisham states that

“This section provides an overview of impulse radio technology and relevant aspects of communications theory. It is provided to assist the reader with understanding the present invention and should not be used to limit the scope of the present invention. It should be understood that the terminology ‘impulse radio’ is used primarily for historical convenience and that the terminology can be generally interchanged with the terminology ‘impulse communications system, ultra-wideband system, or ultra-wideband communication systems’. Furthermore, it should be understood that the described impulse radio technology is generally applicable to various other impulse system applications including but not limited to impulse radar systems and impulse positioning systems. Accordingly, the terminology ‘impulse radio’ can be generally interchanged with the terminology ‘impulse transmission system and impulse reception system.”

Id. at 4:44-60.

111. In my opinion a POSITA would have understood that a “transceiver” is a type of “transponder”. Grisham also notes its preference for its inventions to have “the emitted signal [be] wide-band or ultrawide-band.” *Id.* at 16:47-49. Grisham also describes using an “ultra-wideband” antenna when discussing the ideal

waveforms of the impulse radios. *Id.* at 6:12, 37-43. As shown in FIGS. 6 and 7 below, Grisham details each component of impulse radios, which includes a “transmit antenna 624” and a “receive antenna 704.” *Id.* at 16:39-49, 59-60. Therefore, Grisham describes the impulse radio units shown in Figures 21 and 22, which transmit and receive signals, as ultrawide-band units with an “ultra-wideband” antenna (a first antenna and a second antenna). *See id.* at 23:33-47.



112. Claim element 1c recites the following. **“a control electronics module comprising a processor in communication with at least the transponder sensor module unit;”** It is my opinion that Grisham teaches this control electronics module communicating with the transponder sensor module.

113. Grisham states the following.

“To determine the distance that the first locomotive 1102 is from the second locomotive 2102, *a controller 1110 within the receiving impulse unit 904 can use the revolutionary positioning capabilities of impulse radio technology.* In particular, the impulse radio signal 910 transmitted between the transmitting impulse radio unit 902 and the receiving impulse radio unit 904 enables the controller 1110 to measure distances to extremely fine resolution because of the absence of ambiguous cycles in the waveform of the impulse radio signal 910. In contrast, narrow band systems of traditional communication systems are limited to the modulation envelope and cannot easily distinguish precisely which RF cycle is associated with each data bit because the cycle-to-cycle amplitude differences are so small they are masked by link or system noise. Since the waveform of the impulse radio signal 910 does not have multi-cycle ambiguity, this allows the controller 1110 to positively determine the position of the waveform to less than a wavelength even when the waveform is in or near the noise floor of the system. *The time position measurement can be used by the controller 1110 to measure the propagation delay and determine the link distance between the receiving impulse radio unit 904 and the locomotive 1102.* Once, the distance is known and updated then the speed of the first locomotive 1102 can be determined by the controller 1110.”

EX1006, 23:66-24:24 (*emphasis added*).

114. Grisham additionally teaches that “It should be understood that the first locomotive 1102 can contain the same equipment as the second locomotive 2102 (or

other objects 908) and as such could be notified of the presence and speed of an oncoming second locomotive 2102 (or other objects 908).” EX1006, 24:25-29.

115. It is my opinion that a POSITA would have understood that the controllers taught by Grisham would contain processors or would have been motivated to include them due to their efficiency of processing diverse complex tasks such as ranging and distance calculations, user interface control, and alarm generation. Thus, the controller 1110 (and its processor) communicates with the transponder sensor module (the receiving impulse unit 904 within the transponder sensor module), e.g., to communicate with other radio units via “the impulse radio signal 910 transmitted between” them. EX1006, 23:64-24:24, FIG 22. *See also* 1e below.

116. Claim element 1d recites the following. **“a user interface module including a user interface, the user interface being operable to provide rail vehicle information to a vehicle operator and to receive input from the vehicle operator;”** It is my opinion that Grisham teaches the claimed user interface (via a display) and its functionality.

117. Grisham teaches the following.

“For instance, the receiving impulse radio unit 904 may be incorporated within or coupled to *an after-market display 1108a (showing the receiving impulse radio unit 904) or an in-dash display 1108b (not showing the receiving impulse radio unit 904)*. Either display 1108a or

1108b is capable of alerting a person that there is a locomotive 1102 in their vicinity by generating an alarm (see light 1112) or voice message (see speaker 1114). Moreover, *a person could use the display 1108 having a transmitting impulse radio unit (not shown) to communicate with a person on the locomotive 2102 having a receiving impulse radio unit (not shown). In addition, either display 1108a or 1108b is capable of showing (step 2210) the direction, distance and/or speed of the oncoming first locomotive 1102.*”

EX1006, 23:52-66 (*emphasis added*).

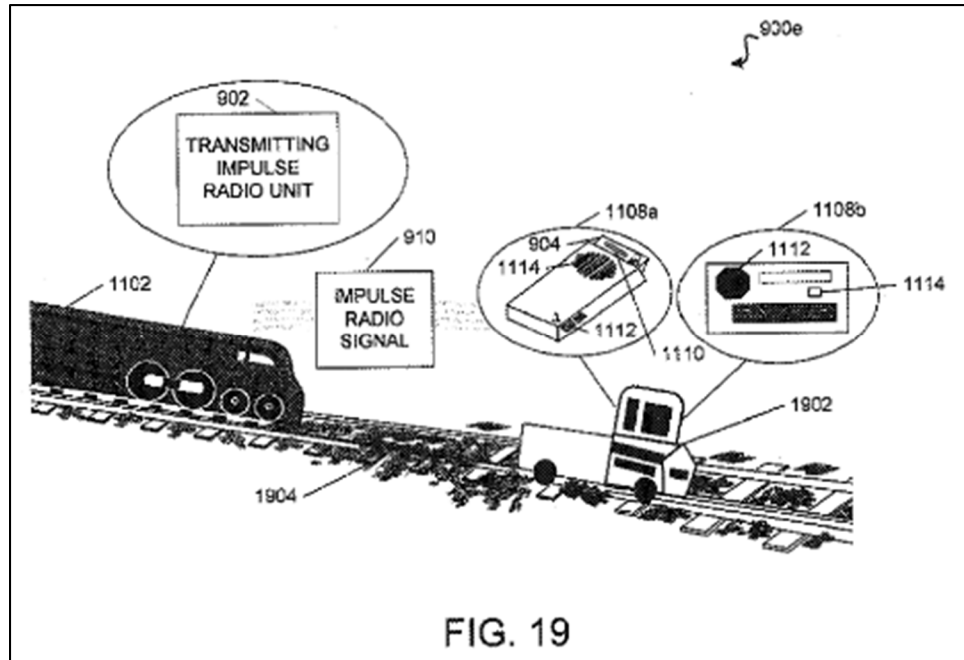
118. A POSITA also would have understood that it was conventional for a display, including an “after-market” display, to receive user input, such as adjustments to the display’s settings. Further, a POSITA would have understood that since each display allows the operator to communicate with the operator of another vehicle it necessarily indicates that each user interface must be able to receive inputs from the vehicle operator.

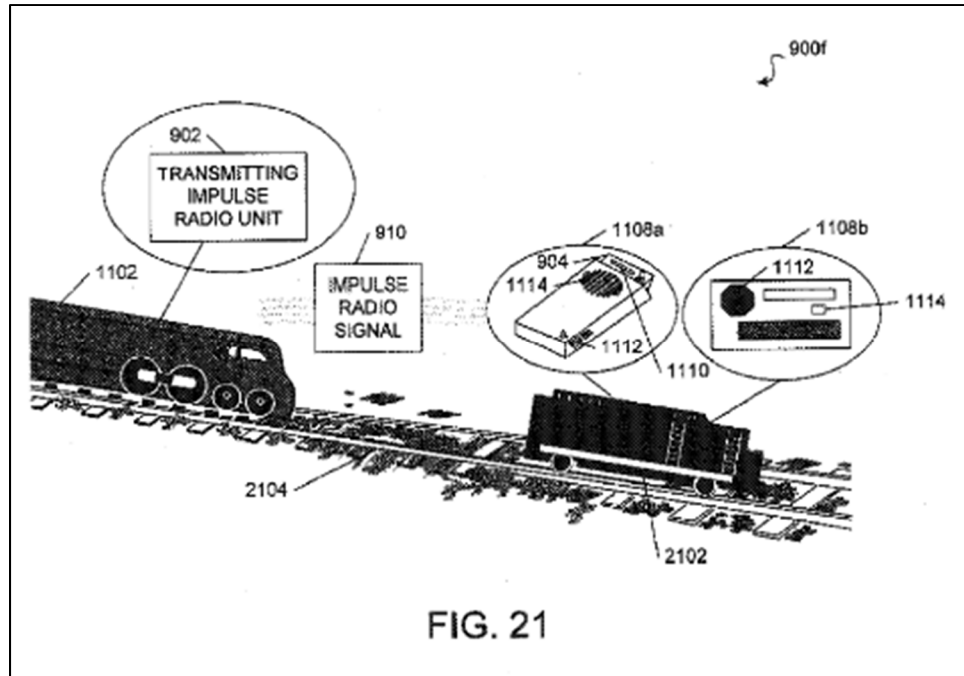
119. Claim element 1e recites **“wherein each vehicle mounted module is operable to communicate with at least one other vehicle mounted module mounted on at least one other rail vehicle.”** In my opinion, Grisham teaches the vehicle mounted units are operable to communicate with each other.

120. As discussed above in Section VIII.A.1., Grisham’s vehicle mounted modules contain UWB transceiver units capable of communicating with each other. Grisham’s transmitting impulse radio unit can “continually transmit (step 2206) an

impulse radio [*i.e.*, a UWB] signal.” *Id.*, 23:40-47. A receiving impulse radio unit 904 on a second train receives that signal. *Id.*, 23:48-49; *see id.*, 24:25-29.

121. For example, Figures 19 and 21 illustrate UWB communications between a transmitting impulse radio unit 902 coupled to a locomotive on the one hand, and a receiving impulse radio unit 904 coupled to a rail work vehicle (in Fig. 19) or a second locomotive (in Fig. 21) on the other. EX1006, Figs. 19, 21; *id.*, 22:45-49, 23:36-40.





122. Claim element 1f recites **“wherein each vehicle mounted module is operable to apply a time of flight technique to determine a separation distance between the rail vehicles.”** It is my opinion that this claim element is taught by Grisham.

123. Grisham teaches the use of time position measurements to calculate a *propagation delay* in order to determine distance between vehicles. A POSITA would have understood that propagation is the process of radio waves traveling (i.e., “flying”) through space, and a delay is simply a time period. Thus, propagation delay is the time that the radio waves take to travel or “fly” from one point to another, which is the same as the claimed “time of flight.” Grisham also states “The time position measurement can be used by the controller 1110 to measure the propagation delay and determine the link distance between the

receiving impulse radio unit 904 and the locomotive 1102. Once, the distance is known and updated then the speed of the first locomotive 1102 can be determined by the controller 1110.” EX1006, 24:18-24.

124. Grisham additionally incorporates US Patent 6,133,876 to Richards by reference at 14:56-62. I understand that by incorporating this patent by reference it becomes part of the specification of the Grisham disclosure. Richards explains time of flight is calculated using two sequences of pulses between two transceivers. EX1013, 2:31-44. The sequences are synchronized at their respective transceivers. *Id.* A “delayed first reference signal is generated in response to the synchronization.” *Id.* at 2:38-40. Richards explains “a time difference between the delayed first reference signal and the first reference signal is measured.” *Id.* at 2:38-42. The difference in the two times is the “total time of flight” of the sequences and the distance between the transceivers (and the trains) is determined from the time difference. *Id.* at 2:42-46. It is my opinion that A POSITA would have known or understood that the time of flight calculations are performed by the embodiment shown in Figures 21 and 22. *See* EX1006, 24:18-24.

2. Claim 11

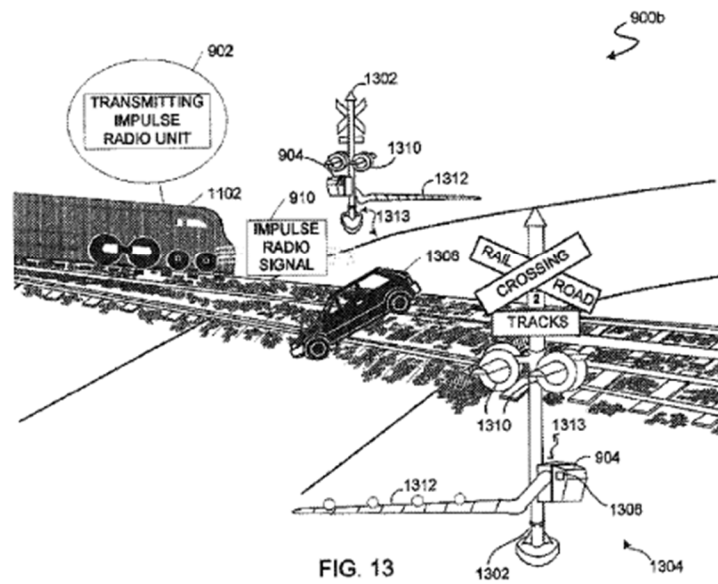
125. Claim 11 recites “**The collision avoidance system of claim 1, further comprising at least one ground speed detection module operable to determine the speed of the rail vehicle, wherein the first vehicle mounted module**

communicates with the at least one ground speed detection module.” It is my opinion that Grisham in combination with knowledge of a POSITA would render claim 11 obvious.

126. As discussed above in Section VIII.A.1., Grisham teaches radio units within the vehicle mounted modules. These units are in communication with the control boxes which are located near the tracks. As illustrated in FIGs 13 (control box 1502) and 14 (step 1606), these units are in communication with control boxes. A POSITA would know that determining subsequent range calculation to a fixed location “near the track” would allow a calculation of ground speed. A POSITA would understand that simple subtraction of a first distance from a second distance yields the difference in distance and that parameter divided by the difference in time between the range measurements gives the speed. Indeed, Grisham teaches

“The time position measurement can be used by the controller 1110 to measure the propagation delay and determine the link distance between the receiving impulse radio unit 904 and the locomotive 1102. ***Once, the distance is known and updated then the speed of the locomotive 1102 can be determined by the controller 1110.***”

EX1006, 24:19-24 (*emphasis added*).



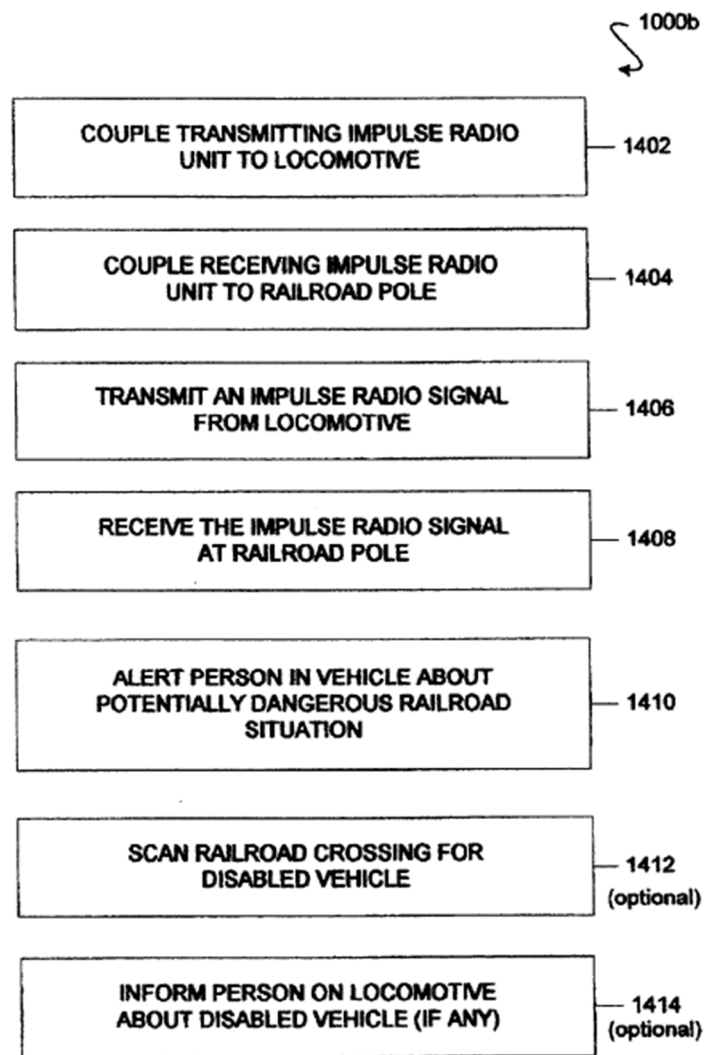


FIG. 14

127. In addition, it was well known that measuring range rate (changes in range over a finite time interval) in order to determine speed, as described above is only able to measure *relative* speed, thus it would have been obvious to a POSITA to include some independent measure of vehicle speed so that the speed of the other sensed vehicle could be reliably determined. Doing so would have been obvious to try and would have been well within the capability of a POSITA, since, by the

priority date of the '227 patent, trains were well-known to include speed measurement devices.

3. Claim 14

128. Claim 14 recites **“The collision avoidance system of claim 1 wherein the ultra wideband unit is adapted to transmit and receive signals with varying center frequencies.”** It is my opinion that Grisham in view of the knowledge of a POSITA would render claim 14 obvious.

129. Grisham teaches the following.

“Impulse radio refers to a radio system based on short, low duty-cycle pulses. An ideal impulse radio waveform is a short Gaussian monocycle. As the name suggests, this waveform attempts to approach one cycle of radio frequency (RF) energy at a desired center frequency. Due to implementation and other spectral limitations, this waveform may be altered significantly in practice for a given application. Many waveforms having very broad, or wide, spectral bandwidth approximate a Gaussian shape to a useful degree. Impulse radio can use many types of modulation, including amplitude modulation, phase modulation, frequency modulation, time-shift modulation (also referred to as pulse position modulation or pulse-interval modulation) and M-ary versions of these. In this document, the time-shift modulation method is often used as an illustrative example. However, Someone skilled in the art will recognize that alternative modulation approaches may, in Some instances, be used instead of or in combination with the time-shift modulation approach.

EX1006, 4:61-5:12.

130. While this teaching is specifically directed at varying the pulse repetition rate, it is my opinion that given the teaching of Grisham above, a POSITA would understand that UWB systems could be operated with variable center frequencies. *See* EX1005, [0049] illustrating the knowledge of a POSITA and the state of the art in UWB. “A sender simultaneously transmits frequency bands (ch) of which center frequency differs to each other, and a receiving side extracts the data by separating into each frequency band. This method is the same as that of a Ultra Wide Band Communication technique using the OFDM (Orthogonal Frequency Division Multiplexing) Modulation.” *Id.*, [0050].

131. Further, a POSITA would have known that there were only two design choices with respect to center frequency of pulses, fixed or variable. It would be obvious to try a variable center frequency because it would allow more frequency diversity in the transmitted signal which in some situations is desirable.

B. Ground 1B: Claims 2-4 are obvious Over Grisham and Douglas

132. It is my opinion that Grisham in view of Douglas renders claims 2-4 obvious.

1. Claim 2

133. Claim element 2a recites **“The collision avoidance system of claim 1, further comprising a central tracking unit in communication with the first**

vehicle mounted module and the second vehicle mounted module.” Further, claim element 2b recites **“wherein the central tracking unit is operable to track the location of at least the first vehicle mounted module and the second vehicle mounted module.”** It is my opinion that Grisham in view Douglas teaches or renders claim 2 obvious.

134. As described in Section VIII.A.1., in an exemplary embodiment, Grisham describes a transceiver impulse radio unit on a first locomotive (a first vehicle mounted module) communicating with and tracking the location of a transceiver impulse radio unit on a second locomotive (a second vehicle mounted module).

135. Douglas discusses “avoiding collisions between trains.” EX1011, Abstract. Douglas teaches an “apparatus 32 located at the station 30,” which broadcasts the location of trains within a certain range (via a list of links to be traversed by and the direction of motion of each train). *Id.*, 4:32-49, 7:10-12. “The apparatus 32 typically, comprises a transmitter and a processor such that information may be transmitted by the apparatus 32. The apparatus may also comprise an input means to receive input and an output means to provide output.” *Id.*, 4:45-49. Apparatus 32’s broadcasts go to “the transceiver 34 of the apparatus 20 of each of the trains.” *Id.*, 6:25-31. “The received list is then provided to the processor 36 and the processor 36 determines if the links to be traversed by the respective train are

adjacent links in the list. If the links to be traversed by the respect train are not adjacent links, the processor provides the corresponding output to the output means 40 to provide an indication of a danger in order to enable action to be taken to prevent the collision.” *Id.*, 6:31-38. Because the list of links to be traversed by and the direction of motion of each train disclose the path of trains, a POSITA would understand Douglas’s station-based apparatus tracks the location of the trains by repeatedly updating the trains’ paths.

136. Both Grisham and Douglas teach train collision avoidance systems by communicating with trains. At the time, a POSITA would have known that trains are part of a large network of tracks and locomotives on those tracks with many intersections of those tracks. A POSITA also would have known that railroad companies by the critical date utilized large numbers of train interface equipment along the sides of those train tracks, known as “wayside” devices or equipment, to communicate information to passing trains and their crews about approaching trains, track conditions, and other safety-critical information. A POSITA would have understood that the embodiments in Grisham scale to larger systems with multiple trains (as described in Douglas) and would take advantage of preexisting wayside infrastructure in a complementary way to Grisham’s direct train-to-train communication embodiment. EX1006 at 24:36-43. Identifying conflicts between the paths of trains can identify potential collisions before the trains enter into the

range where Grisham's train-to-train-communication is effective. In the combination, Douglas's apparatus (central tracking unit) broadcasts this tracking information to Grisham's vehicle mounted modules (*inter alia* radio units, controller). A POSITA would have understood that this apparatus at a station is "central" at least as to the locomotives near its location. As such, a POSITA would have been motivated to combine Douglas's apparatus at a station, which is similar to the interface with conventional wayside devices, with Grisham's first vehicle mounted module and second vehicle mounted module coupled to two trains. Moreover, in this combination each of the systems, Grisham's UWB transceivers, and Douglas's tracking system, would be performing the functions they had been known to perform (i.e. Grisham's transceivers communicating information, and Douglas's tracking system providing the tracking information to be communicated), and thus the combination would be nothing more than a combination of known elements to produce the predictable result of informing the train operators about the locations and operation of other trains in the local vicinity.

2. Claim 3

137. Claim 3 recites **"The collision avoidance system of claim 2, wherein the central tracking unit is distributed among a plurality of rail vehicles, including at least the first and second rail vehicles, wherein the first vehicle**

mounted module comprises a first central tracking unit component.” It is my opinion that Grisham in view of Douglas renders claim 3 obvious.

138. As discussed above with respect to claim 2, Douglas describes an embodiment that uses an apparatus at a station (central tracking unit) to communicate with transceivers on trains a list of links to be traversed by and the direction of motion of each train.

139. Douglas describes that “[a]lternatively, the state table of links 23, 25, 27 each train 12, 14, 16, 18 may be generated at the apparatus 20 each train 12, 14, 16, 18 is equipped with.” EX1011, 7:12-19. Central tracking unit components on multiple trains would take advantage of the collision-avoidance electronics already installed on trains (as described in Grisham). These components would also function in areas that may be far from preexisting railway and train-control infrastructure.

3. Claim 4

140. Claim 4 recites **“The collision avoidance system of claim 2, wherein the central tracking unit is located in a discreet housing.”** It is my opinion that Grisham in view of Douglas teaches or renders obvious claim 4.

141. Douglas discloses its apparatus at a station to be in a discreet⁵ housing, as shown in FIGS. 1 and 1b below. *See* EX1011, FIGS. 1, 1b, 3:1-30. There are only two possible housing options for an apparatus as described in Douglas – discreet or not discreet. It would be a design choice as to which housing is implemented. A POSITA would understand that an apparatus at a station like that in Douglas can be subject to the elements or within view of the passersby, and therefore it would be obvious to a POSITA to select or, at the very least to try, a discreet housing in which to protect the apparatus from the elements and from passersby who may attempt to vandalize the apparatus.

⁵ If Patent Owner argues that “discreet” is a typo and should be “discrete” instead, even though there has been no certificate of correction, a POSITA would have understood that modules in a collision-avoidance system can be integrated into one unit or separated as a set of discrete units, and therefore it would be obvious to a POSITA to select or, at the very least to try, (of the only two possible options—discrete or not discrete) a discrete housing to keep the module in one unit that would be more easily replaced via repair or upgrade.

FIG 1

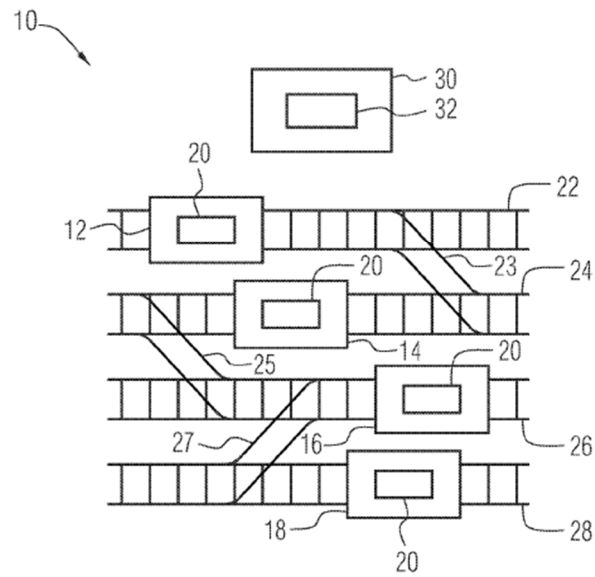
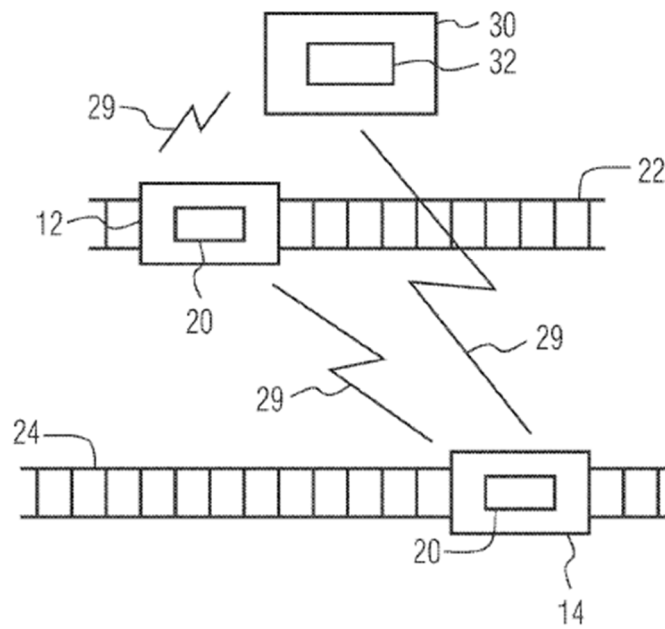


FIG 1b



C. Ground 1C: Claims 5 and 6 are obvious over Grisham in view of Richardson

142. It is my opinion that Grisham in view of Richardson renders claims 5 and 6 obvious.

1. Claim 5

143. It is my opinion that Grisham in view of Richardson renders claim 5 obvious.

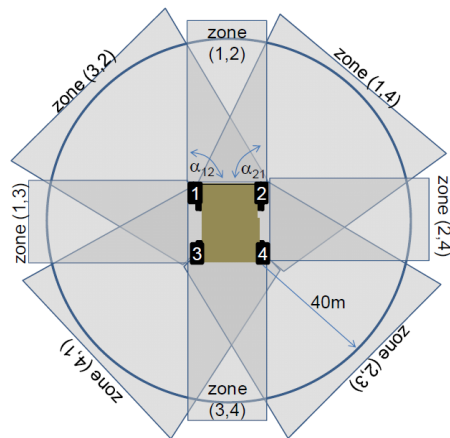
144. Claim element 5a recites **“The collision avoidance system of claim 1, wherein the first vehicle mounted module further comprises an auxiliary transponder sensor module, the auxiliary transponder sensor module mounted on the first rail vehicle with an offset with respect to the transponder sensor module,”** It is my opinion that Grisham in view of Richardson teaches or renders obvious this element. Grisham in view of the knowledge of one of ordinary skill renders claim 1 obvious. *See* Section VIII.A.1.

145. Richardson Figures 6 and 7 illustrate each vehicle having 4 UWB transceivers, with transceivers 1 to 2 and 3 to 4 offset by a distance r_b . EX1008, Figs. 6 and 7 A POSITA would have been motivated to combine Grisham and Richardson as a POSITA would have understood the benefits of providing an auxiliary transponder sensor module with an offset to the transponder sensor module, including better location measurements and improved collision avoidance due to

more precise information relating to length of the vehicle and mounting location of each sensor.

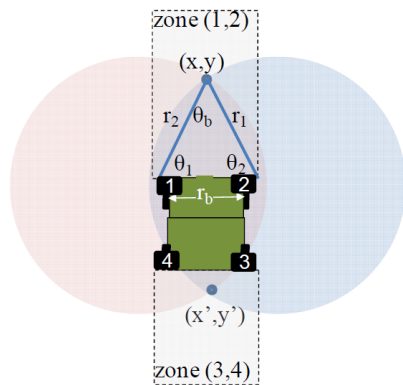
146. Further, a POSITA would have understood that some trains can be over a mile long. Because of this, a POSITA looking at Grisham would have been motivated to look at other vehicle proximity detection systems to supplement Grisham's UWB-based system with a system that can account for the length of these trains, particularly to detect collisions at both the front and rear of the trains. A POSITA would have understood the benefits of providing Richardson's auxiliary transponder sensor module with an offset to the transponder sensor module, including better location measurements and improved collision avoidance due to more precise information relating to length of the vehicle and mounting location of each sensor. Richardson's additional transponders are located offset locations in front and rear which provides for significant flexibility in identifying different zones in the vehicle's location. In my opinion, a POSITA would have understood that Richardson's configuration of transponders would be useful to avoid collisions in front and in the rear and could provide, among other things, calibration information based on length of the vehicle and information about trains moving on adjacent tracks (i.e. on either side of the train).

Figure 6 Eight zone definitions defined by coordinate radio pairs
(see online version for colours)



Notes: Ambiguous positions resulting from bilateration will never be in the same zone.

Figure 7 Bilateration for position measurement in a plane
(see online version for colours)

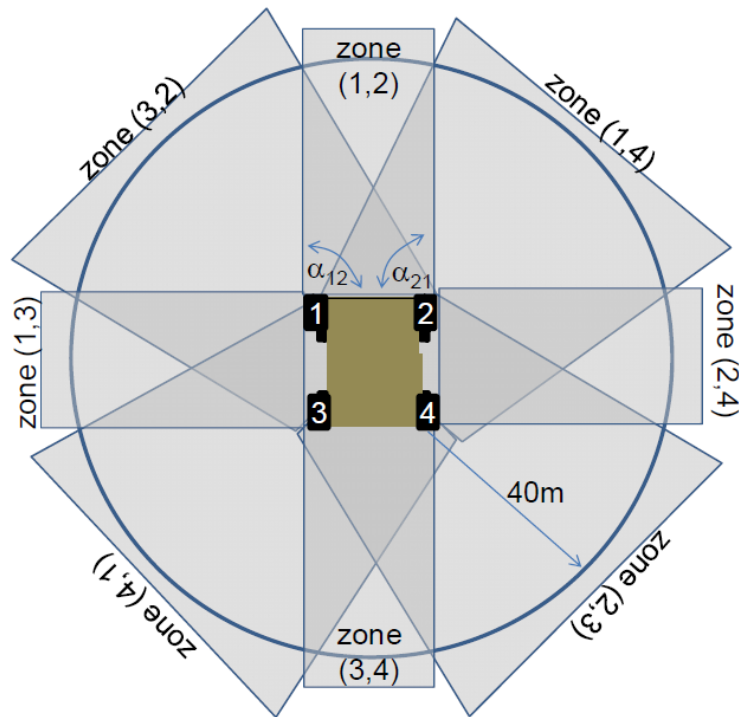


Notes: Ambiguous position at (x', y') is eliminated by assigning targets into zones based on last measurement.

147. Claim element 5b recites **“and wherein the user interface is operable to provide calibration information related to the length of the first rail vehicle, the mounting location of the first transponder sensor module, and the mounting location of the auxiliary transponder sensor module.”** It is my opinion that Grisham in view of Richardson teaches or renders obvious this element. Richardson uses the vehicle length (1 to 3 and 2 to 4) and the mounting location of the transceivers to define 8 detection zones to calibrate ranging from vehicle to vehicle.

See, e.g., EX1008, Fig. 6. It would have been obvious to a POSITA to add this information to the user interface of Grisham. The operator of the train would know the length of the train, so they would be able to verify the accuracy of the calibration if it was provided on the user interface. Verification would be particularly useful when the train changed its length by delivering train cars to their destinations. Further, it is my opinion that this length information would be necessary in the system described in Richardson because it would facilitate determining the width of all zones other than (1,2) and (3,4). A POSITA would have understood that to determine the geometry of the other zones would require knowing the length of the vehicle and as such some mechanism of providing that data would be required, and it would have been an obvious choice to a POSITA to provide that data through a user interface such as those discussed in Grisham.

Figure 6 Eight zone definitions defined by coordinate radio pairs
(see online version for colours)



Notes: Ambiguous positions resulting from bilateration
will never be in the same zone.

2. Claim 6

148. It is my opinion that Grisham in view of Richardson teaches or renders obvious Claim 6.

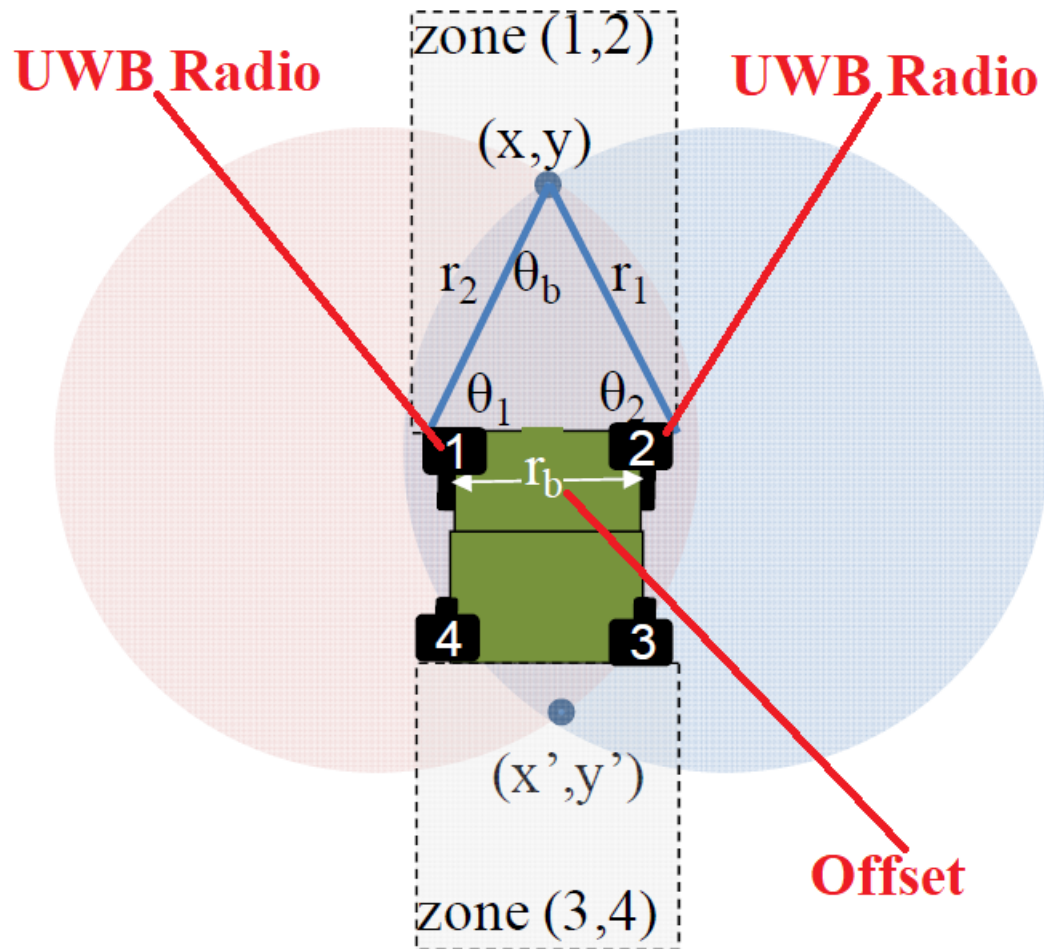
149. Claim element 6a recites **“The collision avoidance system of claim 5, wherein the auxiliary transponder sensor module comprises an auxiliary antenna, the auxiliary antenna being connected to at least one of the first ultra wideband unit or an auxiliary ultra wideband unit,”** It is my opinion that Grisham in view of Richardson teaches or renders obvious this element.

150. As an initial matter, a POSITA would have understood that a UWB transponder requires an antenna to function with reasonable performance. Thus, including an antenna as part of the transponder would have been obvious. In addition, Richardson teaches or suggests this limitation. As discussed above, Richardson teaches the use of UWB radios. Richardson teaches “An ultra wideband impulse radio (UWB-IR) positioning system integrated into the control system of a semi-autonomous vehicle shows promise to significantly improve the platform’s navigation capability.” EX1008, p. 209. Further, Richardson teaches “The height of the *transmit antennae*, *htx*, and *receive antenna*, *hrx*, were both set to 1 m. Truth points were established using a high precision laser” EX1008, Sec. 2.1, p. 214 (*emphasis added*). In my opinion, a POSITA would have been motivated to combine Grisham with Richardson as described above.

151. Claim element 6b recites “**and wherein the auxiliary antenna is mounted on the first rail vehicle with an offset with respect to the first antenna.**” It is my opinion that Grisham in view of Richardson teaches or renders obvious this element.

152. As described above, including an antenna as part of a UWB transponder would have been obvious to a POSITA. In addition, with an antenna associated with a transponder, the antennas would be offset when the transponders were offset. It is also my opinion that Grisham in view of Richardson teaches or renders obvious this

element. Richardson teaches the auxiliary antenna is mounted on the first rail vehicle with an offset with respect to the first antenna. As illustrated in Figure 7, Richardson teaches mounting the auxiliary antenna at an offset (r_b) from the other unit.



Notes: Ambiguous position at (x', y') is eliminated by assigning targets into zones based on last measurement.

D. Ground 1D: Claims 12 and 13 are obvious over Grisham in view of Breed '945

153. It is my opinion that Grisham in view of Breed '945 renders claims 12 and 13 obvious.

1. Claim 12

154. Claim 12 recites **“The collision avoidance system of claim 1, further comprising an inertial measurement unit in communication with at least the control electronics module, the inertial measurement unit being operable to detect changes in the speed of the first rail vehicle.”** It is my opinion that Grisham in view of Breed '945 would render claim 12 obvious. *See* Section VIII.A.1.

155. Like Grisham, Breed '945 describes a system that uses various techniques to identify potential hazards (e.g., other vehicles or obstacles) and warn the operator of a vehicle in order to avoid a collision (see. e.g., Breed '945 at abstract). Breed '945 teaches the use of an inertial measurement unit in communication with a control electronics module. For example, Breed '945, FIG. 5 illustrates a central processor 100 in communication with accelerometers 78 and gyroscopes 80.

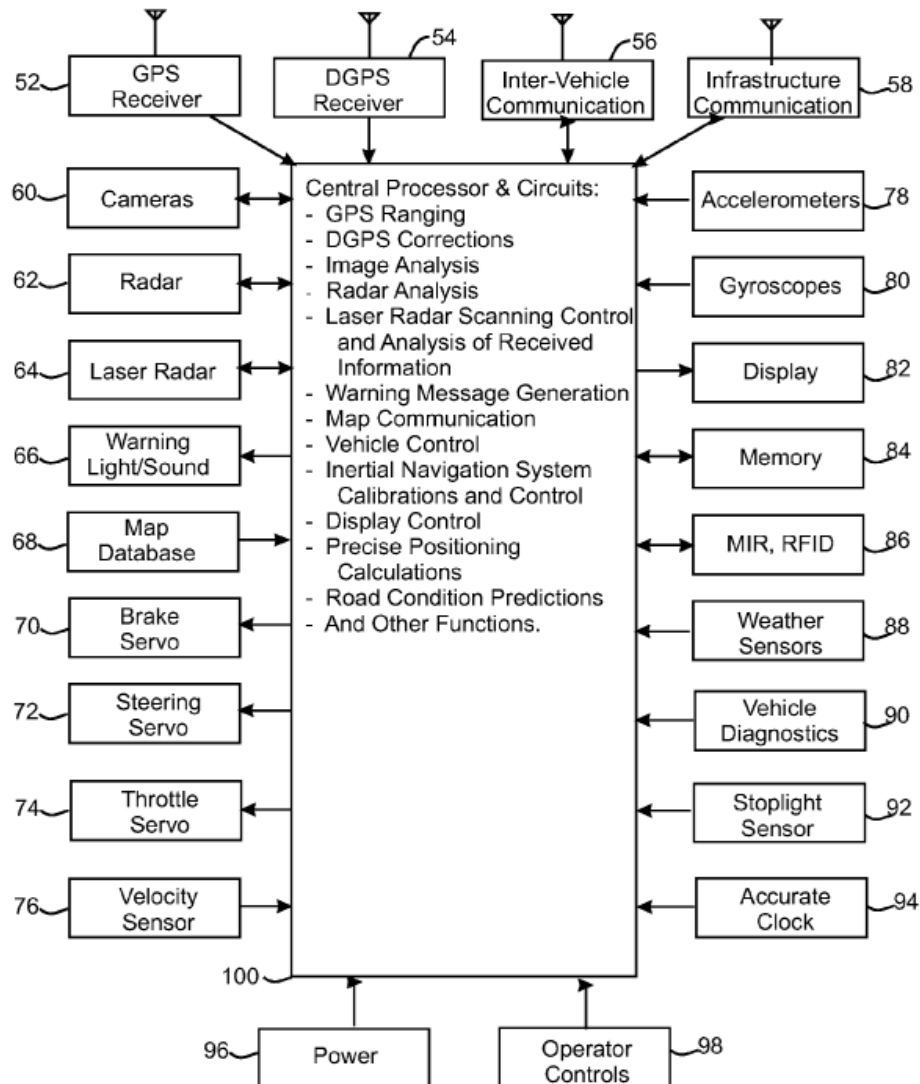


Fig. 5

156. Breed '945 additionally teaches "Inertial measurement unit (IMU), inertial navigation system (INS) and inertial reference unit (IRU) will in general be used interchangeably to mean a device having a plurality of accelerometers and a plurality of gyroscopes generally within the same package. Usually such a device will contain 3 accelerometers and 3 gyroscopes. In some cases, a distinction will be made whereby the INS relates to an IMU or an IRU plus additional sensors

and software such as a GPS, speedometer, odometer or other sensors plus optimizing software which may be based on a Kalman filter.” EX1014 [0093]. Breed ’945 additionally teaches that the accelerometers measure “vehicle acceleration in the latitude, longitude, and vertical directions” EX1014, [0567].

157. It is my opinion that a POSITA would have been motivated to combine the Inertial Measurement Unit in communication with a processor in the controller of Breed ’945 with Grisham improve the efficient operations of positioning. A POSITA looking at Grisham would have understood that measuring range rate (changes in range over a finite time interval) in order to determine speed is only able to measure *relative* speed between the object with the transponder and any other object being measured. This POSITA would have also understood that measuring absolute speed of an object requires knowing the speed of the transponder so that the speed of the sensed object can be derived from the relative speed obtained using range rate measurements. Thus, it would have been obvious to a POSITA to include some independent measure of vehicle speed so that the speed of the other sensed vehicle could be reliably determined. Doing so would have been obvious to try and would have been well within the capability of a POSITA, since, by the priority date of the ‘227 patent, trains were well-known to include speed measurement devices.

158. As a result, a POSITA would have been motivated to look at other speed and acceleration detection systems to supplement Grisham’s UWB-based

system to ensure position data is as exact as possible. For example, a POSITA would have understood that tracking changes in speed or acceleration is important for knowing a train's location and avoiding collisions, and also for determining appropriate evasive actions to avoid the obstacle. Also, Breed '945's acceleration data would "substantially improve the crash sensing algorithms" that Grisham uses to determine whether to trigger an alarm by allowing the system to determine the location, speed, and path of the host train to more reliably detect when a collision was likely.

159. In my opinion, a POSITA would have been motivated to modify Grisham to include Breed '945's inertial measurement units with accelerometers and gyroscopes to provide accurate speed and acceleration data to supplement the relative speed measurements available using UWB and to provide heading information useful to train-safety systems. For example, Breed '945 states "Dead reckoning, using vehicle speed, steering angle and tire rotation information and inertial guidance, can be used to fill in the gaps. Where satellites are out of view, pseudolites, or other systems can be placed along the highway." EX1014, [0211] The main purpose of Grisham is to prevent the collision of rail vehicles travelling at potentially high speeds. EX1006, [title], 2:16-31, 34-46. A POSITA would have known or understood that accelerometers and gyroscopes are accurate and readily available devices that can assist in this task. Breed '945 is additionally directed to a

vehicle-to-vehicle communication system to avoid collisions. Given the catastrophic consequences of collisions between rail vehicles, a POSITA would have been motivated to include additional systems to provide redundancy to potentially guard against system or component failures.

2. Claim 13

160. Claim 13 recites **“The collision avoidance system of claim 12, wherein the inertial measurement unit comprises at least one of an accelerometer or a gyroscope.”** It is my opinion that Breed ’945 teaches this element and therefore in combination with Grisham would render claim 13 obvious.

161. Breed ’945 teaches inertial measurement units via a “device having a plurality of accelerometers and a plurality of gyroscopes generally within the same package.” EX1014, [0093].

E. Ground 1E: Claim 15 is obvious over Grisham in view of Connell

1. Claim 15

162. Claim element 15a recites **“The collision avoidance system of claim 1, wherein the first vehicle mounted module is operable to execute a stopping distance calibration feature that measures a stopping distance under existing conditions,”** Further, claim element 15b recites **“and the measured stopping distance is the distance between a first location of the first rail vehicle when brakes are engaged and a second location where the first rail vehicle comes to**

a stop under the existing conditions.” It is my opinion that Grisham in view of Connell teaches or renders obvious claim 15.

163. Connell teaches a control system that dynamically determines brake shoe effectiveness as the train travels based on braking data (braking arrangement, brake application level, etc.) and train data (train speed, track profile, etc.). Connell teaches

[0025] As illustrated in FIG. 2, and in one preferred and non-limiting embodiment of the present invention, the system 10 includes at least one brake database 12 including braking data 14. This braking data 14 includes braking arrangement data, brake shoe force data, brake shoe friction data, brake application time data, brake application level data, brake retarding force data, brake shoe type data, brake thermal characteristics data and/or braking ratio data, etc. The system 10 further includes at least one train database 16 including train data 18. This train data 18 includes wheel data, rail data, train position data, car position data, train speed data, track data, track location data, track curvature data, track profile data, track grade data, train weight data, car weight data, train length data, car length data, environmental data and/or authority data, etc.

[0026] A control system 20 is in communication with the brake database 12 and the train database 16, and this control system 20 is operable to dynamically determine brake shoe effectiveness data 22 based upon the braking data 14 and the brake database 12 in the train data 18 in the train database 16. As discussed, this brake shoe

effectiveness data 22 includes at least sufficient information in order to determine the ability of the braking arrangement BA to retard the train TR to a specified level, whether a speed level or a complete stop.

EX1012, [0025]-[0026].

164. Connell also teaches that “[o]nce the selecte-d or desired brake shoe effectiveness data 22 is determined, a variety of control and operational parameters of the train TR can be determined or set” *Id.*, [0028].

For example, the operational parameter may be: a speed limit, i.e., whether the train TR can reach or obtain a specified speed limit by a specified point on the track; a maximum speed limit, i.e., how fast the train TR may be safely operated; a braking curve, i.e., the distance required for the train TR to completely stop; a stopping distance; suggested brake arrangement BA usage, e.g., whether dynamic brakes, blended brakes, emergency brakes, etc. should be used; braking arrangement BA usage to retard the train TR to a specified speed level; braking arrangement BA usage to fully retard the train TR to a complete stop, etc. Accordingly, and based upon this determined brake shoe effectiveness data 22, the control system 20 may be utilized to effectively calculate and/or determine a variety of different operational parameters that can be used in safely operating the train TR, and which may be implemented manually by the operator, semi-automatically or in a fully automatic mode through the control system 20 (or, as discussed hereinafter, a separate controller).

Id.

165. Given this teaching, a POSITA would have easily determined or calibrated the appropriate stopping distance by physically testing the rail vehicles under a variety of conditions, and then adopting the appropriate stopping distance calibration under the existing conditions. It is my opinion that a POSITA would have been motivated to incorporate Connell's stopping distance calibrations into Grisham's vehicle mounted modules because it would increase overall safety of the system and further the goals of collision avoidance.

166. Grisham's systems are intended to avoid collisions of any rail vehicle, regardless of speed or track conditions. A POSITA would have understood that a collision-avoidance system would need a way of alerting an operator only to potential collision situations, not merely situations where a train is nearby, given the difference in stopping distances between braking in ideal conditions compared to braking in the rain or the number of trains that can safely be positioned within feet of each other in, for example, a train yard. Further, a POSITA would have understood that having a calibrated stopping distance, such as that provided by Connell, allows the collision avoidance system to set a threshold of separation distance and only alert the operator to conditions where the vehicle's distance and speed to an obstacle were within or approaching the stopping distance.

167. A POSITA thus would have been motivated to incorporate Connell's stopping distance calibration feature for vehicle collision avoidance into Grisham's

collision-avoidance system in order to accurately and effectively avoid collisions when rail vehicles are approaching at different speeds or braking conditions and to avoid nuisance alerts to the operator of the safe approach or close proximity of other trains.

168. Also, as Grisham already detects potential collisions, improving Grisham's detection via calibration of stopping distance for a train would have been a routine and simple change by a POSITA. Grisham's collision avoidance system is directed at the same or similar problem as Connell, that of avoiding collisions between moving vehicles. Grisham detects vehicles that may collide with a train and generates an alarm for potential collisions. Determining the stopping distance of the train based on the actual conditions would improve Grisham's ability to differentiate between potential collisions and safe proximity (in a train yard, for example). This improvement, which is apparent from Connell's stopping distance calibration feature, would have motivated a POSITA to incorporate Connell's stopping distance calibration feature for vehicle collision avoidance into Grisham's collision-avoidance system.

F. Ground 2A: Claims 7-9, 17-19, 21, 22, and 24-26 are obvious over Grisham in view of Nixon

169. It is my opinion that Grisham in view of Nixon renders claims 7-9, 17, 18-19, 21, 22, and 24-27 obvious.

1. Claim 7

170. Claim 7 recites **“The collision avoidance system of claim 1, wherein the first vehicle mounted module further comprises a global positioning system unit, the global positioning system unit operable to receive information from one or more satellites to determine an absolute position of the rail vehicle, wherein the global positioning system unit is in communication with the control electronics module.”** Grisham in view of the knowledge of one of ordinary skill renders claim 1 obvious. *See* Section VIII.A.1. While Grisham does not teach the use of a global positioning system unit that receives information from satellites, Nixon teaches this module and therefore it is my opinion that Grisham in view of Nixon would render claim 7 obvious.

171. Nixon teaches using GPS as a way of determining the absolute position of moving vehicles, such as trains. Nixon teaches “The trail alert equipment can position targets based on its processing of the outputs of a vehicle location system, such as a GPS (Global Positioning System) receiver. The GPS receiver receives GPS signals and determines its position. In this case, the trail alert equipment may display the hostile target position based on the range estimation and its position determined by the GPS receiver.” EX1016 at 6-7. GPS is based on signals received from one or more satellites. Nixon discloses mounting collision avoidance equipment to a vehicle, such as a train. “The trail alert equipment can be applied to any kind of

vehicle, such as an airplane, a boat, a ship, a train, a snowmobile and an A TV.” *See id.* at 6. Nixon explains that the equipment can be equipped with a GPS receiver to determine the location of the vehicle.

172. Nixon teaches using a GPS receiver as part of the collision avoidance equipment. EX1016 at 6. Nixon explains that once the GPS receiver has determined the absolute location, it communicates the position to the collision avoidance equipment, such as Grisham’s controller within unit 902 (a first control electronics module). *See id.* at 7.

173. A POSITA looking at Grisham would have been motivated to look at other positioning systems to determine how to supplement Grisham’s UWB-based collision-avoidance system. For example, a POSITA would have known that UWB is relatively range-limited due to low transmission power. A POSITA would have further understood that trains, especially trains of the Class I railroads, operate on a network of thousands of miles of track where any two trains may be tens or hundreds of miles apart from each other while others may operate in closer proximity. A POSITA would have further understood that trains, especially trains of the Class I railroads, can be over a mile long and take over a mile of distance to stop from the time when the operator first begins to attempt a stoppage of the train, meaning that positioning within the above distance limitations lessens the usefulness of UWB in some potential collision situations necessitating stopping a train. Accordingly, a

POSITA would have understood that position information is important in collision avoidance systems. While UWB is useful for some applications on trains, UWB could benefit from other positioning means to prevent two trains from colliding. A POSITA would have also known that a UWB-based system like Grisham's could relay relative distance between two trains but may require additional processing, to determine relay heading, speed, acceleration, or other important characteristics to know in a collision-avoidance system. Accordingly, a POSITA would have looked to augment Grisham's collision-avoidance system with other complementary technologies. A POSITA would have also understood that trains often operate in rail yards, where the trains maybe in close proximity to one another, but on different tracks. In this situation using only a UWB radar to determine the proximity of another train would not have provided sufficient information to determine if the train represented a hazard. For example, two trains traveling on adjacent tracks may only be a few feet from one another, yet there is no chance that they can collide because the tracks do not cross one another. Similarly, in situations where tracks do cross, the system may determine that two trains are far enough apart to not represent a hazard and may fail to warn the operator(s) sufficiently early to allow the trans to stop. A POSITA would have thus understood that using GPS location data to track the paths of the trains would allow the system to determine if those paths intersected

at any point in the future, and thereby would assure a more robust and error free collision warning system.

174. One of the most common positioning systems by the critical date was GPS, and a POSITA would have known that GPS systems pair well with UWB systems in that GPS can make up for the shortfalls of UWB discussed by providing heading and other information useful, such as the path of the train, to train-safety systems. One such GPS system that is used for a railway collision-avoidance system is described in Nixon.

175. While a POSITA would have understood that GPS has some benefits over UWB as discussed below, a POSITA would not have been motivated to replace Grisham's UWB system with GPS because GPS too has its limitations which can be mitigated by UWB. For example, as explained in Arthur⁶, trains operating in terrain with tunnels have significant limitations if operating merely with GPS. Arthur specifically relates to the use of multiple position-determination techniques in a train-control environment. In particular, Arthur relates to using a combination of GPS-related data with other location-related data to improve the accuracy of the location/speed determination. As Arthur explains, "[n]avigation data provided by GPS alone can be degraded due to operation in tunnels, lack of visibility of satellite

⁶ EX1037

constellation, multi-path interference in urban areas and other factors.” EX1037, 4:66-5:2. Therefore, to improve the location/speed-determination, Arthur discloses a system that uses “sensor fusion functionality,” which “integrates the raw GPS data with locomotive based speed and other data to provide location extrapolation during periods of high position uncertainty.” EX1037, 5:2-5.

176. Generally, commercial UWB has a limited operating range due to low power operations. As discussed previously, it can be extremely accurate in determining distance to other objects and/or UWB units and determining relative position between those objects or UWB units. Without other assistance, UWB does not generally provide absolute position of a UWB Unit. UWB units may communicate with wayside units with known absolute locations and from that communication approximate their location. This can be an expensive solution as the number of wayside units along a track can add significant costs in deployment. GPS provides a measure of absolute position as well as heading, and this, if communicated by UWB units between trains would allow them to determine if a collision was possible, or if they were, for example on parallel tracks where no collision is possible. Additionally, GPS accuracy can vary by several meters or even tens of meters, so it can provide a good measure of a path, but that pay may be offset by some amount due to systemic errors in the system. Using UWB you can get a very precise measure of relative range, and that could be used to correct any systemic

errors in GPS. So, while GPS would provide a better overall picture of where the train is and where other trains are, UWB allows that picture to be refined to the level of accuracy needed to assure that a collision does not occur. Since the main purpose of Grisham is to avoid collisions at all distances a POSITA would have been motivated to augment Grisham's UWB based collision avoidance system with the GPS modules of Nixon in order to ensure collisions were effectively avoided. Both UWB and GPS provide positioning data, so it would have been readily apparent to a POSITA how to implement GPS into the radio units from Grisham.

2. Claim 8

177. Claim 8 recites **“The collision avoidance system of claim 7, wherein the first vehicle mounted module receives information generated by the global positioning system unit and the first ultra wideband unit to determine whether one or more vehicle separation criteria are violated, and generates a warning signal when one or more vehicle separation criteria are violated.”** It is my opinion that Grisham in view of Nixon renders claim 8 obvious.

178. As discussed above with respect to claim 1, Section VIII.A.1., Grisham teaches a collision avoidance system for rail vehicles that uses ultra wideband to determine separation distances and generate warnings should the vehicles violate those separation distances. Grisham teaches the use of an alarm to alert the operator. EX1006, 23:57-60, FIG. 21. Grisham's user-interface display can be configured to

alert a train operator by “generating an alarm (see light 1112) or voice message (see Speaker 1114).” *Id.* Grisham teaches that the alarms activate when an oncoming train is “in their vicinity” (vehicle separation criteria) according to UWB data received by the radio unit. *Id.*, 23:57-58.

179. Further, as discussed in Section VIII.F.1., Nixon teaches using GPS in collision avoidance systems. Nixon discloses an alarm system that produces an alert signal based on the proximity of the trains to each other. *See* EX1016, 5-6. The sound or light is variable with range. *Id.* For example, if the control processor “determines that the target is closer, beeping is faster.” *Id.* Nixon explains that approaching speed is “estimated by tracking the change in distance.” *Id.* at 5-6. Regardless of whether the distance monitor is turned on, “a rapidly approaching vehicle within a certain range will always cause a panic alarm.” *Id.* at 6.

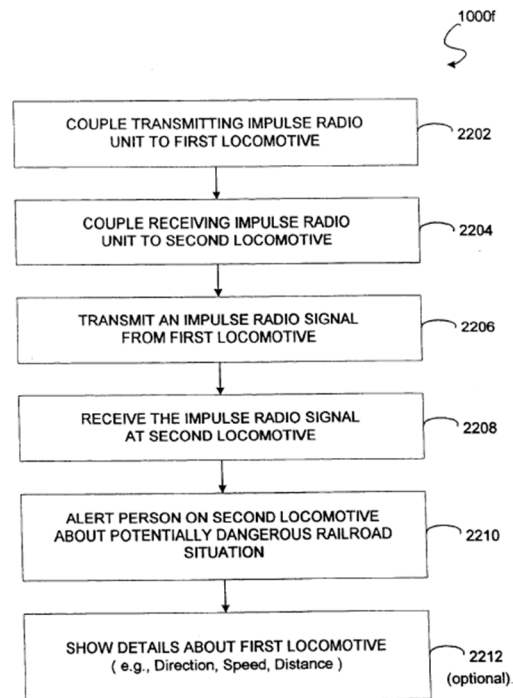
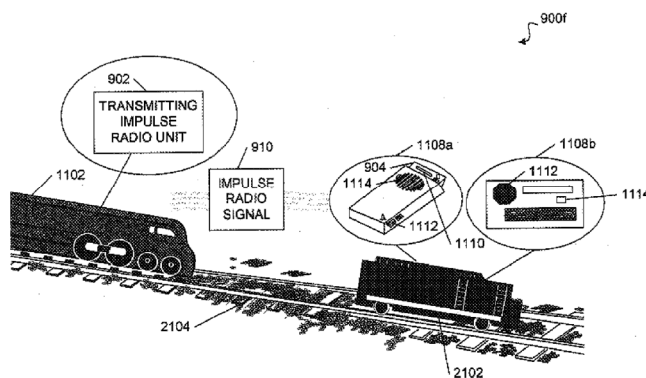
180. Augmenting Grisham’s collision avoidance system with Nixon’s GPS units would produce a collision avoidance system capable of determining a train’s absolute location with GPS, as well as determining a separation from that train to another object, automobile, or train as discussed in Grisham. Since Grisham’s collision avoidance system includes train to train communications using UWB, the trains GPS data (absolute location) may be communicated to the other vehicle and used to determine if a separation distance has been violated in a manner which requires an alarm condition. A POSITA would have understood that trains on

parallel tracks may violate a strict separation distance, but the use of GPS data would ensure that warning signals would only be generated when needed. Thus, a POSITA would have implemented a system that received both UWB and GPS information. Nixon teaches using GPS as a way of determining the position of moving vehicles, such as trains. EX1016, 6-7.

3. Claim 9

181. Claim element 9a recites **“The collision avoidance system of claim 1, wherein the first vehicle mounted module is operable to execute a progressive warning signal if one or more vehicle separation criteria are violated,”** Further, claim element 9b recites **“wherein the progressive warning signal increases in at least one of signal rate, signal frequency, signal prominence, signal volume, or signal severity as the violation of the vehicle separation criteria approaches or extends beyond a vehicle separation threshold.”** It is my opinion that Grisham in view of Nixon teaches, or renders claim 9 obvious.

182. Grisham teaches the use of an alarm to alert the operator. EX1006, 23:57-60, FIGs. 21 and 22. Grisham discusses how the user interface module can be configured to alert a train operator by “generating an alarm (see light 1112) or voice message (see Speaker 1114).” *Id.* Grisham teaches that the alarms activate when an oncoming train is “in their vicinity.” *Id.* at 23:57-58.

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184. In addition to the reasons described in Section VIII.F.3. above, a POSITA would have been motivated to convert Grisham's alarm to Nixon's progressive alarm. Because Grisham already captures speed and distance information from other rail vehicles to trigger an alarm, a progressive alarm would simply and routinely be implemented into its system, and in doing so would provide an audible representation of the extent or urgency of a potential hazard, which would be particularly useful to avoid the operator being distracted by having to look at a display to determine the degree of separation between the trains..

4. Claim 17

185. It is my opinion that Grisham in view of Nixon renders claim 17 obvious.

186. Claim element 17-Pre recites “**A rail vehicle module mountable on a rail vehicle, the module comprising.**” I understand that whether a claim's preamble is treated as a limitation on the scope of the claim is a legal question. For the purposes of my analysis this determination is not important because should the preamble be found limiting, Grisham teaches this claimed module. *See* Section VIII.A.1.

187. Claim element 17a recites “**a transponder sensor module comprising:**” It is my opinion that Grisham teaches the claimed transponder sensor module as used in the '227 patent. *See* Section VIII.A.1.

188. Claim element 17b recites **“a radio communication unit operable to employ time of flight techniques to detect a distance between the rail vehicle and at least one other vehicle.”** It is my opinion that Grisham in view of Nixon teaches or renders obvious a system having one or more vehicular mounted modules that employ time of flight techniques to detect distance between vehicles. *See* Section VIII.A.1.

189. Claim element 17c recites **“a wireless communications antenna operable to send and receive data over the air;”** It is my opinion Grisham in view of Nixon teaches or renders obvious a system having antennas operable to send and receive data wirelessly. The radio units of Grisham continuously transmit and receive impulse radio signals wirelessly. *See* EX1006, FIG. 22, 23:42-48. The signals can include data such as direction, speed, and distance of each rail vehicle. *Id.*, FIG. 22. Grisham discloses that in the preferred embodiment, “the emitted signal is wide-band or ultrawide-band.” *Id.* at 16:47-49. Grisham also describes using an “ultra-wideband” antenna when discussing the ideal waveforms of the impulse radios. *Id.* at 6:12, 37-43. As shown in FIGS. 6 and 7, Grisham details each component of impulse radios, which includes a “transmit antenna 624” and a “receive antenna 704.” *Id.* at 16: 39-41, 59-60.

190. Claim element 17d recites **“a global positioning system unit operable to receive information from one or more satellites to determine an absolute**

position of the rail vehicle;” It is my opinion that Grisham in view of Nixon, teaches or renders obvious a GPS unit that receives information from satellites and can determine absolute position. While Grisham does not teach the use of a GPS unit that receives information from satellites and can determine absolute position, Nixon does. *See* Section VIII.F.1.

191. For at least the reasons discussed in Section VIII.F.1., it is my opinion that a POSITA would be motivated to combine the GPS sensors into the collision avoidance system of Grisham.

192. Claim element 17e recites “**a control electronics module comprising a processor in communication with at least the first transponder sensor module;**” It is my opinion Grisham in view of Nixon teaches or renders obvious the claimed control electronics module. *See* Section VIII.A.1.

193. Claim element 17f recites “**a user interface module including a user interface operable to provide rail vehicle information to a vehicle operator and to receive input from the vehicle operator.**” It is my opinion that Grisham in view of Nixon teaches or renders obvious the claimed user interface. *See* Section VIII.A.1.

194. Claim element 17g recites “**wherein the rail vehicle module communicates with at least one other module mounted on at least one other vehicle to detect a separation distance between the rail vehicle and the at least one other vehicle.**” It is my opinion that Grisham in view of Nixon teaches or

renders obvious inter-vehicle communication to, at a minimum, detect separation distances between vehicles. *See* Section VIII.A.1.

5. Claim 18

195. Claim 18 recites **“The rail vehicle module of claim 17, wherein the radio communication unit comprises an ultra wideband unit configured to send and receive ultra wideband signals.”** It is my opinion that Grisham in view of Nixon teaches or renders obvious the vehicle modules using UWB. *See* Section VIII.A.1.

6. Claim 19

196. Claim 19 recites **“The collision avoidance system of claim 18 wherein the ultra wideband unit is adapted to transmit and receive signals with varying center frequencies.”** It is my opinion that Grisham in view of Nixon teaches or renders obvious would render claim 19 obvious. *See* Section VIII.A.3.

7. Claim 21

197. Claim element 21a recites **“The rail vehicle module of claim 17, wherein the rail vehicle module is operable to utilize information generated by the radio communication unit and the global positioning system unit to determine whether one or more vehicle separation criteria are violated,”** It is my opinion that Grisham in view of Nixon teaches or renders this element obvious. *See* Section VIII.F.2.

198. Claim element 21b recites “**and generate a progressive warning signal if one or more vehicle separation criteria are violated, wherein the progressive warning signal increases in at least one of signal rate, signal frequency, signal prominence, signal volume, or signal severity as the violation of the vehicle separation criteria approaches or extends beyond a vehicle separation threshold.**” For the same reasons discussed with respect to claim 9, it is my opinion that Grisham in view of Nixon teaches or renders this element obvious. *See* Section VIII.F.3.

8. Claim 24

199. It is my opinion that Grisham in view of Nixon renders claim 24 as obvious.

200. Claim element 24-Pre recites “**A collision avoidance system comprising:**.” I understand that whether a claim’s preamble is treated as a limitation on the scope of the claim is a legal question. For the purposes of my analysis this determination is not important because should the preamble be found limiting, Grisham teaches it as explained above. *See* Section VIII.A.1.

201. Claim element 24a recites “**one or more vehicle mounted modules, each vehicle mounted module mountable on a rail vehicle, each vehicle mounted module comprising.**” It is my opinion that Grisham teaches or renders obvious this limitation. *See* Section VIII.A.1.

202. Claim element 24b recites **“a transponder sensor module comprising:”**. Further, claim element 24c recites **a radio communication unit operable to employ time of flight techniques to detect a distance between rail vehicles;”** It is my opinion that Grisham teaches or renders obvious this limitation. *See* Section VIII.A.1.

203. Claim element 24d recites **“and a global positioning system unit operable to receive information from one or more satellites to determine an absolute position of the rail line vehicle.”** It is my opinion that Grisham in view of Nixon teaches or renders obvious this limitation. *See* Section VIII.F.1.

204. Claim 24e recites **“a control electronics module comprising a processor, the control electronics module being in communication with at least the transponder sensor module.”** It is my opinion that Grisham in view of Nixon teaches or renders obvious this limitation. *See* Section VIII.A.1.

205. Claim element 24f recites **“and a user interface operable to provide rail vehicle information to a vehicle operator and to receive input from the vehicle operator.”** It is my opinion that Grisham in view of Nixon teaches or renders obvious this limitation. *See* Section VIII.A.1.

206. Claim element 24g recites **“wherein each of the two or more rail vehicle modules communicate to determine a separation distance between each**

rail vehicle,” It is my opinion that Grisham in view of Nixon teaches or renders obvious this limitation. *See* Section VIII.A.1.

207. Claim element 24h recites **“and wherein each rail vehicle module is operable to use information provided by the radio communication unit and the global positioning system unit to determine whether one or more vehicle separation criteria are violated, and to generate a warning signal if one or more vehicle separation criteria are violated”** It is my opinion that Grisham in view of Nixon, teaches or renders obvious this limitation. *See* Section VIII.F.2.

9. Claim 25

208. Claim 25 recites **“wherein each radio communication unit comprises an ultra wideband unit.”** It is my opinion that Grisham in view of Nixon teaches or renders obvious this claim. *See* Section VIII.A.1.

10. Claim 26

209. Claim 26 recites **“The collision avoidance system of claim 24, wherein the progressive warning signal increases in at least one of signal rate, signal frequency, signal prominence, signal volume, or signal severity as the violation of the vehicle separation criteria approaches or extends beyond a vehicle separation threshold.”** It is my opinion that Grisham in view of Nixon teaches or renders claim 26 obvious. *See* Section VIII.F.3.

G. Ground 2B: Claim 20 is obvious over Grisham in view of Nixon and Richardson

1. Claim 20

210. It is my opinion that Grisham in view of Nixon and Richardson renders 20 obvious.

211. Claim element 20a recites **“The rail vehicle module of claim 17, further comprising a second wireless communications antenna mounted on the rail vehicle with an offset with respect to the first antenna.”** It is my opinion that Grisham in view of Richardson teaches or renders obvious this element. Grisham in view of Nixon renders claim 17 obvious. *See* Section VIII.F.4. As previously discussed, Richardson teaches a second wireless communications antenna mounted on a vehicle with an offset with respect to the first antenna. Figure 7 of Richardson teaches mounting a second wireless communications antenna at an offset (r_b) from the other unit. *See* Sections VIII.C.1 and VIII.C.2. For the purpose of the obviousness analysis, the “first antenna” and “first wireless communications antenna” is treated as the “wireless communications antenna” from claim 17, and a POSITA would know that it is part of the first transponder sensor module. Also, a POSITA would understand that the antenna identified as the auxiliary antenna in claim 6 is the second wireless communications antenna. In addition, a POSITA would understand that the antenna identified as the auxiliary antenna in claim 6 is the second wireless communications antenna.

212. Claim element 20b recites **“wherein the rail vehicle module is operable to receive calibration information related to the length of the rail vehicle, the mounting location of the first wireless communications antenna and the mounting location of the second wireless communications antenna.”** As previously discussed, Richardson teaches this element. *See* Sections VIII.C.1. and VIII.C.2.

H. Ground 2C: Claims 22, 27, and 28 are obvious over Grisham, Nixon, and Douglas

213. It is my opinion that Grisham in view of Nixon and Douglas renders claims 22, 27, and 28 obvious.

1. Claim 22

214. Claim 22 recites **“The rail vehicle module of claim 17, further comprising a central tracking unit component, wherein the central tracking unit component is in communication with a central tracking unit component mounted on the at least one other vehicle.”** It is my opinion that Grisham in view of Nixon and Douglas teaches, or renders claim 22 obvious. *See* Sections VIII.B.1 and VIII.B.2. Therefore a POSITA would understand that Grisham in view of Nixon and Douglas renders claim 22 obvious.

215. Additionally, a POSITA would have been motivated to have the plurality of central tracking unit components communicate to each other in order to give critical up-to-date information to conductors.

2. Claim 27

216. Claim 27 recites **“The collision avoidance system of claim 24, further comprising a central tracking unit in communication with each rail vehicle module, the central tracking unit operable to track the location of each rail vehicle module.”** It is my opinion that Grisham in view of Nixon and Douglas, teaches or renders claim 27 obvious. *See* Section VIII.B.1.

3. Claim 28

217. Claim 28 recites **“The collision avoidance system of claim 27, wherein the central tracking unit is distributed among a plurality of rail vehicles, including at least the first and second rail vehicles, wherein the first vehicle mounted module comprises a first central tracking unit component.”** It is my opinion that Grisham in view of Nixon and Douglas renders claim 28 obvious. *See* Section VIII.B.2.

I. Ground 2D: Claim 10 is obvious over Grisham in view of Nixon and McDaniel

1. Claim 10

218. Claim 10 recites **“The collision avoidance system of claim 9, wherein the first vehicle mounted module executes an adaptive threshold feature that modifies one or more vehicle separation thresholds based on the speed of the first rail vehicle and the speed of the second rail vehicle.”** It is my opinion that Grisham in view of Nixon and McDaniel teaches or renders this claim 10 obvious.

It is my opinion that claim 9 is obvious over Grisham in view of Nixon. *See* Section VIII.F.3.

219. McDaniel teaches a threshold warning distance. For example:

[0038] Once the closing rate has been determined and the velocity data has been received, a velocity, V_2 , associated with target object 130 may be estimated (Step 330). For example, controller 120 may estimate the velocity of target object 130 based on the velocity of the host machine 110 and the determined closing rate between host machine 110 and target machine 130, using the following formula: $V_2 = V_1 - R_r$.

As can be seen from the formula above, the velocity associated with the target object 130, V_2 , is zero when the closing rate, R_r , is equal to the velocity of the host machine, V_1 , which indicates that target object 130 is neither approaching nor retreating (i.e., stationary, moving in a direction substantially orthogonal, etc.) with respect to host machine 110.

[0039] Once the velocity of the target object has been estimated, a ***threshold warning distance, D , may be calculated (Step 340). For example, controller 120 may calculate the threshold warning distance based on the respective velocities of host machine 110 and target object 130, as well as a current stopping distance required by each object.*** This threshold distance is typically associated with the minimum distance that may be required by host machine 110 to avoid a collision. According to one embodiment, threshold distance may be determined with respect to target object 130. Processes and method for

calculating the threshold warning distance will be described in detail below.

EX1015 [0038]-[0039] (*emphasis added*).

220. Further, Grisham's systems are intended to avoid collisions of any rail vehicle, regardless of speed or track conditions. A POSITA would have understood that a collision-avoidance system would need a way of alerting an operator only to potential collision situations, not merely situations where a train is nearby, given the number of trains that can safely be positioned within feet of each other in, for example, a train yard. Additionally, a POSITA would understand that safe separation distances to avoid collision are determined by a number of factors including differences of speeds between the vehicles in question. A POSITA thus would have been motivated to incorporate McDaniel's adaptive threshold warning system for vehicle collision avoidance into Grisham's collision-avoidance system in order to accurately and effectively avoid collisions when rail vehicles are approaching at different speeds and to avoid nuisance alerts to the operator of the safe approach or close proximity of other trains. McDaniel's threshold distance is determined based on train velocities. EX1015, [0039]. As Grisham already collected speed and distance data, modifying them to implement an adaptive threshold feature would have been a routine and simple change by a POSITA.

J. Ground 2E: Claim 16 is obvious over Grisham, Nixon, McDaniel, and Connell

1. Claim 16

221. Claim element 16a recites **“The collision avoidance system of claim 15, wherein the first vehicle mounted module executes a progressive warning signal if one or more vehicle separation criteria are violated.”** Further, claim element 16b recites **“wherein the progressive warning signal increases in at least one of signal rate, signal frequency, signal prominence, signal volume, or signal severity as the violation of the vehicle separation criteria approaches or extends beyond a vehicle separation threshold.”** Further, claim element 16c recites **“and wherein the first vehicle mounted module executes an adaptive threshold feature that modifies one or more vehicle separation thresholds based on the measured stopping distance.”** It is my opinion that Grisham in view of Nixon, McDaniel, and Connell teaches or renders all elements obvious. *See* Sections VIII.E.1., VIII.F.3., and VIII.I.1.

222. As discussed in Section VIII.E.1. above, Connell teaches determining or calibrating the appropriate stopping distance by physically testing the rail vehicles under existing conditions. In addition to modifying the adaptive threshold based on the speed of the trains, a POSITA would have been motivated to implement Connell’s measured stopping distance into the adaptive threshold to improve the accuracy of the threshold.

K. Ground 2F: Claim 23 is obvious over Grisham in view of Nixon, McDaniel, Connell and Breed '945

1. Claim 23

223. Claim 23 recites **“The collision avoidance system of claim 16, further comprising an inertial measurement unit in communication with at least the control electronics module, the inertial measurement unit being operable to detect changes in the speed of the first rail vehicle.** It is my opinion that Grisham in view of Nixon, McDaniel, Connell and Breed '945 teaches or renders this claim 23 obvious. As discussed in Section VIII.J.1. above, claim 16 is obvious over Grisham in view of Nixon, McDaniel, and Connell. While this combination doesn't explicitly teach an inertial measurement unit communicating with a control electronics module, Breed '945 does. *See* Section VIII.D.1.

224. For at least the reasons stated above in Section VIII.D.1. with respect to claim 12, a POSITA would have been motivated to add the claimed inertial measurement unit to the combination of Grisham, McDaniel, and Nixon. in the addition of the inertial measurement unit taught in Breed '945 would be a trivial addition and as discussed above would improve the overall accuracy and safety of the collision avoidance system.

L. Ground 3A: Claims 1, 7, 8, 11-14, 17-19, 24, and 25 are Obvious Over Suzuki alone or in combination with Grisham

225. It is my opinion that the Suzuki reference alone or in combination with Grisham render claims 1, 7, 8, 11-14, 17-19, 24, and 25 obvious.

1. Claim 1

226. It is my opinion that Suzuki alone or in combination with Grisham renders claim 1 obvious.

227. Claim element 1-Pre recites **“A collision avoidance system comprising.”** I understand that whether a claim’s preamble is treated as a limitation on the scope of the claim is a legal question. For the purposes of my analysis this determination is not important because should the preamble be found limiting, it is taught by Suzuki.

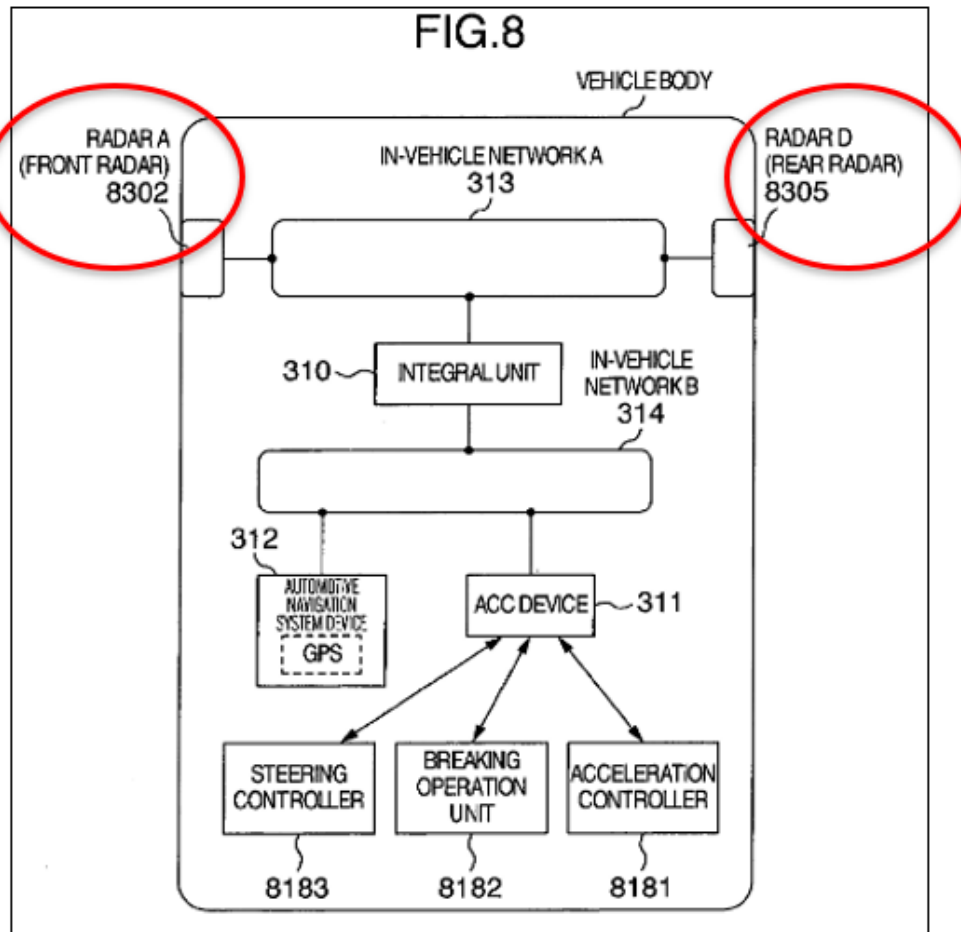
228. Suzuki teaches that a hazard warning is issued to a driver, or a pre-crash operation is carried out according to a separation distance between two vehicles, determined via a vehicle mounted UWB radar and communication device. “For an obstacle vehicle in front, the distance between two cars is measured using the radar function, and according to this distance, a hazard warning is issued to a driver, or a pre-crash operation is carried out.” EX1005, (57).

229. “Moreover, with the use of the communication function, by informing its own position to each other between vehicles equipped with the communication

function by means of the UWB, the distance to a surrounding vehicle close to its own vehicle is measured, and according to this distance a hazard warning is issued to the driver, or a pre-crash safety operation is carried out.” EX1005, [0008].

230. Claim element 1a recites **“one or more vehicle mounted modules, each vehicle mounted module mountable on a rail vehicle, each vehicle mounted module comprising:”** It is my opinion that Suzuki teaches a system having one or more vehicular mounted modules.

231. For example, Suzuki teaches mounting a plurality of in-vehicle radar devices, including one on the front of the vehicle and another on the back. “[n]ext, an embodiment of a vehicle driving control system in the case where a plurality of in-vehicle radar devices shown in Fig. 3 are mounted is described with reference to Fig. 8. Assume that in a vehicle body to which radars are mounted, a radar A302 is mounted on the front in the typical traveling direction and a radar D305 is mounted at the back. Although two or more radars may be mounted, it is preferable that they are mounted in the range to cover at least the back and front.” *Id.*, [0035].



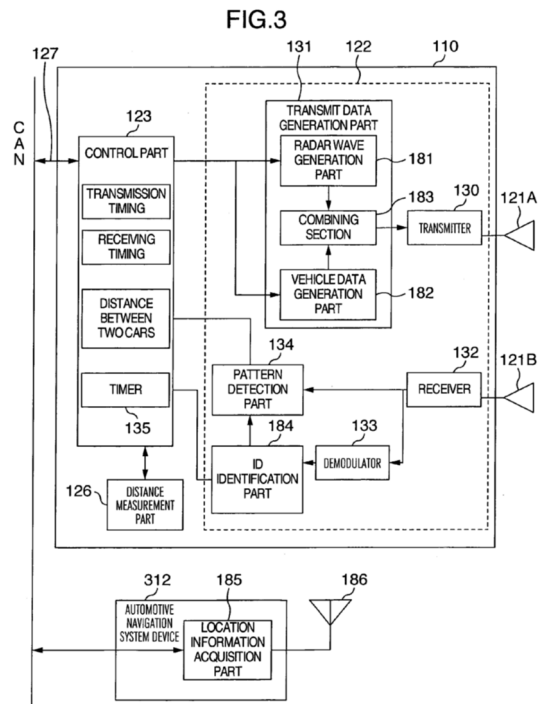
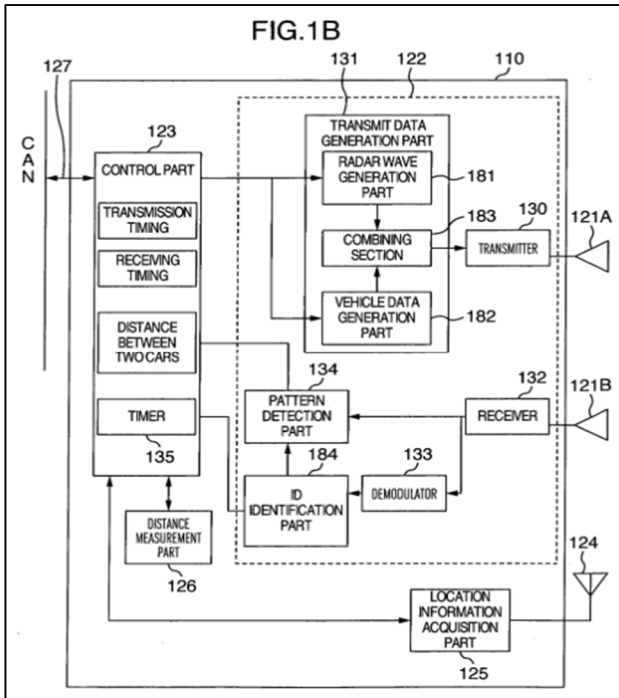
232. Suzuki discloses in-vehicle radar devices 110 in various configurations containing a number of interrelated components as shown in Figs. 1B and 3. EX1005, Figs. 1B, 3. These devices may operate in conjunction with a user interface that issues warnings to drivers as shown in FIG. 8. *Id.*, Fig. 8. Suzuki explains that the embodiments of Figs. 1B and 3 are incorporated into the radar embodiment of Fig. 8. Suzuki teaches the following.

[0035] Next, an embodiment of a vehicle driving control system in the case where a plurality of in-vehicle radar devices shown in Fig. 3 are mounted is described with reference to Fig. 8. Assume

that in a vehicle body to which radars are mounted, a radar A302 is mounted on the front in the typical traveling direction and a radar D305 is mounted at the back. Although two or more radars may be mounted, it is preferable that they are mounted in the range to cover at least the back and front.

[0036] The ACC device 311 which is a radar and vehicle driving control unit is connected via a network. The above described radar A302 and radar D305 are connected to an in-vehicle network A313. Moreover, the ACC device 311 and the automotive navigation system 312 are connected to an in-vehicle network B314. Furthermore, an integral unit 310 is connected to the both in-vehicle networks A and B. This integral unit 310 comprises the functions of the control part 123 and the vehicle-to-vehicle distance measurement part 126 of the in-vehicle radar device shown in Fig. 1B, and combines the controls of the radar functions each into one. Moreover, it collects and processes the information on the respective radars A and D and also has a gateway function between the in-vehicle network A313 and in-vehicle network B314.

EX1005, [0035]-[0036].



233. It is my opinion that it would have been obvious that the vehicle mounted modules in Suzuki could be mounted on rail vehicles in the same way it teaches for mounting on automobiles. Suzuki's preferred embodiment uses motor vehicles ("cars") rather than rail-line vehicles. A POSITA would have understood Suzuki's teachings to be applicable more broadly to all ground vehicles, including rail-line vehicles, because Suzuki generally refers to "vehicles" throughout its disclosure, only sometimes further specifying that those vehicles are "cars." Indeed, a POSITA would understand that some rail vehicles, like dual-mode work vehicles (also known as DMVs, road-rail vehicles, or hi-rail trucks) like railroad work

vehicles, are essentially motor vehicles or cars with the ability to operate on tracks and roads.

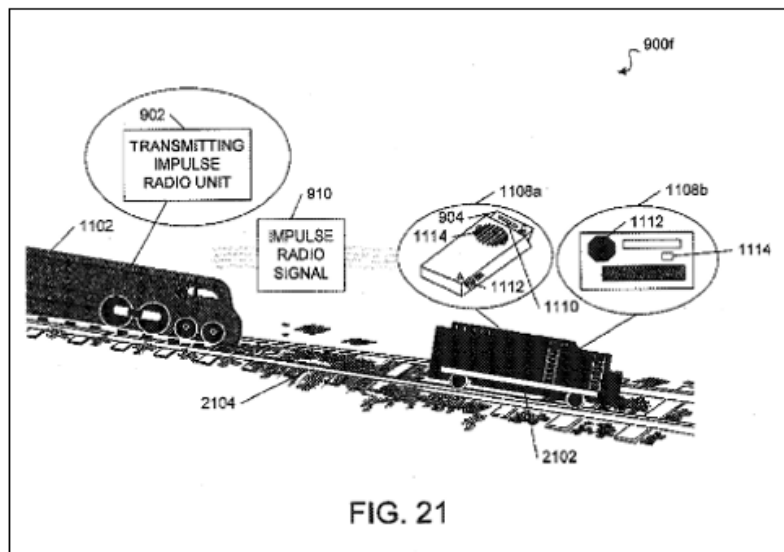
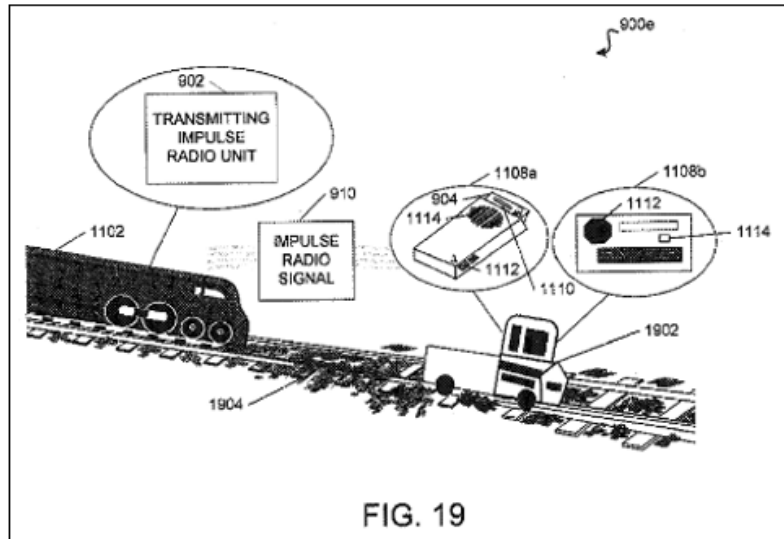
234. A POSITA would have understood that cars and rail vehicles both benefit from systems for collision avoidance to improve safety, and that systems for use in cars and rail vehicles would need to and in fact do work well together. It would have thus been obvious to apply automotive systems to rail vehicles, and that the modules in Suzuki could be used in rail vehicles. Since rail vehicles have fewer degrees of freedom of movement than cars, a POSITA would have further understood that a system for collision avoidance for cars could readily be applied to rail vehicles, as it would simply be applying a more robust technology to a simpler technical problem.

235. It is additionally my opinion that a POSITA would understand that applying Suzuki's vehicle mounted modules to rail vehicles would require minimal modification. In fact, mounting a module to a rail vehicle would involve less technical and design effort, since, unlike automobiles, rail vehicles have far fewer esthetic constraints, and many more locations suitable for mounting such modules. Moreover, a POSITA would have understood that rail systems and car systems operate in overlapping geographical environments, and, further, that there are many more cars than rail vehicles. Thus, a POSITA would naturally look to modifying a system for cars as disclosed in Suzuki to use in rail vehicles. In addition, a POSITA

would have understood that collisions between rail vehicles and automobiles are very dangerous⁷, and the proximity of both automobiles and rail vehicles at numerous rail crossings would warrant fitting both automobiles and rail vehicles so that such accidents could be more effectively avoided.

236. I am further of the opinion that the combination of Suzuki and Grisham teaches the use of one or more vehicular modules mounted on rail vehicles. For example, Grisham in Figures 19 and 21 illustrate the use of UWB communications between a transmitting impulse radio unit 902 coupled to a rail vehicle, such as a locomotive, on one hand and a receiving impulse radio unit 904 coupled to a different type of rail vehicle in Fig. 19 and to a second locomotive in Fig 21.

⁷ According to the Federal Rail Administration, there were 2061 rail-auto accidents in the United States in 2021, and these resulted in 1045 injuries (over 50% of crashes), and 250 fatalities (12% of crashes). *See* EX1033; *see also* EX1034, EX1035.



237. Grisham additionally discusses these illustrations.

“Referring to FIGS. 19 and 20, there are diagrams illustrating in greater detail the components and steps of a fifth embodiment of the railroad collision avoidance system 900e and method 1000e. In this embodiment, the railroad collision avoidance system 900e includes a transmitting impulse radio unit 902 coupled (step 2002) to a locomotive

1102 and a receiving impulse radio unit 904 coupled (step 2004) to a work vehicle 1902.”

EX1006, 22:42-49.

238. Additionally, Grisham states the following.

“Referring to FIGS. 21 and 22, there are diagrams illustrating in greater detail the components and steps of a sixth embodiment of the railroad collision avoidance system 900f and method 1000f. In this embodiment, the railroad collision avoidance system 900f includes a transmitting impulse radio unit 902 coupled (step 2202) to a first locomotive 1102 and a receiving impulse radio unit 904 coupled (step 2204) to a second locomotive 2102.”

EX1006, 23:33 – 40.

239. It is my opinion that a POSITA would be motivated to mount the systems of Suzuki on rail vehicles as discussed above. Should the board disagree that Suzuki alone is sufficient to render obvious this element, clearly Grisham teaches the use of these types of devices in rail vehicles. Both references relate to the use of UWB sensor and communications systems in the operation of vehicles to avoid collisions, and thus a skilled artisan would look to their combined teachings. In fact, Grisham and Suzuki address the same problem – vehicular collision avoidance – in substantially the same way, using UWB radars to sense potential hazards, one in cars and the other in cars and trains. In Figs 11 and 12 Grisham explicitly discloses an embodiment with a mounted UWB unit in a car communicating with a mounted UWB unit in a rail vehicle; thus, a POSITA would

naturally look to other systems involving collision avoidance in cars such as in Suzuki.

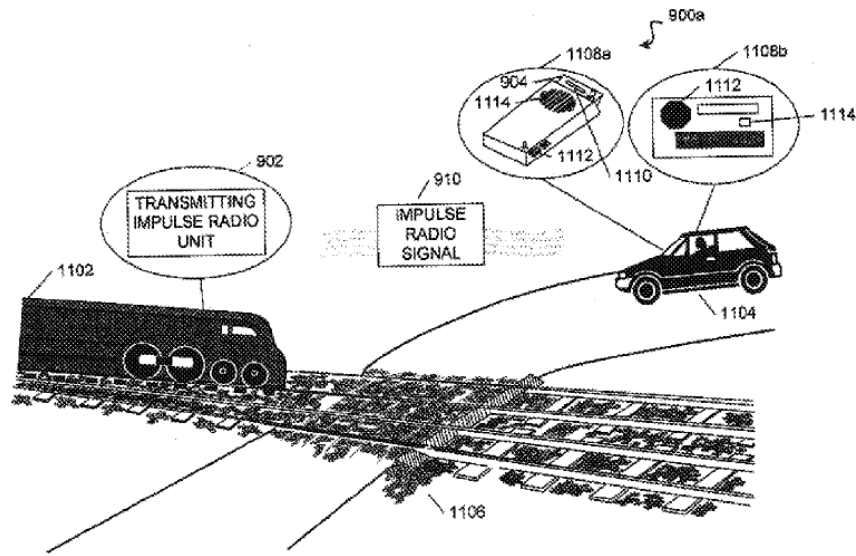


FIG. 11

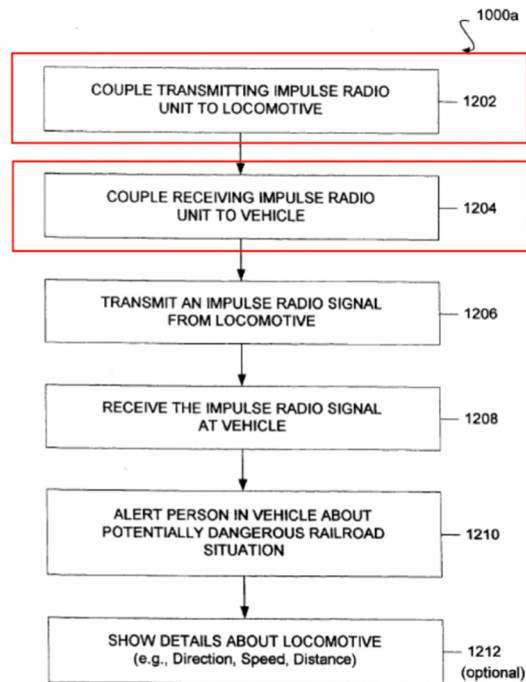


FIG.12

240. Grisham expressly teaches how to use its rail system in any other vehicles such as a car. “It should be understood that any vehicles 1104 that include the receiving impulse radio units 904 as described above with respect to FIG. 11 would also operate in this embodiment. Ex. 1006, 22:28-30. Grisham teaches why collision avoidance systems using UWB sensors would be beneficial in rail vehicles, and, as described above it would be a trivial modification for a POSITA to apply the vehicle mounted modules of Suzuki to rail vehicles as in the collision avoidance system taught by Grisham.

241. It is my opinion that a POSITA would further have been motivated to combine Suzuki and Grisham because the pertinent prior art includes both cars and

rail vehicles, and since solutions to their common problem of collision avoidance would benefit from interoperability or compatibility between cars and rail vehicles, as taught explicitly by Grisham's car-train embodiment illustrated in Fig. 11. It is well-known that many rail-auto accidents occur at un-protected at grade rail crossings.⁸

242. A POSITA would have understood that equipping both automobiles and trains with compatible systems, as disclosed in Grisham, would allow trains to warn automobile drivers of their presence long before the train represented a hazard, and thereby would enhance overall safety, particularly given the embodiment disclosed in Grisham in which cars and rail vehicles are used in the same system. Since rail vehicles have fewer degrees of freedom of movement than cars as rail vehicles are constrained to travel on defined railways and cars are not, a POSITA would have understood that a system for collision avoidance for cars could readily be applied to a system for collision avoidance for rail vehicles, as it would simply be applying a more robust technology to a simpler technical problem. For example, a POSITA reading Grisham would have understood that rail systems and car systems

⁸ According to the Federal Rail Administration 60% of rail accidents occur at unprotected rail crossings, and 80% of rail crossings in the United States are unprotected (i.e. without lights or barriers). *See e.g.* EX1036.

would provide the greatest benefit when they are compatible with each other. Further that there are many more cars, at least in the United States, than rail vehicles. Thus, a POSITA would naturally look to adapting a system for rail vehicles and cars as disclosed in Grisham to be compatible with the system for cars such as that disclosed in Suzuki.

243. Claim element 1b recites **“a transponder sensor module operable to send and receive data wirelessly, the transponder module comprising a first ultra wideband unit and a first antenna.”** It is my opinion that Suzuki teaches this claimed transponder sensor module.

244. For example, Suzuki teaches the use of an in-vehicle radar device 110 that sends via an antenna 121A and receives via antenna 121B both radar waves and data including location information for the vehicle and a Vehicle ID. Suzuki teaches the following.

“In the in-vehicle radar device 110, a control part 123 sends to a radar transceiver 122 a command to transmit a radar wave in a predetermined cycle or at a timing determined according to the driving speed. In the control part 123, a timing at which this command to transmit was made is read from a timer 135 and stored as the transmit timing. In the radar transceiver 122, a pulse of radar wave is generated by a transmission data generation part 131 according to a command from the control part 123, and a transmit data including the obtained own location information and the own vehicle ID are prepared, and a radar wave 140

made by adding the transmit data to the pulse of radar wave is transmitted by a transmitter 130 via an antenna 121A.”

EX1005, [0014].

245. Suzuki also teaches the following.

“A radar wave is received by a radar transceiver 122 via a receiving antenna 121B. As to the mounting position of the receiving antenna 121B of the in-vehicle radar device, the receiving antenna 121B is mounted on a position, such as on the upper part of the roof or on the dashboard of this vehicle, where the communication in the front and back direction of the vehicle is carried out easily.”

EX1005, [0015].

246. These are illustrated in Figs. 1B and 3.

247. Claim element 1c recites the following. **“a control electronics module comprising a processor in communication with at least the transponder sensor module unit;”** It is my opinion that Suzuki teaches this control electronics module communicating with the transponder sensor module. It discloses an integral unit 310 which includes “the control part 123 and the vehicle-to-vehicle distance measurement part 126” that are connected to radar devices mounted to the front and rear of a vehicle via in-vehicle network A313 and in-vehicle network B314. Suzuki further teaches that “it collects and processes the information” from the respective front and rear mounted radar devices. EX1005, [0036], Figs. 3, 8 (above). While it does not expressly state it uses a processor, it does describe processing of information, it is my opinion that a POSITA would understand this processing would

be performed by a processor or at least would have been preferably performed by a processor.

248. Claim element 1d recites the following. **“a user interface module including a user interface, the user interface being operable to provide rail vehicle information to a vehicle operator and to receive input from the vehicle operator;”** It is my opinion that Suzuki teaches the claimed user interface and its functionality.

249. Suzuki teaches “Moreover, with the use of the communication function, by informing its own position to each other between vehicles equipped with the communication function by means of the UWB, the distance to a surrounding vehicle close to its own vehicle is measured, and according to this distance a hazard warning is issued to the driver or a pre-crash safety operation is carried out.” EX1005, [0008]

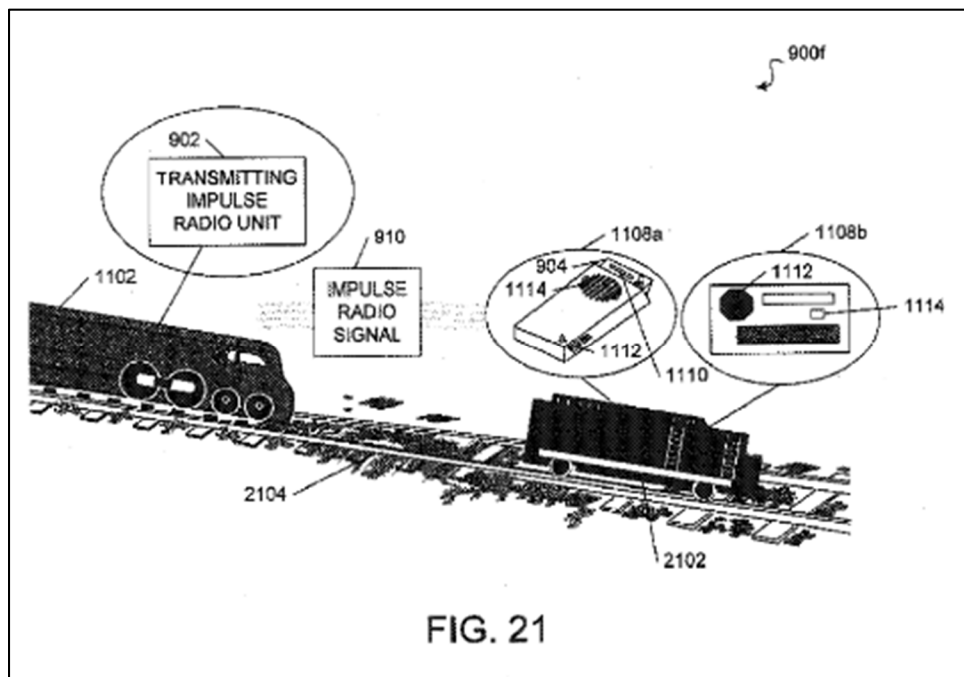
250. Suzuki also teaches “[i]n the warning function, if the obtained distance C between two cars is a predetermined distance or less, a warning indicating that an adjacent vehicle is accessing the driver is issued by means of voice, sound, display or the like.” *Id.*, [0018] and “In the in-vehicle radar device 110 of Fig. 1, the distance between two cars calculated by the vehicle-to-vehicle distance measurement part 126 is transmitted to the warning function of the driver via the control part 123 and network 127, and the warning function, if the obtained distance between two cars is

a predetermined distance or less, issues a warning indicating that a close vehicle is accessing the driver, by means of voice, sound, display or the like.” *Id.*, [0028]

251. While Suzuki does not explicitly state that the user interface can receive input from the vehicle operator, it would be obvious to one of ordinary skill that the warning and alarm displays and the navigation systems of Suzuki preferably would receive input from a driver. Examples of these types of inputs would include muting alarms and adjusting alarm volumes. Further, it was well known at the time that Automotive Navigation Systems, such as disclosed by Suzuki element 312 would include the ability for an operator to input a desired destination into the system for guidance. These types of input devices and modes were well known at the time, widely used, and are within the scope of what the '227 patent discloses to be devices capable of allowing an operator to have input into the system.

252. Further, it would be obvious to a POSITA that warning systems and alarm displays in Suzuki could be applied to rail vehicles. Additionally, a POSITA would have understood that card and rail vehicles face collision avoidance problems and that applying warning and alarm systems for cars to rail vehicles would not require any substantial modification to the systems. As previously discussed, collision avoidance systems adapted to railway vehicles can be significantly less complex than automobile systems because, for example, the degree of freedom of movement of rail vehicles is much more limited than automobiles.

253. While it is my opinion that Suzuki teaches or renders obvious this claimed element, the combination of Suzuki and Grisham does so as well. Grisham teaches a user interface module that provides information to an operator and is configured to receive input from the user. Grisham's user interface is configured to alert an operator through the use of visual and audible alarms. Grisham states "the receiving impulse radio unit 904 makes sure that a person operating the second locomotive 2102 is alerted (step 2208) about the presence of the first locomotive 1102." EX1006, 23:48-52. The alert may be via an after-market (1108a) device or in-dash display (1108b) and can be "an alarm (see light 1112) or voice message (see speaker 1114)." *Id.*, 23:52-59.



254. Grisham further states that "a person could use the display 1108 having a transmitting impulse radio unit (not shown) to communicate with a person on the

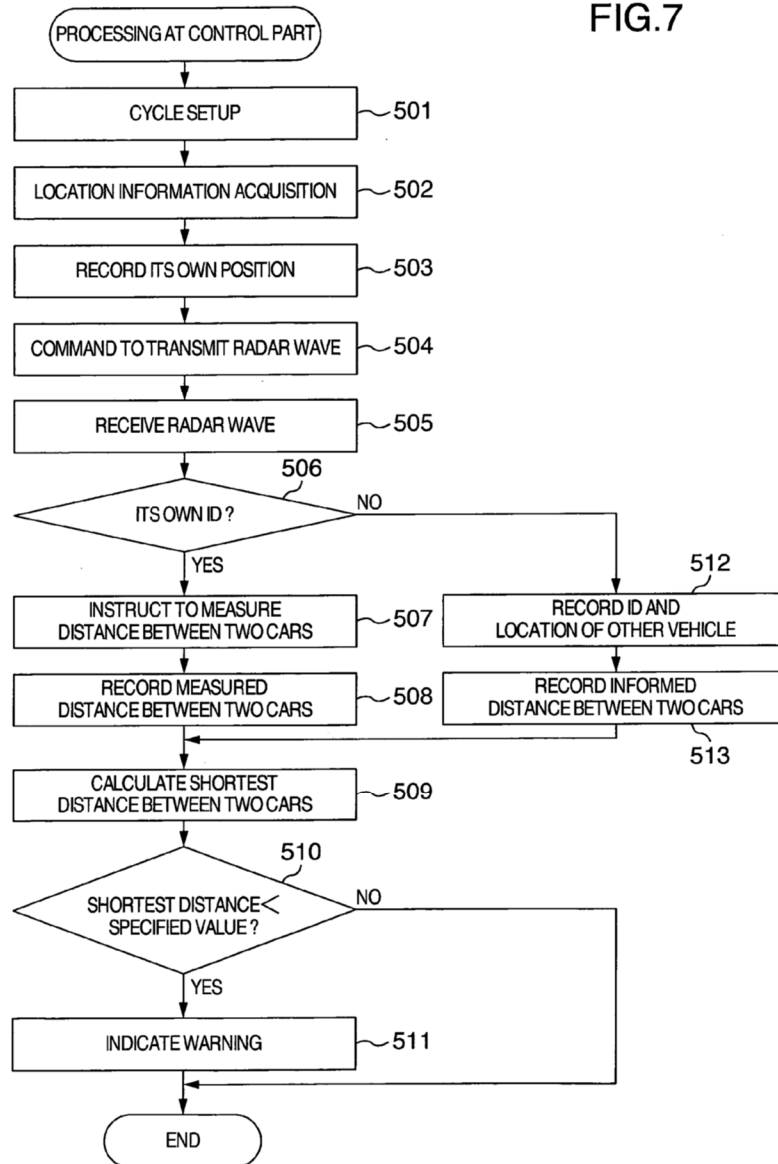
locomotive 2102 having a receiving impulse radio unit (not shown).” EX1006, 23:60-63. Communicating with a person the locomotive requires the person to input messages or data into the user interface which will be sent to the locomotive and the person alerted to the message visually, audibly or in some manner that would alert the person to the received message.

255. Claim element 1e recites **“wherein each vehicle mounted module is operable to communicate with at least one other vehicle mounted module mounted on at least one other rail vehicle.”** In my opinion, Suzuki expressly teaches the vehicle mounted units are operable to communicate with each other. Suzuki teaches each device being configured to include both a communication function and a radar function. Suzuki states, “by informing its own position to each other between vehicles equipped with the communication function by means of the UWB, the distance to a surrounding vehicle close to its own vehicle is measured;” EX1005, [0008] “radar wave is received by a radar transceiver 122 via a receiving antenna 121B. As to the mounting position of the receiving antenna 121B of the in-vehicle radar device, the receiving antenna 121B is mounted on a position, such as on the upper part of the roof or on the dashboard of this vehicle, where the communication in the front and back direction of the vehicle is carried out easily. The received radar wave is converted and amplified to a lower frequency in a receiver 132 to generate a received signal. The received signal is demodulated in a

demodulator 133, and the own vehicle ID is compared with an ID of the received signal in an ID identification part to thereby identify whether the received signal is the reflection wave of a radar wave which the own vehicle transmitted or a radar wave which other vehicle transmitted.” EX1005, [0015] and “Moreover, if it is the received signal of a radar wave transmitted from an in-vehicle radar device mounted in other vehicle, the received signal which has been demodulated in the demodulator 133 is received, and the vehicle ID and the location information of other vehicle are extracted from this received signal and transmitted to the vehicle-to-vehicle distance measurement part 126.” EX1005, [0016].

256. Further as illustrated in Suzuki FIG. 7 a UWB module receiving a signal identifies whether it is its own ID or a different vehicle ID in conditional step 506, if it is its own ID, it processes the distance between cars by radar techniques in steps 507 and 508. If the received transmission contains a different vehicle ID, it records the ID and the location of the transmitting vehicle in step 512.

FIG.7



257. As stated, it is my opinion that this claim element is expressly taught by Suzuki. It is additionally taught by Grisham. For example, Grisham teaches

“Referring to FIGS. 21 and 22, there are diagrams illustrating in greater detail the components and Steps of a sixth embodiment of the railroad collision avoidance system 900f and method 1000f. In this embodiment, the railroad collision avoidance system 900f includes a transmitting impulse radio unit 902 coupled (step 2202) to a first

locomotive 1102 and a receiving impulse radio unit 904 coupled (step 2204) to a Second locomotive 2102. Since neither of the locomotives 1102 and 2102 would normally be aware of each other's presence on the same railroad track 2104, the transmitting impulse radio unit 902 would continually transmit (step 2206) an impulse radio signal 910. As described above, the impulse radio signal 910 has a known pseudorandom Sequence of pulses that look like a Series of Gaussian waveforms (see FIGS. 1-3). Upon receiving (step 2206) the impulse radio signal 910 at the Second locomotive 2102, the receiving impulse radio unit 904 makes Sure that a person operating the Second locomotive 2102 is alerted (step 2208) about the presence of the first locomotive 1102."

EX1006, 23:33-52.

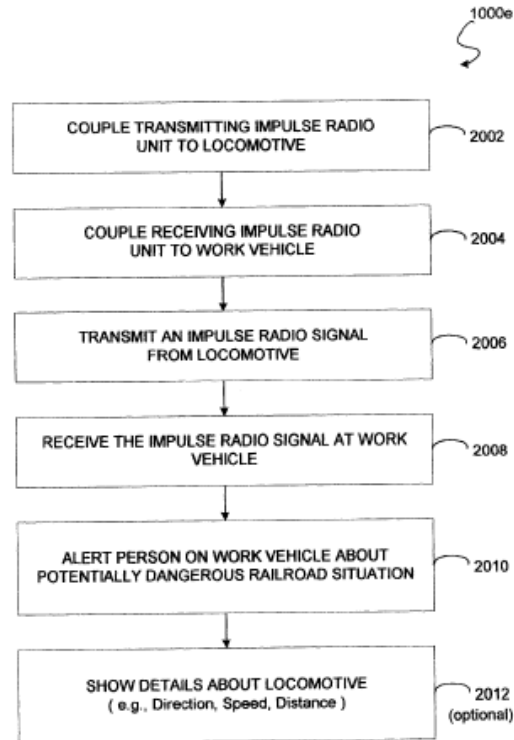
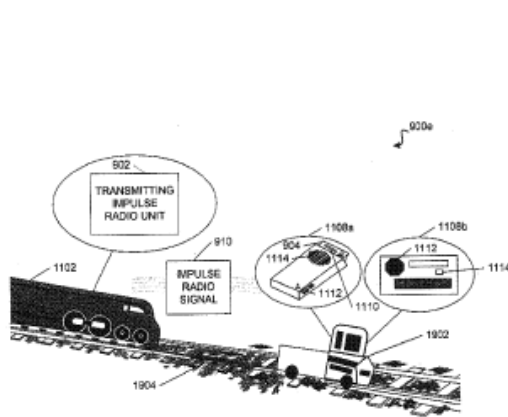
258. Grisham further states

"In this embodiment, the railroad collision avoidance system 900e includes a transmitting impulse radio unit 902 coupled (step 2002) to a locomotive 1102 and a receiving impulse radio unit 904 coupled (step 2004) to a work vehicle 1902. Since the locomotive 1102 would normally not be aware of the presence of the work vehicle 1902 on the same railroad tracks 1904, the transmitting impulse radio unit 902 may continually transmit (step 2006) an impulse radio signal 910. As described above, the impulse radio signal 910 has a known pseudorandom Sequence of pulses that look like a series of Gaussian waveforms (see FIGS. 1-3). Upon receiving (step 2008) the impulse radio signal 910, the receiving impulse radio unit 904 makes sure that

the person operating the work vehicle 1902 is alerted (step 2010) about the potentially dangerous situation.”

EX1006, 22:45-60.

259. The communications between the vehicle mounted units is further illustrated in Grisham’s FIGs 19 – 22.



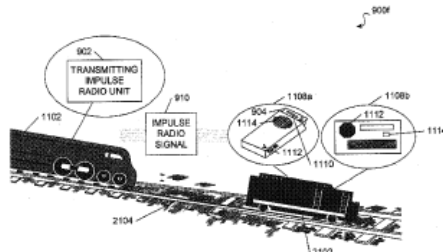


FIG. 21

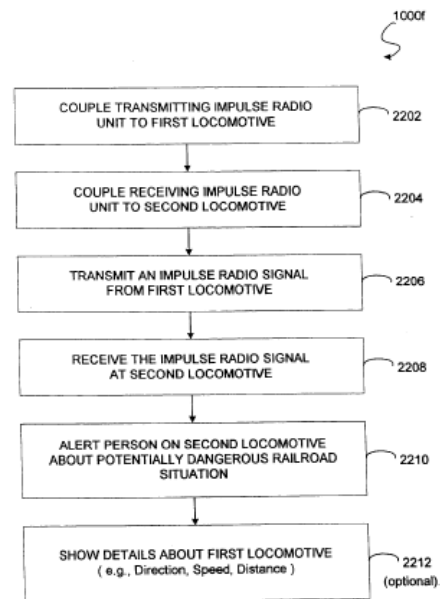


FIG. 22

260. For reasons I previously discussed, it is my opinion that a POSITA would find it obvious to incorporate Suzuki's vehicle mounted modules on locomotives and other rail-line vehicles.

261. Claim element 1f recites **“wherein each vehicle mounted module is operable to apply a time of flight technique to determine a separation distance between the rail vehicles.”** It is my opinion that this claim element is taught by both Suzuki and Grisham. As previously noted in connection with FIG. 7 above, Suzuki employs UWB modules configured to have both a radar function and a communications function. With respect to the radar function, Suzuki expressly teaches time-of-flight processing to obtain separation distance. Suzuki states

“the transmission timing and the reception timing obtained from the pattern detection part 134 are sent to the vehicle-to-vehicle distance

measurement part 126, and then in the vehicle-to-vehicle distance measurement part 126 the value of a distance obtained by multiplying the time difference between these transmission timing and reception timing by the speed of light is divided by two to thereby calculated the distance to a vehicle which reflected the radar wave . . .”

EX1005, [0032].

262. Suzuki additionally acknowledges that UWB communication and radar technology were well known and under standardization since 2002 and were designed to measure distances between objects using time-of-flight techniques.

Suzuki states

“UWB (Ultra Wide Band), which is currently under development for the purpose of the next generation wireless broadband communication, has been under standardization since 2002. It is also known that in the case where a transceiver for generating a waveform of electric wave of this UWB is designed, a pulse wave which the own vehicle transmitted reflects off an object and the round-trip time between the receiving wave and the transmitted pulse is measured, thereby allowing the transceiver to have a radar function to measure the distance between the transceiver and the object. Then, in European industry consortium, SARA (Short-range Automotive Radar frequency Allocation), a short range radar using UWB using the frequency of a 24 GHz band is currently studied, and a study of the in-vehicle UWB radar is also ongoing. Moreover, a car platoon carrying out vehicle-to-vehicle communication while putting data on the transmitting and receiving waves of the UWB radar is also under study by the above SARA.”

EX1005, [0004].

263. As previously discussed, it is my opinion that the vehicular modules used by Suzuki in automobiles would be easily configured for locomotives and other rail-line vehicles. A POSITA would look to Suzuki while designing collision avoidance systems for rail vehicles, because both automobiles and rail-line vehicles face the same or similar problem of avoiding collisions, and that by employing the well-known time-of-flight techniques discussed by Suzuki one could easily ascertain accurate separation distances between vehicles. As a POSITA would further understand the same time-of-flight calculations used by Suzuki's vehicle modules would be used in rail vehicle modules. Further, a POSITA would recognize that the collision avoidance problem in rail-line vehicles is somewhat easier than in automobiles because rail vehicles have fewer degrees of freedom in their range of motions. For example, rail vehicles are bound to tracks and typically require significantly larger turning radius and generally only move forward or backwards on a fixed track with a fixed position.

264. As previously discussed, it would be obvious to a POSITA to incorporate the vehicle modules discussed by Suzuki onto rail-line vehicles especially given the teachings of Grisham.

2. Claim 7

265. Claim 7 recites **“The collision avoidance system of claim 1, wherein the first vehicle mounted module further comprises a global positioning system**

unit, the global positioning system unit operable to receive information from one or more satellites to determine an absolute position of the rail vehicle, wherein the global positioning system unit is in communication with the control electronics module.” It is my opinion that Suzuki teaches this module and therefore alone or in combination with Grisham would render claim 7 obvious.

266. Suzuki teaches in vehicle modules contain GPS receivers. For example, Suzuki states “the in-vehicle radar device 110 receives signal from a GPS satellite via an antenna 124 and measures its own position to transmit this to a vehicle-to-vehicle distance measurement part 126.” EX1005, [0013]; *see also* Figs. 3 and 8 (element 312), [0021] (“the signal from a GPS satellite is received via an antenna 186, and its own position is measured by the location information acquisition part 185 in an automotive navigation system 312”), [0045] (“The longitude and latitude of its own vehicle are obtained in the location information acquisition parts 125, 185 through a GPS or the like.”).)

FIG.3

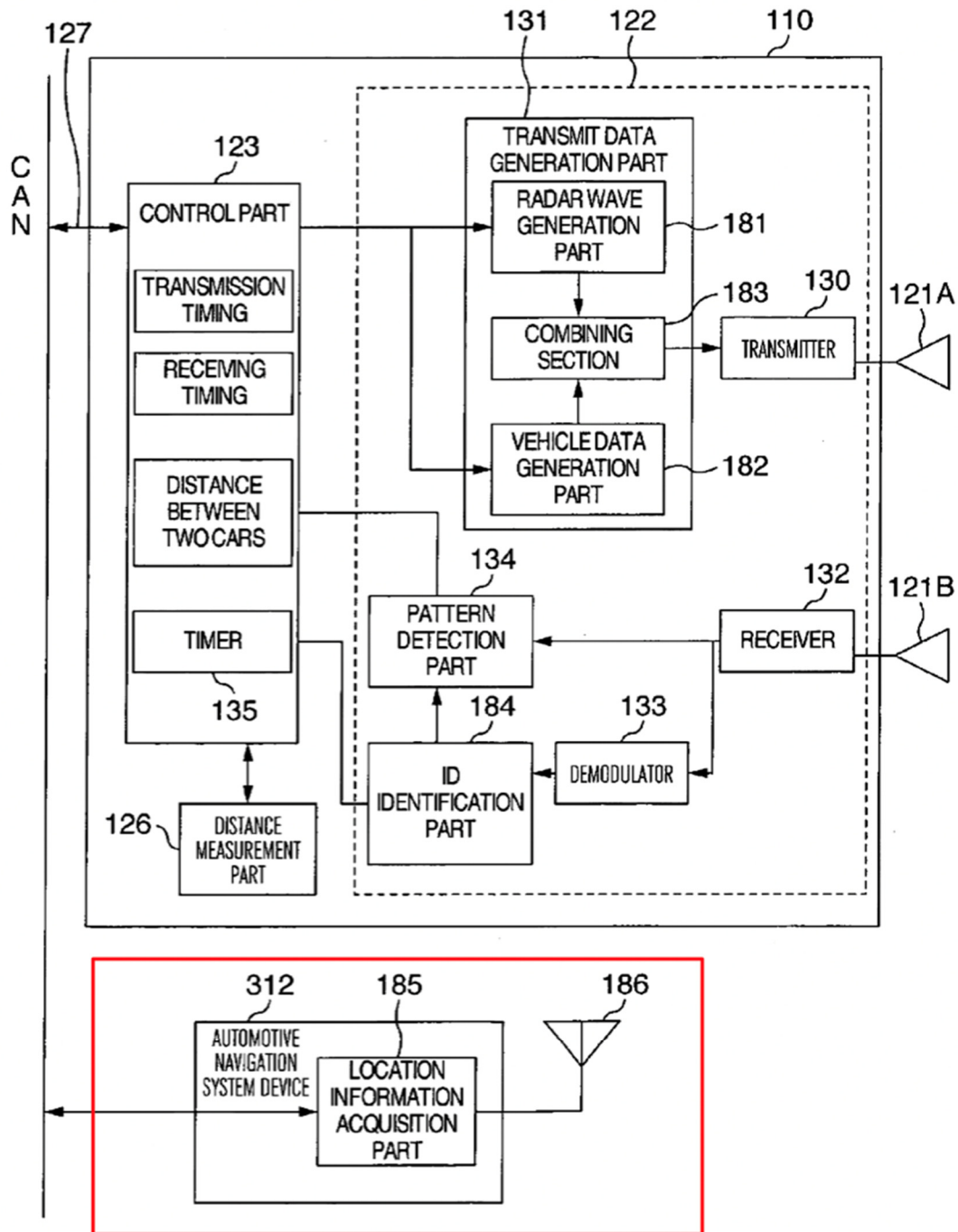
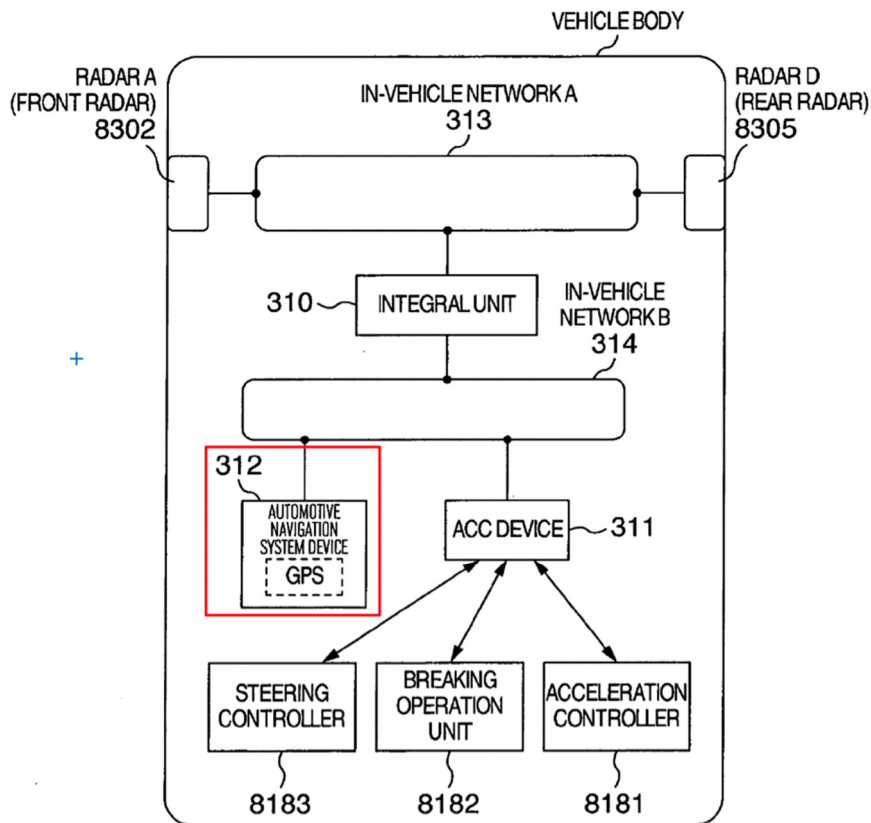


FIG.8



267. A POSITA would understand that Suzuki's Automotive Navigation System Device 312 contains a GPS Unit that communicates with satellites through antenna 186.

268. Further, as illustrated in FIG. 3 (above) Suzuki's Automotive Navigation System Device 312, including the GPS module, is in communication with the control electronics module (Suzuki's "Control Part 123") through Suzuki's Controller Area Network (CAN).

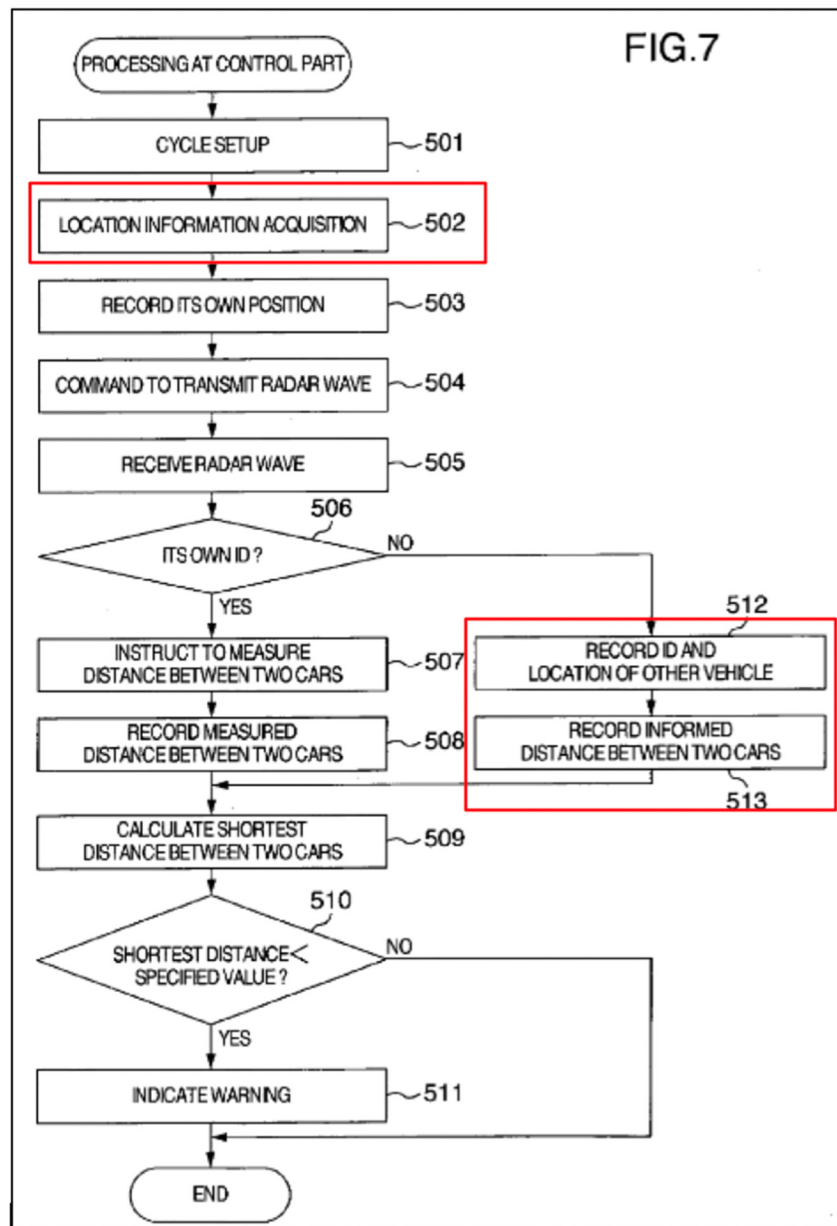
269. For reasons I described above I believe a POSITA would understand that the vehicle modules of Suzuki could be easily mounted on locomotives or other rail vehicles. This mounting is a trivial modification that a POSITA would be motivated to make given the teaching of Suzuki and the nature of the problems both automobiles and rail-line vehicles face in collision avoidance.

3. Claim 8

270. Claim 8 recites **“The collision avoidance system of claim 7, wherein the first vehicle mounted module receives information generated by the global positioning system unit and the first ultra wideband unit to determine whether one or more vehicle separation criteria are violated, and generates a warning signal when one or more vehicle separation criteria are violated.”** It is my opinion that Suzuki teaches this element and therefore alone or in combination with Grisham would render claim 8 obvious.

271. In Suzuki FIG 7 and associated discussion, Suzuki discloses using the combination of UWB and GPS to determine if a vehicle separation criterion has been violated. The process flow illustrated in FIG. 7 is described in connection with device configuration of FIG. 1B EX1005, [0029]. Step 502 is labeled “Location Information Acquisition” in the specification it describes this function “Next, the control part 123 reads its own location information obtained from the location information acquisition part 125 (step 502), and stores this to a memory in the control

part 123 (step 503).” *Id.*, [0030] Further, with respect to the discussion of FIG. 1B, the specification states “A location information acquisition part 125 mounted in the in-vehicle radar device 110 receives signal from a GPS satellite via an antenna 124 and measures its own position to transmit this to a vehicle-to-vehicle distance measurement part 126.” *Id.*, [0013]



272. Further in FIG. 7 steps 510 and 511 Suzuki teaches determining if a separation distance has been violated and if so, sounding a warning. Suzuki further states

“From the distance A between two cars or the distance B between two cars obtained by receiving a radar wave, the shortest distance C between two cars is calculated in the control part 123 (step 509). Next, the control part 123 determines whether the distance C between two cars is a specified value or less (step 510), and if it is the specified value or less, the control part 123 issues a warning indication to an external device (for example, a warning device) (step 511).”

EX1005, [0034].

273. As previously discussed, while Suzuki is focused on automobile collision avoidance, a POSITA would be motivated to use the modules and processing algorithms disclosed in Suzuki in a rail-line environment for all of the reasons above.

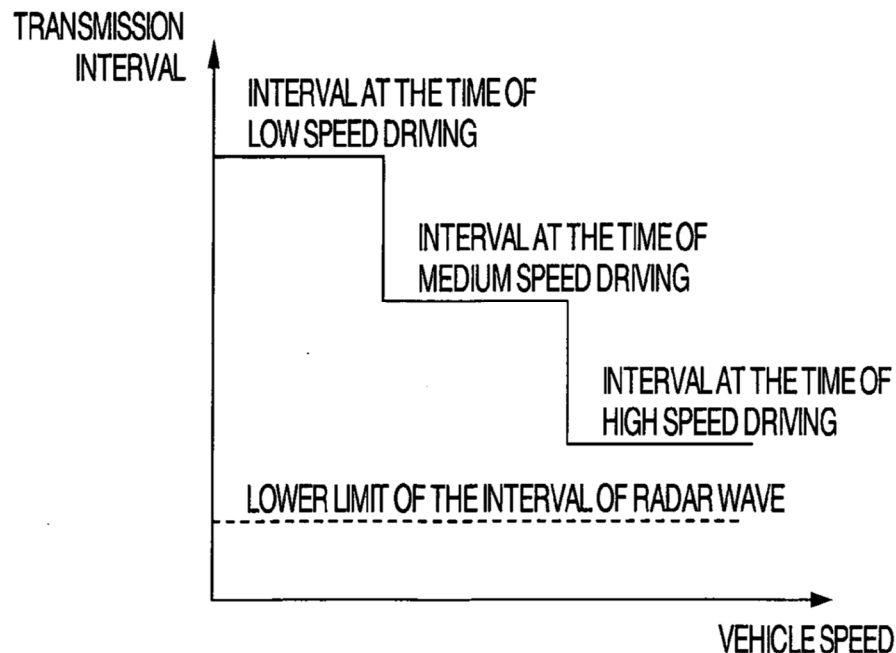
4. Claim 11

274. Claim 11 recites **“The collision avoidance system of claim 1, further comprising at least one ground speed detection module operable to determine the speed of the rail vehicle, wherein the first vehicle mounted module communicates with the at least one ground speed detection module.”** It is my opinion that Suzuki teaches this element and therefore alone or in combination with Grisham would render claim 11 obvious.

275. Suzuki teaches modifying certain parameters based on vehicle speed. For example, it states “The control part 123 receives vehicle speed information from the control device of the vehicle via the network, determines the transmission

interval of the radar wave based on a relationship as shown in the graph of Fig. 5B according to each vehicle speed, and indicates the transmission timing to the transmission data generation part 131.” EX1005, [0023].

FIG.5B



276. In my opinion, it would be obvious a POSITA to use the speed detection system of Suzuki to determine the speed of rail vehicles as well as automobiles. Generally, as previously discussed, these types of sensors and measurements in rail vehicles are much less complex than in automobiles. With respect to speed detection there were several off the shelf components capable of detecting speed of either automobiles or rail vehicles. For example, a POSITA was well aware of off the shelf wheel rotation speed sensors that could easily be employed to measure vehicle

speed. In addition, there were other types of speed sensors such as magnetoresistive, inductive, variable reluctance magnetic, and Hall effect magnetic sensors. Moreover, using a UWB radar to determine the distance, and through successive measurements over time, the relative speed of a nearby vehicle does not provide its absolute speed. A POSITA would have understood that using Suzuki's speed detection system the speed of the host vehicle could be independently determined, and this, the speed of the other vehicle could be computed using the host vehicle speed and the relative speed between the two vehicles.

277. While I believe that the teachings of Suzuki are sufficient to render this claim obvious, Grisham additionally teaches a ground speed detection module. For example, Grisham teaches the following.

“In addition, either display 1108a or 1108b is capable of showing (step 2210) the direction, distance and/or speed of the oncoming first locomotive 1102. To determine the distance that the first locomotive 1102 is from the second locomotive 2102, a controller 1110 within the receiving impulse unit 904 can use the revolutionary positioning capabilities of impulse radio technology. In particular, the impulse radio signal 910 transmitted between the transmitting impulse radio unit 902 and the receiving impulse radio unit 904 enables the controller 1110 to measure distances to extremely fine resolution because of the absence of ambiguous cycles in the waveform of the impulse radio signal 910. In contrast, narrow band Systems of traditional communication Systems are limited to the modulation envelope and

cannot easily distinguish precisely which RF cycle is associated with each data bit because the cycle-to-cycle amplitude differences are So Small they are masked by link or System noise. Since the waveform of the impulse radio signal 910 does not have multi-cycle ambiguity, this allows the controller 1110 to positively determine the position of the waveform to less than a wavelength even when the waveform is in or near the noise floor of the system. The time position measurement can be used by the controller 1110 to measure the propagation delay and determine the link distance between the receiving impulse radio unit 904 and the locomotive 1102. Once, the distance is known and updated then the speed of the first locomotive 1102 can be determined by the controller 1110.

EX1006, 23:64-24:24

278. A POSITA would understand these radio units to be a type of ground speed detection module because the controller within the radio unit determines the speed of the train based on the measurements by the ultrawide-band units, particularly when one of the radio units is on a control box or railroad pole, and is thus stationary. As was known by one of ordinary skill determining relative speed from a successive set of distance measurements is a trivial calculation. Additionally, for the reasons discussed above, it would be obvious to apply the speed detection module of Suzuki to rail vehicles given the need to design a more robust collision avoidance system for rail vehicles and the systems taught in Suzuki for collision avoidance in automobiles. If the Board were to determine the teachings of Suzuki

alone insufficient to render claim 11 obvious, it is my opinion that the teachings of Suzuki in view of Grisham do so.

5. Claim 12

279. Claim 12 recites **“The collision avoidance system of claim 1, further comprising an inertial measurement unit in communication with at least the control electronics module, the inertial measurement unit being operable to detect changes in the speed of the first rail vehicle.”** It is my opinion that Suzuki teaches this element and therefore alone or in combination with Grisham would render claim 12 obvious.

280. As discussed with respect to Claim 11 (above) Suzuki teaches a module that can determine the speed of the vehicle. Further, Suzuki’s controller 123 receives vehicle speed information from a control device via the Controller Area Network (CAN). Suzuki states the following. “The control part 123 receives vehicle speed information from the control device via the network.” EX1005, [0023]. Suzuki discusses various types of data, including acceleration data, which is an inertial measurement, which the vehicles collect and communicate to each other given varying available channel bandwidths. Suzuki states

“Although the data transfer rate in the vehicle-to-vehicle communication is increased by widening the frequency band, which is used in the Ultra Wide Band Communication, if the available channels are limited, it is necessary to stop the communication data with a low

priority and assign the data with a high priority. As the communication contents used for the vehicle-to-vehicle communication, two types; (1) Vehicle driving control information (in particular, information related to driving stability, ability to follow the front car, and safety) and (2) Information required for convenience service for drivers, can be considered. For the data to be sent concerning the respective communication contents, priorities as shown in Fig. 16 can be considered.”

EX1005, [0051].

281. As noted in [0051], the types of data are found in Fig. 16.

FIG.16

DATA TYPE	PRIORITY	NUMBER OF OCCUPIED CHANNELS
• VEHICLE DRIVING CONTROL INFORMATION • INDIVIDUAL VEHICLE ID (IDENTIFICATION DATA) • ITS OWN SPEED (WHEEL SPEED) • BRAKE ON/OFF • BRAKE PRESSURE INFORMATION • ACCELERATOR OPEN RATIO INFORMATION • STEER ANGLE INFORMATION (STEERING WHEEL SENSOR INFORMATION) • ACCELERATION / DECELERATION IN TRAVELING DIRECTION (ACCELERATION SENSOR INFORMATION) • ENGINE ROTATIONAL SPEED • GEAR INFORMATION	1	TRANSMIT 1 CHANNEL RECEIVE 1 CHANNEL
• VOICE COMMUNICATION	2	TRANSMIT 1 CHANNEL RECEIVE 1 CHANNEL
• IN-VEHICLE VIDEO COMMUNICATION (VIDEO TELEPHONE)	3	TRANSMIT 1 CHANNEL RECEIVE 1 CHANNEL
• INTERNET COMMUNICATION USING CAR-TO-CAR COMMUNICATION AND ROAD-TO-CAR COMMUNICATION	4	TRANSMIT 1 CHANNEL RECEIVE 1 CHANNEL

282. As illustrated in Fig. 16 the high priority data collected and communicated from vehicle to vehicle include “ITS OWN SPEED (WHEEL SPEED)” and “ACCELERATION/DECELERATION IN TRAVELING DIRECTION (ACCELERATION SENSOR INFORMATION). A POSITA would understand that “Acceleration Sensor Information” could include various types of sensors, but this type of data would typically be measured with an accelerometer. A POSITA would understand that an accelerometer is a type of Acceleration Sensor which as is known in the art is a device which can measure inertia.

283. An inertial measurement unit operable to detect changes in vehicle speed would have been obvious to a POSITA given the acceleration sensor information taught in Suzuki. A POSITA would have understood that Suzuki disclose the presence of an inertial measurement unit because it includes acceleration sensor information in Fig. 16. In fact, common, off-the-shelf acceleration sensors, such as accelerometers, were readily available and would be used in both cars and rail vehicles. It is therefore my opinion that where Suzuki teaches a priority 1 parameter referred to as originating from “acceleration sensor information,” it is explicitly teaching or rendering obvious the Inertial Measurement Unit of claim 12.

284. While as discussed throughout, Suzuki explicit teaching is directed to automobiles, it would inform a POSITA how to apply its modules and algorithms to rail vehicles. In the alternative, it is my opinion that a POSITA could easily combine

the teachings of Suzuki and Grisham to easily arrive at the claimed invention. A POSITA would have been motivated to combine the detection of changes in speed of vehicles (automobiles) taught by Suzuki with Grisham's collision avoidance systems in rail vehicles to detect changes in speed of the rail vehicles.

6. Claim 13

285. Claim 13 recites **“The collision avoidance system of claim 12, wherein the inertial measurement unit comprises at least one of an accelerometer or a gyroscope.”** It is my opinion that Suzuki teaches this element and therefore alone or in combination with Grisham would render claim 13 obvious.

286. As I mention above with respect to claim 12, a POSITA would know that gyroscopes and accelerometers (such as the acceleration sensor mentioned in FIG. 16) are typical components in inertial measurement units. For the same reasons discussed in claim 12, it is my opinion that Suzuki alone or in the alternative Suzuki in view of Grisham renders claim 13 obvious.

7. Claim 14

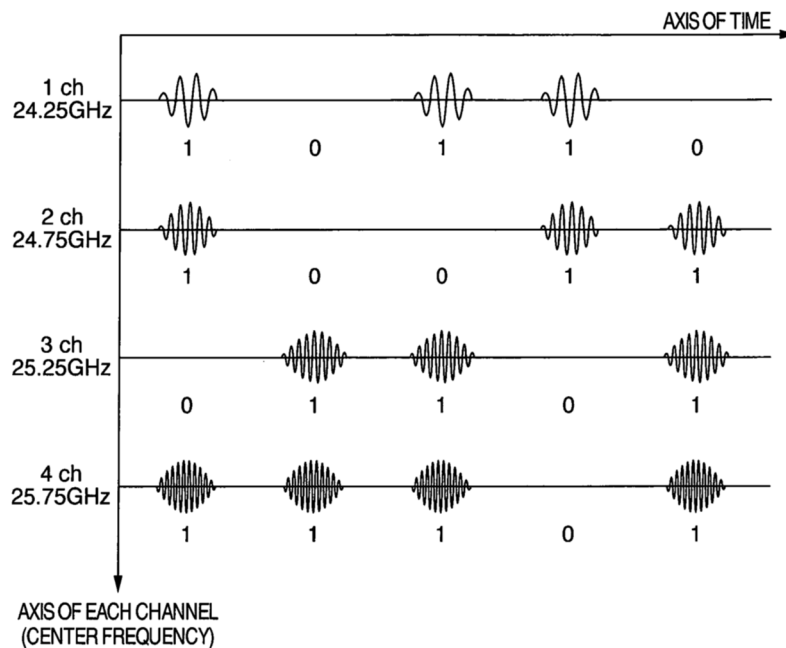
287. Claim 14 recites **“The collision avoidance system of claim 1 wherein the ultra wideband unit is adapted to transmit and receive signals with varying center frequencies.”** It is my opinion that Suzuki teaches this element and therefore alone or in combination with Grisham would render claim 14 obvious.

288. Suzuki teaches

“Fig. 15 describes the principle of the data communication in each frequency channel. This view shows an image in which a pulse wave having a center frequency of each channel of 1ch to 4 ch is transmitted on the time axis, and the waveform of the pulse wave is an image of the amplitude of the electric field of electric wave. If a time zone without pulse is expressed as 0 and a time zone with a pulse as 1, then a data communication of 0/1 is possible. A sender simultaneously transmits frequency bands (ch) of which center frequency differs to each other, and a receiving side extracts the data by separating into each frequency band. This method is the same as that of a Ultra Wide Band Communication technique using the OFDM (Orthogonal Frequency Division Multiplexing) Modulation.”

EX1005, [0050].

FIG.15



289. A POSITA would understand FIG 15 and the teaching of Suzuki's [0050] to illustrate that Suzuki's UWB modules transmit and receive signals with varying center frequencies. Further, Suzuki teaches

“Also in the in-vehicle radar device using the present invention, it is important to prevent the electric wave interference with the surrounding wireless system so as not to affect other wireless system and thus to coexist with other wireless system. Then, the present invention is intended to realize an in-vehicle wireless device or an obstacle detection unit, wherein the operation frequency band and transmission power are varied based on a predetermined location information on a map. Then, in the radar function of a multi-banded Ultra Wide Band Communication and in the vehicle-to-vehicle communication, the operation frequency band is made variable as to suitably select the operating frequency band for each region, the unused frequency which does not affect the wireless communication device in the region is used, and the transmission power is controlled corresponding to the frequency band to use. In this Ultra Wide Band Communication, as a vehicle moves, the frequency bands which the surrounding wireless system uses are calculated from the information on the current location detected by the location information acquisition part which detects its own position, and thereby, the frequencies available in each region corresponding to the situation of surrounding wireless communication equipment are made the frequency band to use in the Ultra Wide Band Communication, and the transmission power of this frequency band is increased to expand the communication coverage. In this way, it is also

possible to extend the radio wave distance as to be able to communicate with vehicles in a wider range.”

EX1005, [0040]

290. Since Suzuki expressly teaches this element a POSITA would understand that Suzuki alone or in combination with Grisham render claim 14 obvious.

8. Claim 17

291. It is my opinion that Suzuki alone or alternatively in view of Grisham renders claim 17 obvious.

292. Claim element 17-Pre recites “**A rail vehicle module mountable on a rail vehicle, the module comprising.**” I understand that whether a claim’s preamble is treated as a limitation on the scope of the claim is a legal question. For the purposes of my analysis this determination is not important because should the preamble be found limiting, it would be obvious over of the teachings of Suzuki alone or, in the alternative in view of Grisham as explained above. *See* Section VIII.L.1.

293. Claim element 17a recites “**a transponder sensor module comprising:**” It is my opinion that Suzuki alone or alternatively in combination with Grisham, teaches or renders obvious the claimed transponder sensor module as used in the ’227 patent. *See* Section VIII.L.1.

294. Claim element 17b recites “**a radio communication unit operable to employ time of flight techniques to detect a distance between the rail vehicle**

and at least one other vehicle.” It is my opinion that Suzuki alone or alternatively in combination with Grisham, teaches or renders obvious a system having one or more vehicular mounted modules that employ time of flight techniques to detect distance between vehicles. *See* Section VIII.L.1.

295. Claim element 17c recites **“a wireless communications antenna operable to send and receive data over the air;”** It is my opinion that Suzuki alone or alternatively in combination with Grisham, teaches or renders obvious a system having antennas operable to send and receive data wirelessly. A POSITA would be motivated to use the single-antenna embodiment of Figure 2 in the in-vehicle radar device 110 because it would reduce the cost of antennas and save space inside of the vehicle module unit. *See* Section VIII.L.1., EX1005, FIGs 1B and 3, elements 121A, 121B, 124, and 186.

296. Claim element 17d recites **“a global positioning system unit operable to receive information from one or more satellites to determine an absolute position of the rail vehicle;”** It is my opinion that Suzuki alone or alternatively in combination with Grisham, teaches or renders obvious a GPS unit that receives information from satellites and can determine absolute position. *See* Section VIII.L.2.; EX1005, FIGs 1B, 3 and 8, elements 125 and 312.

297. Claim element 17e recites **“a control electronics module comprising a processor in communication with at least the first transponder sensor**

module;” It is my opinion that Suzuki alone or alternatively in combination with Grisham, teaches or renders obvious the claimed control electronics module. *See* Section VIII.L.1.

298. Claim element 17f recites **“a user interface module including a user interface operable to provide rail vehicle information to a vehicle operator and to receive input from the vehicle operator.”** It is my opinion that Suzuki alone or alternatively in combination with Grisham, teaches or renders obvious the claimed user interface. *See* Section VIII.L.1.

299. Claim element 17g recites **“wherein the rail vehicle module communicates with at least one other module mounted on at least one other vehicle to detect a separation distance between the rail vehicle and the at least one other vehicle.”** It is my opinion that Suzuki alone or alternatively in combination with Grisham, teaches or renders obvious inter-vehicle communication to, at a minimum, detect separation distances between vehicles. *See* Section VIII.L.1.

9. Claim 18

300. Claim 18 recites **“The rail vehicle module of claim 17, wherein the radio communication unit comprises an ultra wideband unit configured to send and receive ultra wideband signals.”** It is my opinion that Suzuki alone or alternatively in combination with Grisham, teaches or renders obvious the vehicle modules using UWB. *See* Section VIII.L.1.

10. Claim 19

301. Claim 19 recites “**The rail vehicle module of claim 18, wherein the ultra wideband unit is adapted to transmit and receive signals with varying center frequencies.**” It is my opinion that Suzuki alone or alternatively in combination with Grisham, teaches or renders obvious the use of UWB signals with varying center frequencies. *See* Section VIII.L.7.

11. Claim 24

302. It is my opinion that Suzuki alone or alternatively in view of Grisham renders claim 24 obvious.

303. Claim element 24-Pre recites “**A collision avoidance system comprising.**” I understand that whether a claim’s preamble is treated as a limitation on the scope of the claim is a legal question. For the purposes of my analysis this determination is not important because should the preamble be found limiting, it would be obvious over of the teachings of Suzuki alone or, in the alternative in view of Grisham as explained above. *See* Section VIII.L.1.

304. Claim element 24a recites “**one or more vehicle mounted modules, each vehicle mounted module mountable on a rail vehicle, each vehicle mounted module comprising.**” It is my opinion that Suzuki alone or alternatively in combination with Grisham, teaches or renders obvious this limitation. *See* Section VIII.L.1.

305. Claim element 24b recites **“a transponder sensor module comprising.”** It is my opinion that Suzuki alone or alternatively in combination with Grisham, teaches or renders obvious this limitation. *See* Section VIII.L.1.

306. Claim element 24c recites **“a radio communication unit operable to employ time of flight techniques to detect a distance between rail vehicles.”** It is my opinion that Suzuki alone or alternatively in combination with Grisham, teaches or renders obvious this limitation. *See* Section VIII.L.1.

307. Claim element 24d recites **“and a global positioning system unit operable to receive information from one or more satellites to determine an absolute position of the rail line vehicle.”** It is my opinion that Suzuki alone or alternatively in combination with Grisham, teaches or renders obvious this limitation. *See* Section VIII.L.2.

308. Claim element 24e recites **“a control electronics module comprising a processor, the control electronics module being in communication with at least the transponder sensor module.”** It is my opinion that Suzuki alone or alternatively in combination with Grisham, teaches or renders obvious this limitation. *See* Section VIII.L.1.

309. Claim element 24f recites **“and a user interface operable to provide rail vehicle information to a vehicle operator and to receive input from the**

vehicle operator.” It is my opinion that Suzuki alone or alternatively in combination with Grisham, teaches or renders obvious this limitation. *See* Section VIII.L.1.

310. Claim element 24g recites “**wherein each of the two or more rail vehicle modules communicate to determine a separation distance between each rail vehicle,**” It is my opinion that Suzuki alone or alternatively in combination with Grisham, teaches or renders obvious this limitation. *See* Section VIII.L.1.

311. Claim element 24h recites “**and wherein each rail vehicle module is operable to use information provided by the radio communication unit and the global positioning system unit to determine whether one or more vehicle separation criteria are violated and to generate a warning signal if one or more vehicle separation criteria are violated.**” It is my opinion that Suzuki alone or alternatively in combination with Grisham, teaches or renders obvious this limitation. *See* Section VIII.L.3.

12. Claim 25

312. Claim 25 recites “**The collision avoidance system of claim 24, wherein each radio communication unit comprises an ultrawideband unit.**” As stated in connection with claim element 1b it is my opinion that Suzuki alone or in combination with Grisham teaches this claim. *See* Section VIII.L.1.

M. Ground 3B: Claims 2-6, 20, 22, and 27-28 are obvious over Suzuki and Richardson or Suzuki, Grisham, and Richardson

313. As set forth in Ground 3A, it is my opinion that the Suzuki in view of Richardson or in the alternative or in further combination with Grisham render claims 2-6, 20, 22, 27 and 28 obvious.

1. Claims 2 and 3

314. Claim element 2a recites **“The collision avoidance system of claim 1, further comprising a central tracking unit in communication with the first vehicle mounted module and the second vehicle mounted module.”** Further, claim element 2b recites **“wherein the central tracking unit is operable to track the location of at least the first vehicle mounted module and the second vehicle mounted module.”** Further, claim 3 recites **“The collision avoidance system of claim 2, wherein the central tracking unit is distributed among a plurality of rail vehicles, including at least the first and second rail vehicles, wherein the first vehicle mounted module comprises a first central tracking unit component.”** It is my opinion that Suzuki in view of Richardson or alternatively in further combination with Grisham, teaches or renders obvious these claims.

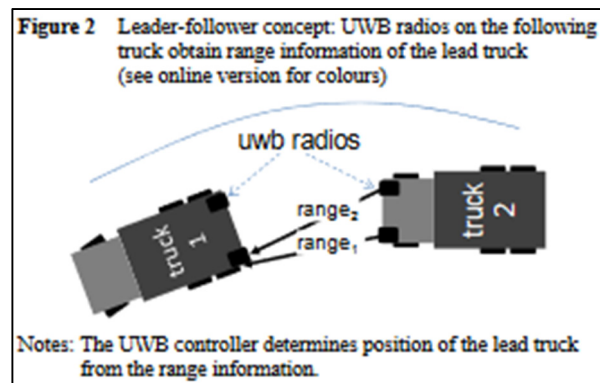
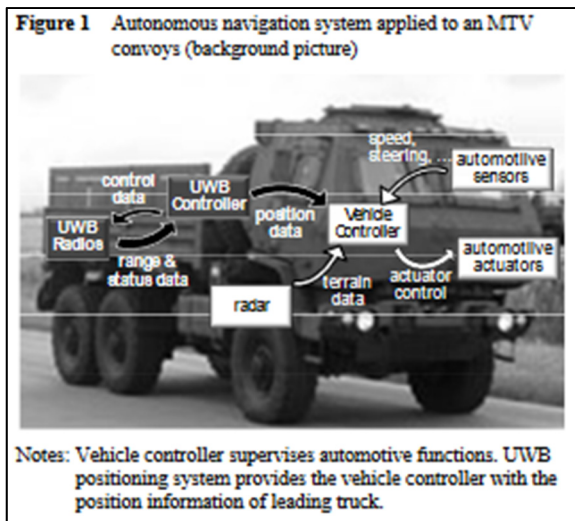
315. Suzuki describes a “platoon” functionality by a plurality of vehicles each having its in-vehicle radar devices. Suzuki teaches

[0055] Next, a car platoon by a plurality of vehicles equipped with the above-described in-vehicle radar device is described using Fig. 17.

Although four vehicles 301 to 304 are described in Fig. 17, the number of vehicles just needs to be two or more. Each vehicle comprises the same functions, and the vehicle radars 8302, 8305 shown in Fig. 8 are connected to the acceleration control part 8181, break operation unit 8182, steering control part 8183, and a switch for entering/leaving a car platoon (not shown), via the network 127. Under a command from the integral unit 310, acceleration of the vehicle is carried out in the acceleration control part 8181, and deceleration of the vehicle in the breaking operation unit 8182, and changes of the traveling direction in the steering control part 8183.

[0056] First, a situation is described in which the vehicle 304 newly enters and merges with the car group currently driving in a platoon formation. In a situation 201, the vehicles 301 to 303 are driving in a car platoon mode. In this situation, the vehicle 302 measures the distance to the vehicle 301 and the vehicle 303 measures the distance to the vehicle 302 by means of the above-described in-vehicle radar devices, respectively, and they carry out the vehicle control so that the distance between two cars is constant. Although in the vehicle 301 a personal driving is carried out by the driver because the vehicle 301 is leading, its traveling direction is transmitted to the following vehicles 302, 303 by means of the communication function of the in-vehicle radar device. In the vehicles 302, 303, an appropriate steering operation is carried out based on the obtained information on the traveling direction.

EX1005, [0055]-[0056].



316. As shown in Figs. 1 and 2, Richardson teaches a convoy of semi-autonomous vehicles in a “leader-follower operation in which the following truck, using UWB radios mounted on its cab, determines the position of the lead truck.” EX1008, p. 210, Figs. 1, 2. Each vehicle has “four radios that allow the truck to simultaneously act as a leader and follower.” EX1008, p. 210. The “UWB controller” on each vehicle “determines position of the lead truck from the range information.” *Id.*

317. Richardson teaches

“The controller manages the operation of each coordinate radio and receives range data from each radio. An orthogonal time hopping channel is defined between each pair of vehicles to allow for simultaneous position updates in a convoy with multiple trucks. Each vehicle can use its radios to request ranges from a leading vehicle or respond to range requests from a following vehicle. Individual radios

for requesting and responding are selected by the controller to minimise position errors due to geometry as discussed below.”

EX1008, p. 212 Sec. 2.3

318. Having the four radios mounted on each vehicle and each vehicle’s UWB controller in communication with not only the four UWB radios on itself but also the UWB radios mounted on other vehicles allows each vehicle to be able to track the vehicle in front of it and the vehicle behind it.

319. A POSITA would have understood, relevant to claim 2, that the UWB controller in a vehicle in Richardson’s convoy that is central to other vehicles constitutes a “central tracking unit” as claimed at least because it is in communication with and tracking the location of the UWB radios on its vehicle, is in communication with and tracking the location of the UWB radios on adjacent vehicles, and is central to those other vehicles. Moreover, because Richardson discloses the distributed CTU of claim 3 (as discussed below), and because claim 3 depends from claim 2, Richardson necessarily discloses the “central tracking unit” of claim 2 because, as I have been informed, a dependent claim falls within the scope of its parent claim.

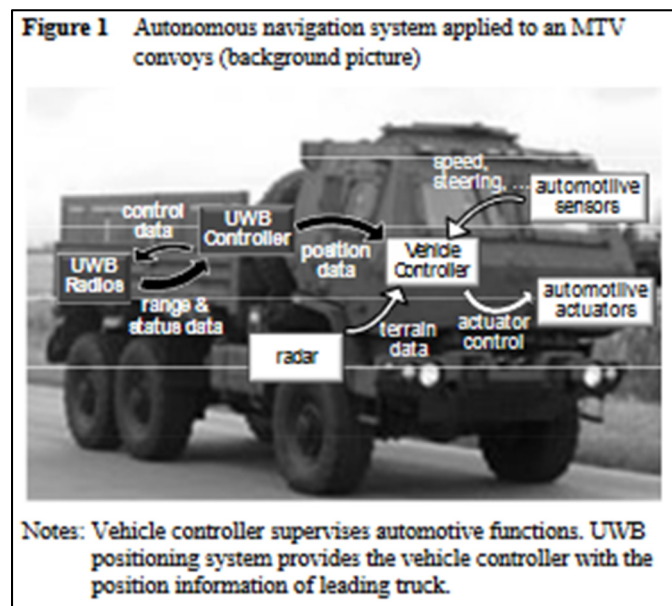
320. A POSITA would have further understood, relevant to claim 3, that a convoy could include many vehicles that could be considered central to other vehicles, and thus that many vehicles distributed in the convoy have UWB

controllers that constitute a “central tracking unit distributed among a plurality” of vehicles.

321. It is my opinion that a POSITA would have been motivated to combine the teachings of Suzuki with Richardson as well as in the alternative, Suzuki, Richardson, and Grisham. These references are all directed to collision avoidance in vehicular systems that employ ranging and vehicle-proximity detection to improve safety and because Suzuki’s disclosure of UWB communication and control over a “platoon” of vehicles is analogous to Richardson’s disclosure of UWB communication and control over a “convoy” of vehicles. A POSITA would have looked to known technologies, such as Richardson’s use of a UWB controllers acting as (distributed) CTUs to improve the collision avoidance systems of Suzuki and Grisham, which would yield a reasonable expectation of success. For example, in situations where a train with the system of Suzuki installed had another similarly equipped train ahead and another similarly equipped train behind, the middle train would meet this limitation. A POSITA also would have understood that users of Suzuki’s or Grisham’s collision avoidance system would benefit from using a CTU as taught by Richardson, including reducing potential collisions by monitoring in a unified manner the locations of and distances between multiple vehicles.

2. Claim 4

322. Claim 4 recites “**The collision avoidance system of claim 2, wherein the central tracking unit is located in a discreet housing.**” It is my opinion that Suzuki in view of Richardson or alternatively in further combination with Grisham, teaches or renders obvious Claim 4. Richardson teaches that the central tracking unit (vehicle controller) is in a discrete housing in Fig 1.



323. It is my opinion that a POSITA would have known that the use of a discrete housing⁹ is merely a design choice selecting one of two known options,

⁹ If Patent Owner argues that “discreet” is a typo of “discrete,” even though there has been no certificate of correction, a POSITA would have understood that modules in a collision-avoidance system can be integrated into one unit or

discrete or not discrete. A POSITA would understand that UWB controllers like that in Richardson can be subject to the elements or within view of the user, and therefore it would be obvious to a POSITA to select or, at the very least to try, a discreet housing in which to protect the UWB controller from the elements and from causing a user distraction while driving. It would have been obvious for a POSITA to choose from the known options and would produce a predictable result.

3. Claim 5

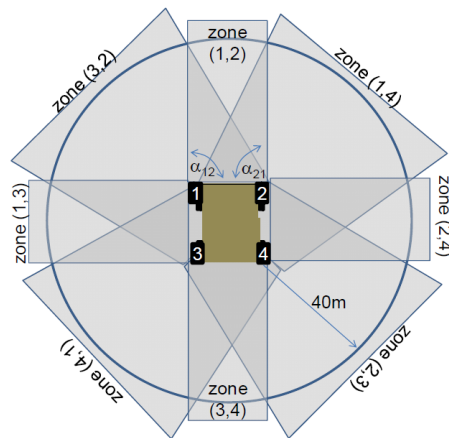
324. It is my opinion that Suzuki in view of Richardson or alternatively in further combination with Grisham, teaches or renders obvious Claim 5.

325. Claim element 5a recites **“The collision avoidance system of claim 1, wherein the first vehicle mounted module further comprises an auxiliary transponder sensor module, the auxiliary transponder sensor module mounted on the first rail vehicle with an offset with respect to the transponder sensor module,”** It is my opinion that Suzuki in view of Richardson or alternatively in further combination with Grisham, teaches or renders obvious this element.

separated as a set of discrete units, and therefore it would be obvious to a POSITA to select or, at the very least to try, (of the only two possible options—discrete or not discrete) a discrete housing to keep the module in one unit that would be more easily replaced via repair or upgrade.

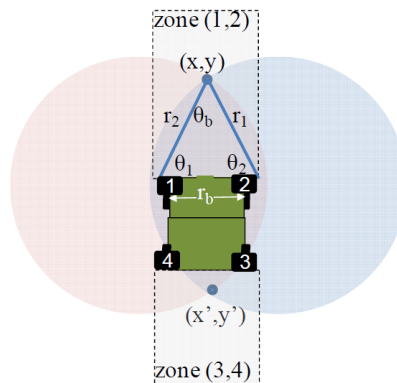
326. Figures 6 and 7 illustrate each vehicle having 4 UWB transceivers, 1 and 2 offset by a distance r_b . (EX1008, Figs. 6 and 7.) A POSITA would have been motivated to combine Suzuki and Richardson for the same reasons discussed above. Additionally, a POSITA would have understood the benefits of providing an auxiliary transponder sensor module with an offset to the transponder sensor module, including better location measurements and improved collision avoidance due to more precise information relating to length of the vehicle and mounting location of each sensor. Further, Suzuki expressly teaches use of multiple sensors on a vehicle in offset locations (for example, front and rear of the vehicle), thus a POSITA would naturally look to references such as Richardson with multiple sensors per vehicle and their use of offsets between the multiple sensors.

Figure 6 Eight zone definitions defined by coordinate radio pairs
(see online version for colours)



Notes: Ambiguous positions resulting from bilateration will never be in the same zone.

Figure 7 Bilateration for position measurement in a plane
(see online version for colours)

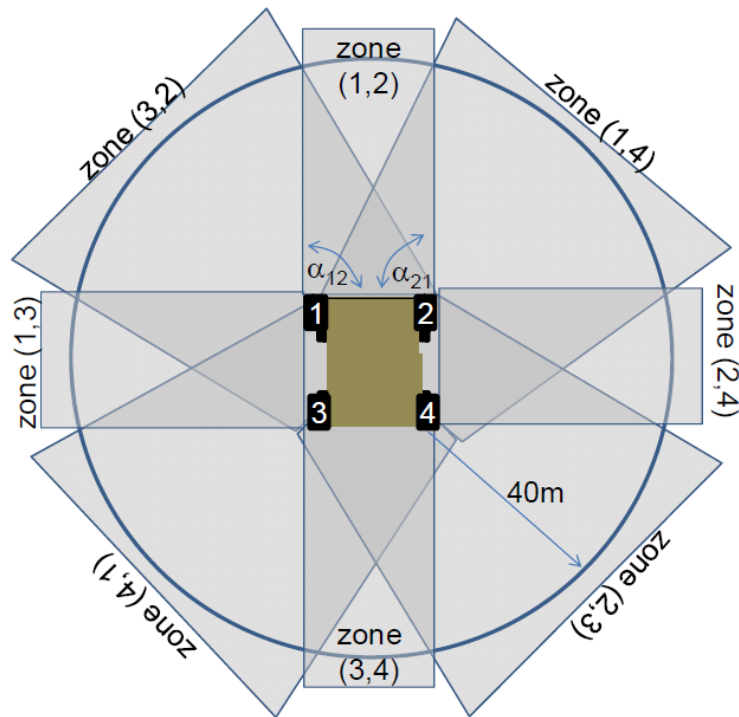


Notes: Ambiguous position at (x', y') is eliminated by assigning targets into zones based on last measurement.

327. Claim element 5b recites **“and wherein the user interface is operable to provide calibration information related to the length of the first rail vehicle, the mounting location of the first transponder sensor module, and the mounting location of the auxiliary transponder sensor module.”** Richardson uses the vehicle length (1 to 3 and 2 to 4) and the mounting location of the transceivers to define 8 zones to calibrate ranging from vehicle to vehicle. (See, e.g., EX1008, Fig. 6.) While Richardson does not explicitly teach providing this information on a user

interface, it would have been obvious to a POSITA to add this information to the user interface of Suzuki and/or, in the alternative, Suzuki and Grisham. For example, a train operator can verify the calibration information related to the length of the train against the actual length, which may change as the train drops off cars at their destinations. Further, it is my opinion that this length information would be necessary in the system described in Richardson because it would facilitate determining the width of all zones other than (1,2) and (3,4). A POSITA would understand that in order to determine the geography of the other zones would require the length of the vehicle and as such some mechanism of providing that data would be required. It would have been an obvious choice to a POSITA to provide that data through a user interface such as those discussed in Suzuki and Grisham.

Figure 6 Eight zone definitions defined by coordinate radio pairs
(see online version for colours)



Notes: Ambiguous positions resulting from bilateration
will never be in the same zone.

328. As stated above, it is my opinion that a POSITA would have been motivated to combine the teachings of Suzuki and Richardson, or in the alternative Suzuki, Grisham, and Richardson for the reasons discussed above. *See* Section VIII.M.1.

4. Claim 6

329. It is my opinion that Suzuki in view of Richardson or alternatively in further combination with Grisham, teaches or renders obvious Claim 6.

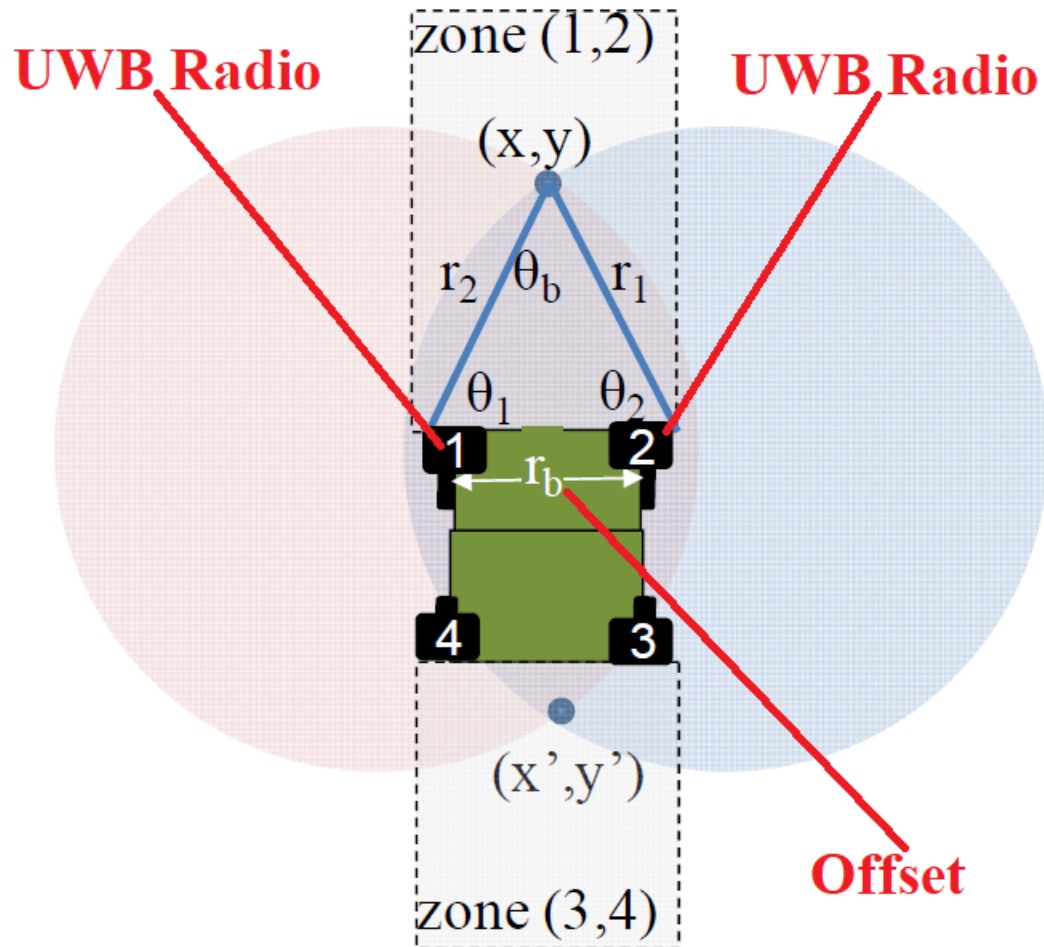
330. Claim element 6a recites **“The collision avoidance system of claim 5, wherein the auxiliary transponder sensor module comprises an auxiliary**

antenna, the auxiliary antenna being connected to at least one of the first ultra wideband unit or an auxiliary ultra wideband unit,” It is my opinion that Suzuki in view of Richardson or alternatively in further combination with Grisham, teaches or renders obvious this element.

331. Richardson teaches or suggests this limitation. As discussed above, Richardson teaches the use of UWB radios. Richardson teaches “An ultra wideband impulse radio (UWB-IR) positioning system integrated into the control system of a semi-autonomous vehicle shows promise to significantly improve the platform’s navigation capability.” EX1008, introduction, p.209. Further, Richardson teaches “The height of the *transmit antennae*, *htx*, and *receive antenna*, *hrx*, were both set to 1 m. Truth points were established using a high precision laser” EX1008, Sec. 2.1, p.214 (*emphasis added*). A POSITA would have understood that implementing Richardson’s (first) auxiliary transceiver (with a first offset of the first radio unit) would have offset the (first) auxiliary antenna (connected to the first auxiliary transceiver) from the first antenna. A POSITA would have been motivated to combine Suzuki with Richardson, and in the alternative, Suzuki, Richardson and Grisham as described above.

332. Claim element 6b recites “**and wherein the auxiliary antenna is mounted on the first rail vehicle with an offset with respect to the first antenna.**” It is my opinion that Suzuki in view of Richardson or alternatively in

further combination with Grisham, teaches or renders obvious this element. Richardson teaches the auxiliary antenna is mounted on the first rail vehicle with an offset with respect to the first. As illustrated in Figure 7, Richardson teaches mounting the auxiliary antenna at an offset (r_b) from the other unit.



Notes: Ambiguous position at (x', y') is eliminated by assigning targets into zones based on last measurement.

5. Claim 20

333. Claim element 20a recites “**The rail vehicle module of claim 17, further comprising a second wireless communications antenna mounted on the**

rail vehicle with an offset with respect to the first antenna.” It is my opinion that Suzuki in view of Richardson or alternatively in further combination with Grisham, teaches or renders obvious this element. As previously discussed, Richardson teaches a second wireless communications antenna mounted on a vehicle with an offset with respect to the first antenna. Figure 7 (above) of Richardson teaches mounting a second wireless communications antenna at an offset (r_b) from the other unit.

334. Claim element 20b recites **“wherein the rail vehicle module is operable to receive calibration information related to the length of the rail vehicle, the mounting location of the first wireless communications antenna and the mounting location of the second wireless communications antenna.”**

335. Richardson teaches a vehicle module operable to receive calibration information related to the length of the vehicle, the mounting location of the first wireless communications antenna and the mounting location of the second wireless communications antenna, and Grisham teaches rail vehicles. Further Richardson uses the vehicle length (1 to 3 and 2 to 4) and the mounting location of the transceivers to define 8 zones to calibrate ranging from vehicle to vehicle. (*See, e.g.,* EX1008, Fig. 6.) It is my opinion that this length information would be necessary to calibrate the system described in Richardson because it would facilitate determining the width of all zones other than (1,2) and (3,4). A POSITA would understand that

the in order to determine the geography of the other zones would require the length of the vehicle.

336. As stated above, it is my opinion that a POSITA would have been motivated to combine the teachings of Suzuki and Richardson, or in the alternative Suzuki, Grisham, and Richardson for the reasons discussed above. *See* Sections VIII.M.3 and VIII.M.4.

6. Claim 22

337. Claim 22 recites **“The rail vehicle module of claim 17, further comprising a central tracking unit component, wherein the central tracking unit component is in communication with a central tracking unit component mounted on the at least one other vehicle.”** It is my opinion that Suzuki in view of Richardson or alternatively in further combination with Grisham, teaches or renders claim 22 obvious.

338. Richardson teaches a CTU component in communication with a CTU component mounted on the at least one other vehicle. Richardson teaches the claimed central tracking unit. Richardson teaches “The controller manages the operation of each coordinate radio and receives range data from each radio. An orthogonal time hopping channel is defined between each pair of vehicles to allow for simultaneous position updates in a convoy with multiple trucks. Each vehicle can use its radios to request ranges from a leading vehicle or respond to range requests

from a following vehicle. Individual radios for requesting and responding are selected by the controller to minimise position errors due to geometry as discussed below.” EX1008, p. 212 Sec. 2.3.

339. As stated above, it is my opinion that a POSITA would have been motivated to combine the teachings of Suzuki and Richardson, or in the alternative Suzuki, Grisham, and Richardson for the reasons discussed above. *See* Section VIII.M.1.

7. Claim 27

340. Claim 27 is dependent from independent claim 24, it recites **“The collision avoidance system of claim 24, further comprising a central tracking unit in communication with each rail vehicle module, the central tracking unit operable to track the location of each rail vehicle module.”** It is my opinion that Suzuki in view of Richardson or alternatively in further combination with Grisham, teaches or renders claim 27 obvious.

341. As discussed above, it is my opinion that Suzuki alone, or in the alternative Suzuki in view of Grisham renders obvious independent claim 24. *See* Section VIII.L.11. Richardson teaches a CTU in communication with each vehicle module, the CTU operable to track the location of each vehicle module, and Grisham teaches rail vehicles. Richardson teaches a CTU component in communication with a CTU component mounted on the at least one other vehicle. Richardson teaches the

claimed central tracking unit. Richardson teaches “The controller manages the operation of each coordinate radio and receives range data from each radio. An orthogonal time hopping channel is defined between each pair of vehicles to allow for simultaneous position updates in a convoy with multiple trucks. Each vehicle can use its radios to request ranges from a leading vehicle or respond to range requests from a following vehicle. Individual radios for requesting and responding are selected by the controller to minimise position errors due to geometry as discussed below.” EX1008, p. 212 Sec. 2.3.

342. As stated above, it is my opinion that a POSITA would have been motivated to combine the teachings of Suzuki and Richardson, or in the alternative Suzuki, Grisham, and Richardson for the reasons discussed above. *See* Section VIII.M.1.

8. Claim 28

343. Claim 28 depends from dependent claim 27, which in turn depends from independent claim 24. It is my opinion that Suzuki in view of Richardson or alternatively in further combination with Grisham, teaches or renders claim 27 obvious. *See* Section VIII.M.7.

344. Claim element 28a recites **“28. The collision avoidance system of claim 27, wherein the central tracking unit is distributed among the rail vehicle**

modules,” It is my opinion that Suzuki in view of Richardson or alternatively in further combination with Grisham, teaches or renders this element obvious.

345. 28b recites **“wherein each of the one or more rail vehicle modules includes a central tracking unit component, each central tracking unit component being in communication with the control electronics module of the rail vehicle module.”** It is my opinion that Suzuki in view of Richardson or alternatively in further combination with Grisham, teaches or renders this element obvious.

346. Richardson teaches a CTU distributed among vehicle modules (tracking components that are distributed on the vehicles in a convoy). “The controller manages the operation of each coordinate radio and receives range data from each radio. An orthogonal time hopping channel is defined between each pair of vehicles to allow for simultaneous position updates in a convoy with multiple trucks. Each vehicle can use its radios to request ranges from a leading vehicle or respond to range requests from a following vehicle. Individual radios for requesting and responding are selected by the controller to minimise position errors due to geometry as discussed below.” EX1008, p. 212 Sec. 2.3.

347. As stated above, it is my opinion that a POSITA would have been motivated to combine the teachings of Suzuki and Richardson, or in the alternative

Suzuki, Grisham, and Richardson for the reasons discussed above. *See* Section VIII.M.1.

N. Ground 3C: Claims 9, 21, and 26 are obvious over Suzuki Nixon or Suzuki, Grisham and Nixon

348. As set forth in Ground 3C, it is my opinion that Suzuki in view of Nixon or alternatively Suzuki in view of Nixon, further in view of Grisham render claims 9, 21, and 26 obvious.

1. Claim 9

349. It is my opinion that claim 9 is obvious over Suzuki alone or in the alternative Suzuki in view of Grisham. *See* Sections VIII.L.1 and VIII.L.11.

350. Claim element 9a recites **“The collision avoidance system of claim 1, wherein the first vehicle mounted module is operable to execute a progressive warning signal if one or more vehicle separation criteria are violated,”** Further, claim element 9b recites **“wherein the progressive warning signal increases in at least one of signal rate, signal frequency, signal prominence, signal volume, or signal severity as the violation of the vehicle separation criteria approaches or extends beyond a vehicle separation threshold.”** It is my opinion that Suzuki in view of Nixon or alternatively in further combination with Grisham, teaches or renders claim 9 obvious.

351. Neither Suzuki alone nor in combination with Grisham expressly discloses progressive warnings. However, Nixon teaches such subject matter. Nixon

discloses an alarm system that produces an alert signal based on the proximity of the trains to each other. *See* EX1016 at 5-6. Specifically, Nixon describes an alert transceiver with a control processor that estimates range and speed of oncoming trains from signals received from alert transceivers of the oncoming trains. *See id.* at 5. The control processor then outputs alert signals and an alarm produces a sound or light based on the alert signals. *Id.* The sound or light is variable with range. *Id.* Nixon teaches if the control processor “determines that the target is closer, beeping is faster.” *Id.* Nixon explains that approaching speed is “estimated by tracking the change in distance.” *Id.* at 5-6. Regardless of whether the distance monitor is turned on, “a rapidly approaching vehicle within a certain range will always cause a panic alarm.” *Id.* at 6.

2. Claim 21

352. Claim 21a recites **“The rail vehicle module of claim 17, wherein the rail vehicle module is operable to utilize information generated by the radio communication unit and the global positioning system unit to determine whether one or more vehicle separation criteria are violated,”** It is my opinion that Suzuki or further in view of Grisham teaches or renders this element obvious. *See* Section VIII.L.2.

353. Claim element 21b recites **“and generate a progressive warning signal if one or more vehicle separation criteria are violated, wherein the**

progressive warning signal increases in at least one of signal rate, signal frequency, signal prominence, signal volume, or signal severity as the violation of the vehicle separation criteria approaches or extends beyond a vehicle separation threshold.” For the same reasons discussed with respect to claim 9, it is my opinion that Grisham in view of Nixon teaches or renders this element obvious. *See* Section VIII.N.1.

3. Claim 26

354. Claim 24 depends from independent claim 24. As discussed above, claim 24 is obvious over Suzuki alone or in combination with Grisham. *See* paragraphs Section VIII.L.11. Claim 24 recites **“The collision avoidance system of claim 24, wherein the progressive warning signal increases in at least one of signal rate, signal frequency, signal prominence, signal volume, or signal severity as the violation of the vehicle separation criteria approaches or extends beyond a vehicle separation threshold.”** While the “progressive warning” as used in this claim has no antecedent basis, for the purposes of this analysis I have assumed that it is a typographical error and is referring to the “warning” in claim 24. While neither Suzuki nor Grisham teach this type of progressive alarm, Nixon does. *See claim 9 above*

O. Ground 3D: Claim 15 is obvious over Suzuki and Connell or Suzuki, Grisham and Connell

1. Claim 15

355. Claim element 15a recites **“The collision avoidance system of claim 1, wherein the first vehicle mounted module is operable to execute a stopping distance calibration feature that measures a stopping distance under existing conditions,”** Further, claim element 15b recites **“and the measured stopping distance is the distance between a first location of the first rail vehicle when brakes are engaged and a second location where the first rail vehicle comes to a stop under the existing conditions.”** It is my opinion that Suzuki in view of Connell or further in view of Grisham renders this claim obvious. *See* Section VIII.E.1.

356. A POSITA would have known that varying driving conditions and speeds produce different stopping distances. They would be motivated to apply the stopping distance calibration algorithms discussed in Connell to improve the overall safety of the collision avoidance system taught in Suzuki for the same reasons discussed in connection with Grisham above.

P. Ground 3E: Claim 10 is obvious over Suzuki, Nixon and McDaniel or Suzuki, Nixon, McDaniel and Grisham

1. Claim 10

357. Claim 10 recites **“The collision avoidance system of claim 9, wherein the first vehicle mounted module executes an adaptive threshold feature that**

modifies one or more vehicle separation thresholds based on the speed of the first rail vehicle and the speed of the second rail vehicle.” It is my opinion that Suzuki in view of Nixon and McDaniel or alternatively in further combination with Grisham, teaches or renders this claim 10 obvious.

358. As discussed with respect to claim 9, Suzuki in view of Nixon or further in view of Grisham renders claim 9 obvious. While, this combination fails to teach or suggest the use of adaptive thresholds, McDaniel does. *See* Sections VIII.N.1 and VIII.I.1.

Q. Ground 3F: Claims 16 and 23 are obvious over Suzuki, Nixon, McDaniel, and Connell or Suzuki, Nixon, McDaniel, Connell, and Grisham

1. Claim 16

359. It is my opinion that Suzuki in view of Suzuki, Connell, Nixon, and McDaniel or in the alternative Suzuki, Connell, Nixon, McDaniel, and Grisham render claims 16 and 23 as obvious.

360. Claim 16 recites **“The collision avoidance system of claim 15, wherein the first vehicle mounted module executes a progressive warning signal if one or more vehicle separation criteria are violated, wherein the progressive warning signal increases in at least one of signal rate, signal frequency, signal prominence, signal volume, or signal severity as the violation of the vehicle separation criteria approaches or extends beyond a vehicle separation**

threshold, and wherein the first vehicle mounted module executes an adaptive threshold feature that modifies one or more vehicle separation thresholds based on the measured stopping distance.” It is my opinion that Suzuki in view of Connell, Nixon and McDaniel teaches or renders claim 16 obvious. *See* Sections VIII.N.1. and VIII.P.1.

2. Claim 23

361. Claim 23 depends from 16 which as discussed above is obvious in view of Suzuki in view of Nixon and McDaniel or in the alternative Suzuki, Nixon, McDaniel and Grisham.

362. Claim 23 recites **“The collision avoidance system of claim 16, further comprising an inertial measurement unit in communication with at least the control electronics module, the inertial measurement unit being operable to detect changes in the speed of the first rail vehicle.”** As discussed above with respect to claim 12 Suzuki teaches the use of an inertial measurement unit in the control electronics module. *See* Section VIII.L.5.

IX. CONCLUSION

I declare that all statements made herein of my own knowledge are true, that all statements made on information and belief are believed to be true, and that these statements were made with the knowledge that willful false statements and

the like are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

I declare under penalty of perjury that the foregoing is true and correct.

Dated: 1/13/2023



Scott Andrews

X. CLAIM LISTING

The following claim listing assigns element labels (e.g., [1A], [1B], etc.) to certain claims for clarity.

Claim 1
[1-Pre] 1. A collision avoidance system comprising:
[1A] one or more vehicle mounted modules, each vehicle mounted module mountable on a rail vehicle, each vehicle mounted module comprising:
[1B] a transponder sensor module operable to send and receive data wirelessly, the transponder module comprising a first ultra wideband unit and a first antenna;
[1C] a control electronics module comprising a processor in communication with at least the transponder sensor module unit; and
[1D] a user interface module including a user interface, the user interface being operable to provide rail vehicle information to a vehicle operator and to receive input from the vehicle operator; and
[1E] wherein each vehicle mounted module is operable to communicate with at least one other vehicle mounted module mounted on at least one other rail vehicle, and
[1F] wherein each vehicle mounted module is operable to apply a time of flight technique to determine a separation distance between the rail vehicles.
Claim 2
[2A] 2. The collision avoidance system of claim 1, further comprising a central tracking unit in communication with the first vehicle mounted module and the second vehicle mounted module,
[2B] wherein the central tracking unit is operable to track the location of at least the first vehicle mounted module and the second vehicle mounted module.
Claim 3
[3A] 3. The collision avoidance system of claim 2, wherein the central tracking unit is distributed among a plurality of rail vehicles, including at least the first and second rail vehicles,
[3B] wherein the first vehicle mounted module comprises a first central tracking unit component.
Claim 4

4. The collision avoidance system of claim 2, wherein the central tracking unit is located in a discreet housing.
Claim 5
[5A] 5. The collision avoidance system of claim 1, wherein the first vehicle mounted module further comprises an auxiliary transponder sensor module, the auxiliary transponder sensor module mounted on the first rail vehicle with an offset with respect to the transponder sensor module, and
[5B] wherein the user interface is operable to provide calibration information related to the length of the first rail vehicle, the mounting location of the first transponder sensor module, and the mounting location of the auxiliary transponder sensor module.
Claim 6
[6A] 6. The collision avoidance system of claim 5, wherein the auxiliary transponder sensor module comprises an auxiliary antenna, the auxiliary antenna being connected to at least one of the first ultra wideband unit or an auxiliary ultra wideband unit, and
[6B] wherein the auxiliary antenna is mounted on the first rail vehicle with an offset with respect to the first antenna.
Claim 7
[7A] 7. The collision avoidance system of claim 1, wherein the first vehicle mounted module further comprises a global positioning system unit, the global positioning system unit operable to receive information from one or more satellites to determine an absolute position of the rail vehicle,
[7B] wherein the global positioning system unit is in communication with the control electronics module.
Claim 8
8. The collision avoidance system of claim 7, wherein the first vehicle mounted module receives information generated by the global positioning system unit and the first ultra wideband unit to determine whether one or more vehicle separation criteria are violated, and generates a warning signal when one or more vehicle separation criteria are violated.
Claim 9
[9A] 9. The collision avoidance system of claim 1, wherein the first vehicle mounted module is operable to execute a progressive warning signal if one or more vehicle separation criteria are violated, and
[9B] wherein the progressive warning signal increases in at least one of signal rate, signal frequency, signal prominence, signal volume, or signal severity as the violation of the vehicle separation criteria approaches or extends beyond a vehicle separation threshold.

Claim 10
10. The collision avoidance system of claim 9, wherein the first vehicle mounted module executes an adaptive threshold feature that modifies one or more vehicle separation thresholds based on the speed of the first rail vehicle and the speed of the second rail vehicle.
Claim 11
11. The collision avoidance system of claim 1, further comprising at least one ground speed detection module operable to determine the speed of the rail vehicle, wherein the first vehicle mounted module communicates with the at least one ground speed detection module.
Claim 12
12. The collision avoidance system of claim 1, further comprising an inertial measurement unit in communication with at least the control electronics module, the inertial measurement unit being operable to detect changes in the speed of the first rail vehicle.
Claim 13
13. The collision avoidance system of claim 12, wherein the inertial measurement unit comprises at least one of an accelerometer or a gyroscope.
Claim 14
14. The collision avoidance system of claim 1 wherein the ultra wideband unit is adapted to transmit and receive signals with varying center frequencies.
Claim 15
[15A] 15. The collision avoidance system of claim 1, wherein the first vehicle mounted module is operable to execute a stopping distance calibration feature that measures a stopping distance under existing conditions,
[15B] wherein the stopping distance measures the distance between the point where the brakes are engaged to the point where the vehicle comes to a stop under the existing conditions.
Claim 16
[16A] 16. The collision avoidance system of claim 15, wherein the first vehicle mounted module executes a progressive warning signal if one or more vehicle separation criteria are violated,
[16B] wherein the progressive warning signal increases in at least one of signal rate, signal frequency, signal prominence, signal volume, or signal severity as the violation of the vehicle separation criteria approaches or extends beyond a vehicle separation threshold, and
[16C] wherein the first vehicle mounted module executes an adaptive threshold feature that modifies one or more vehicle separation thresholds based on the measured stopping distance.

Claim 17
[17-Pre] 17. A rail vehicle module mountable on a rail vehicle, the module comprising:
[17A] a transponder sensor module comprising:
[17B] a radio communication unit operable to employ time of flight techniques to detect a distance between the rail vehicle and at least one other vehicle;
[17C] a wireless communications antenna operable to send and receive data over the air; and
[17D] a global positioning system unit operable to receive information from one or more satellites to determine an absolute position of the rail vehicle;
[17E] a control electronics module comprising a processor in communication with at least the first transponder sensor module; and
[17F] a user interface module including a user interface operable to provide rail vehicle information to a vehicle operator and to receive input from the vehicle operator;
[17G] wherein the rail vehicle module communicates with at least one other module mounted on at least one other vehicle to detect a separation distance between the rail vehicle and the at least one other vehicle.
Claim 18
18. The rail vehicle module of claim 17, wherein the radio communication unit comprises an ultra wideband unit configured to send and receive ultra wideband signals.
Claim 19
19. The rail vehicle module of claim 18, wherein the ultra wideband unit is adapted to transmit and receive signals with varying center frequencies.
Claim 20
[20A] 20. The rail vehicle module of claim 17, further comprising a second wireless communications antenna mounted on the rail vehicle with an offset with respect to the first antenna,
[20B] wherein the rail vehicle module is operable to receive calibration information related to the length of the rail vehicle, the mounting location of the first wireless communications antenna and the mounting location of the second wireless communications antenna.
Claim 21
[21A] 21. The rail vehicle module of claim 17, wherein the rail vehicle module is operable to utilize information generated by the radio communication unit and the global positioning system unit to determine whether one or more vehicle separation criteria are violated, and

[21B] generate a progressive warning signal if one or more vehicle separation criteria are violated, wherein the progressive warning signal increases in at least one of signal rate, signal frequency, signal prominence, signal volume, or signal severity as the violation of the vehicle separation criteria approaches or extends beyond a vehicle separation threshold.
Claim 22
[22A] 22. The rail vehicle module of claim 17, further comprising a central tracking unit component,
[22B] wherein the central tracking unit component is in communication with a central tracking unit component mounted on the at least one other vehicle.
Claim 23
23. The collision avoidance system of claim 16, further comprising an inertial measurement unit in communication with at least the control electronics module, the inertial measurement unit being operable to detect changes in the speed of the first rail vehicle.
Claim 24
[24-Pre] 24. A collision avoidance system comprising
[24A] one or more vehicle mounted modules, each vehicle mounted module mountable on a rail vehicle, each vehicle mounted module comprising:
[24B] a transponder sensor module comprising:
[24C] a radio communication unit operable to employ time of flight techniques to detect a distance between rail vehicles; and
[24D] a global positioning system unit operable to receive information from one or more satellites to determine an absolute position of the rail line vehicle;
[24E] a control electronics module comprising a processor, the control electronics module being in communication with at least the transponder sensor module; and
[24F] a user interface operable to provide rail vehicle information to a vehicle operator and to receive input from the vehicle operator;
[24G] wherein each of the two or more rail vehicle modules communicate to determine a separation distance between each rail vehicle, and
[24H] wherein each rail vehicle module is operable to use information provided by the radio communication unit and the global positioning system unit to determine whether one or more vehicle separation criteria are violated, and to generate a warning signal if one or more vehicle separation criteria are violated.
Claim 25
25. The collision avoidance system of claim 24, wherein each radio communication unit comprises an ultra wideband unit.

Claim 26
26. The collision avoidance system of claim 24, wherein the progressive warning signal increases in at least one of signal rate, signal frequency, signal prominence, signal volume, or signal severity as the violation of the vehicle separation criteria approaches or extends beyond a vehicle separation threshold.
Claim 27
27. The collision avoidance system of claim 24, further comprising a central tracking unit in communication with each rail vehicle module, the central tracking unit operable to track the location of each rail vehicle module.
Claim 28
[28A] 28. The collision avoidance system of claim 27, wherein the central tracking unit is distributed among the rail vehicle modules,
[28B] wherein each of the one or more rail vehicle modules includes a central tracking unit component, each central tracking unit component being in communication with the control electronics module of the rail vehicle module.